

Product Architecture/ Design for Manufacturing

4013.315 Architectural Engineering System Design

May 20th, 2009

Moonseo Park

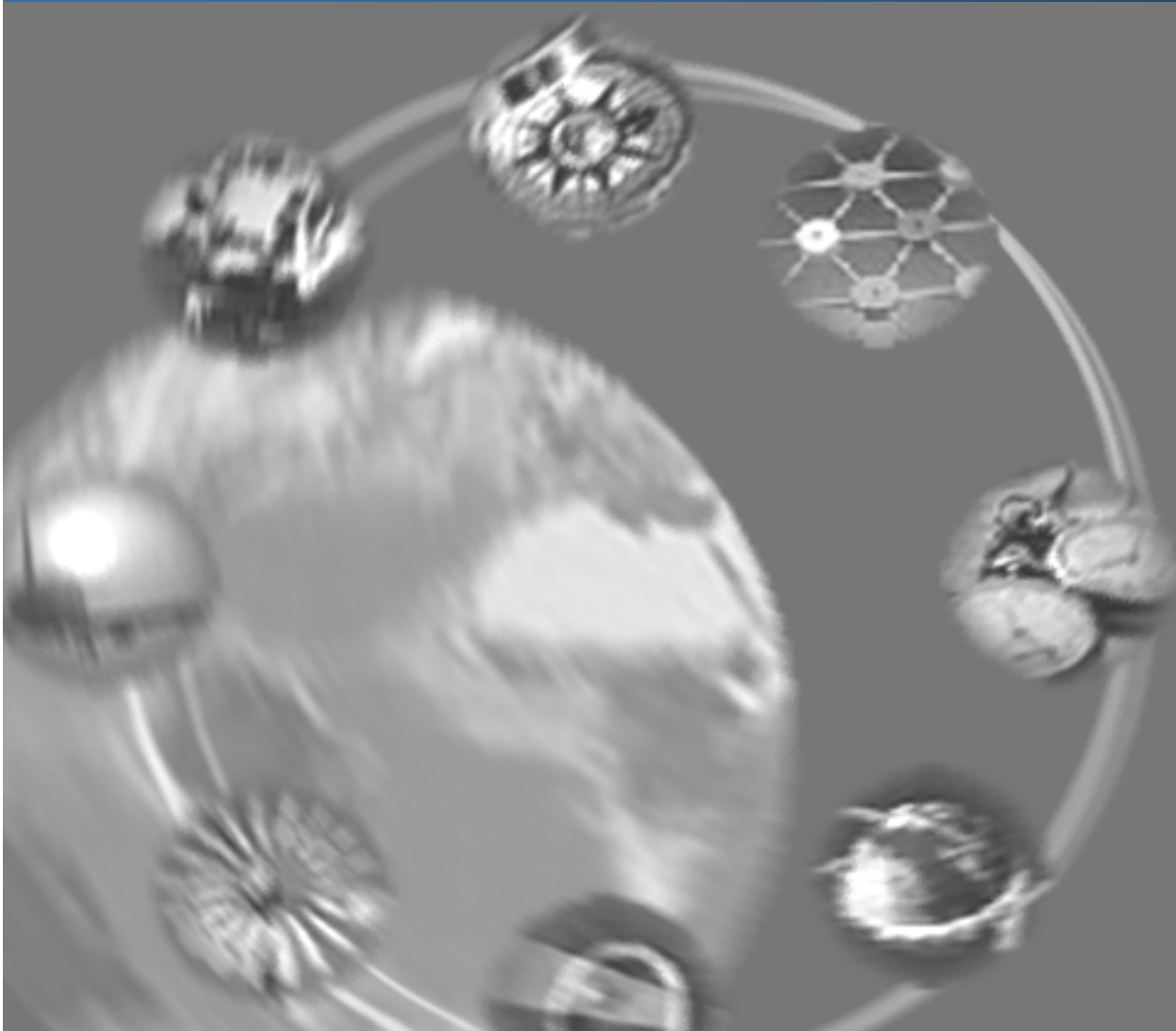
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Product Architecture

Product Design and Development

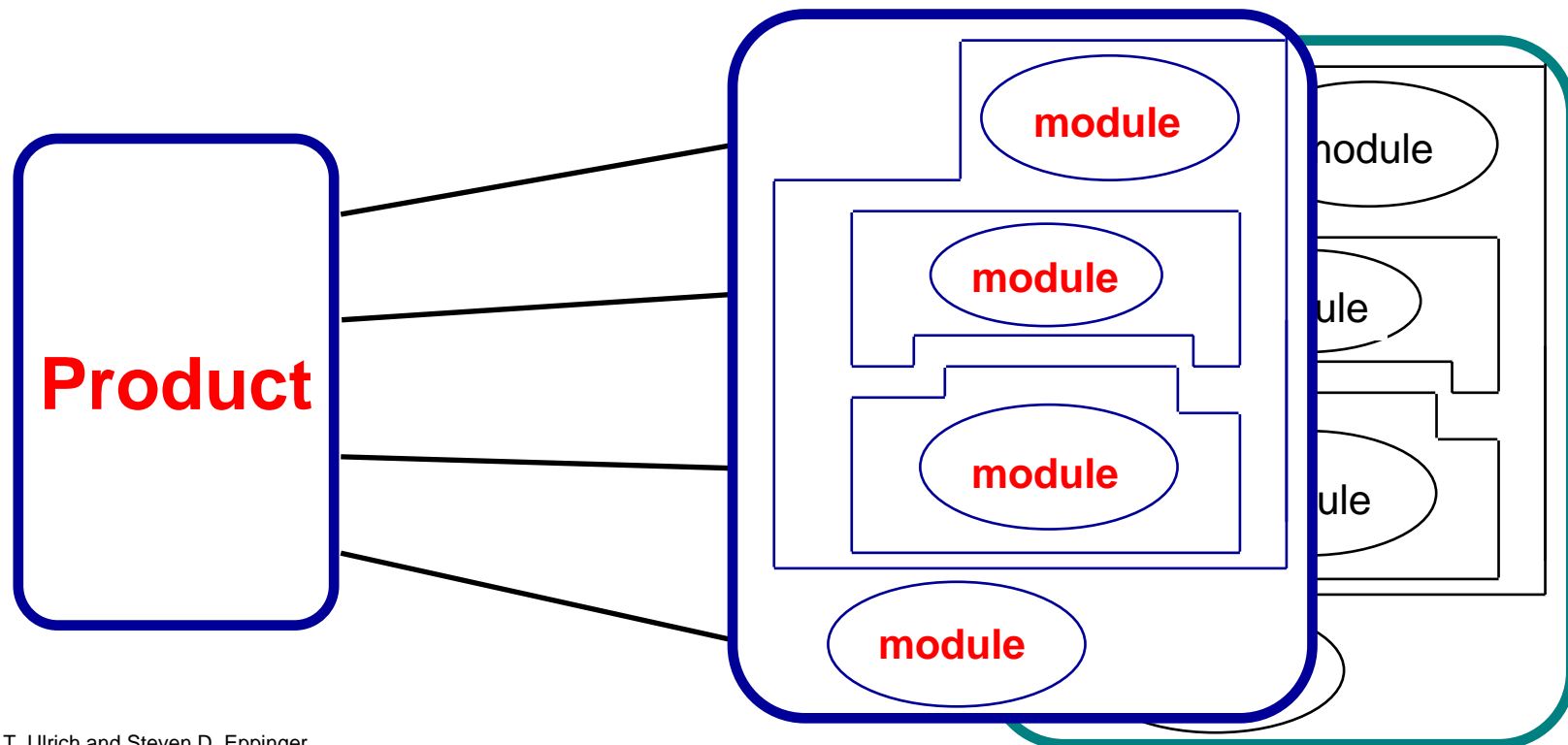
Karl T. Ulrich and Steven D. Eppinger
2nd edition, Irwin McGraw-Hill, 2000.

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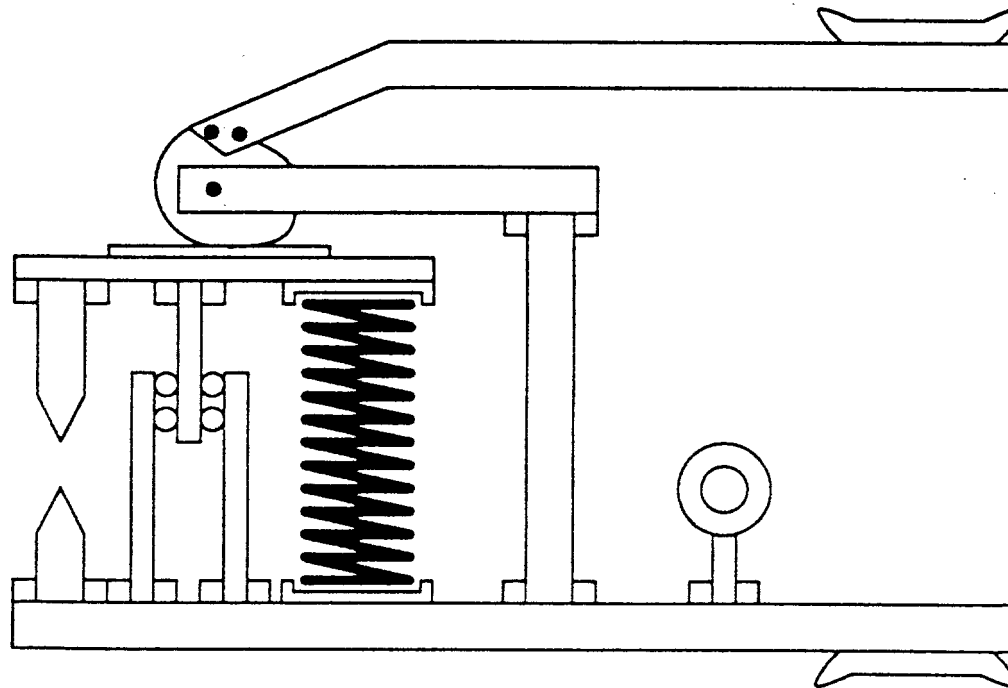
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Product Architecture

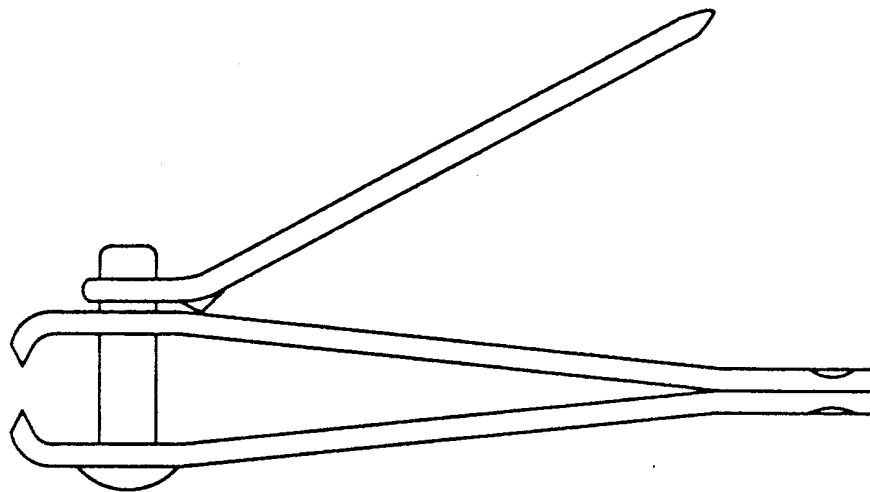
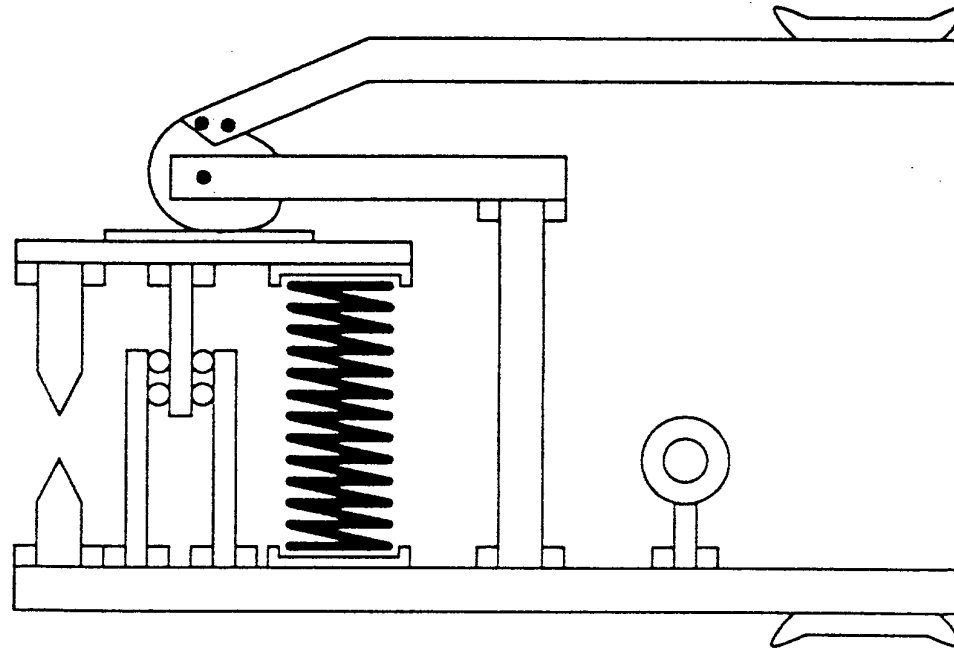
The arrangement of functional elements into physical chunks which become the building blocks for the product or family of products.



What is this?



Nail Clippers?



Modular Product Architectures

- Chunks implement one or a few functions entirely.
- Interactions between chunks are well defined.
- Modular architecture has advantages in simplicity and reusability for a product family or platform.



Swiss Army Knife



Sony Walkman

Platform Architecture of the Sony Walkman



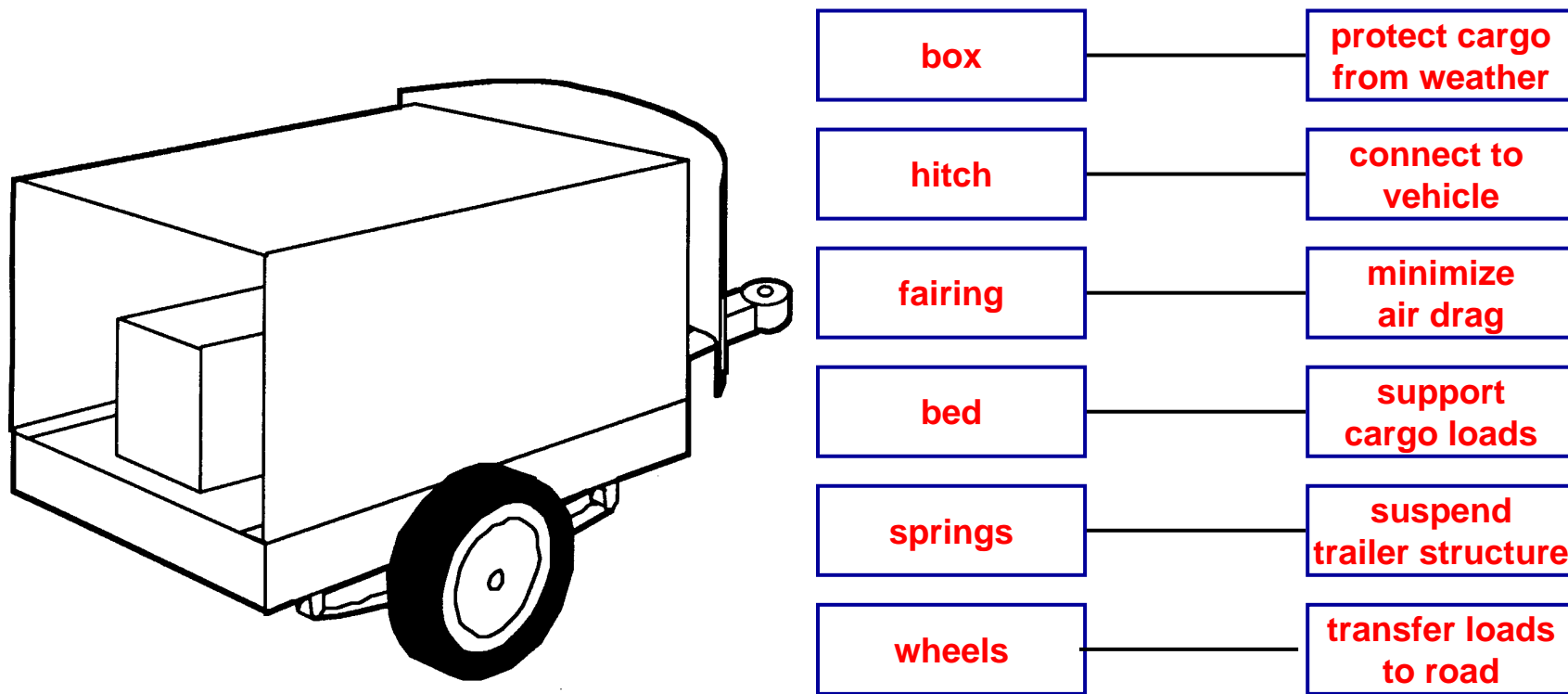
Integral Product Architectures

- Functional elements are implemented by multiple chunks, or a chunk may implement many functions.
- Interactions between chunks are poorly defined.
- Integral architecture generally increases performance and reduces costs for any specific product model.

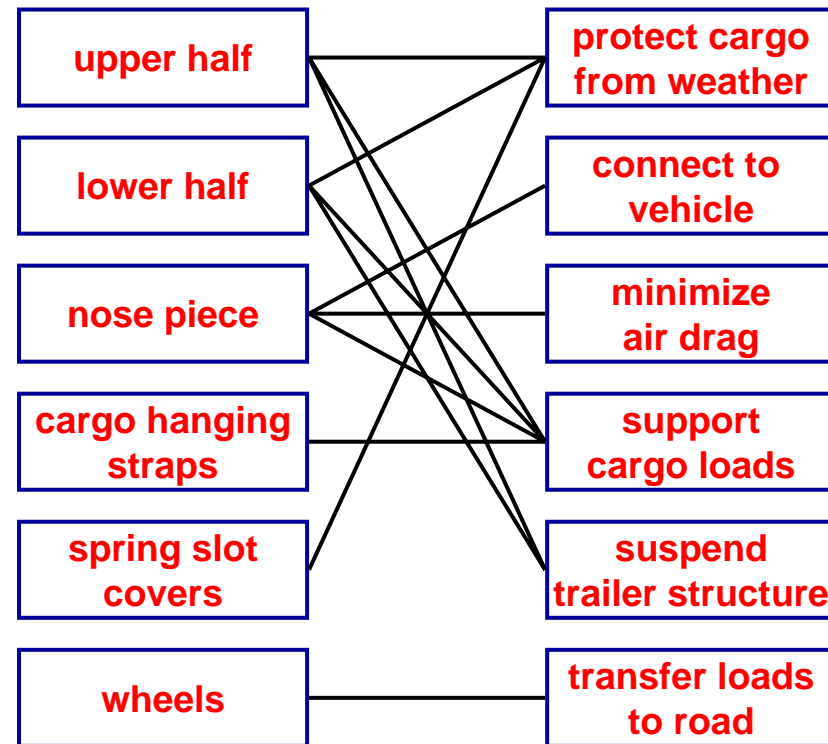
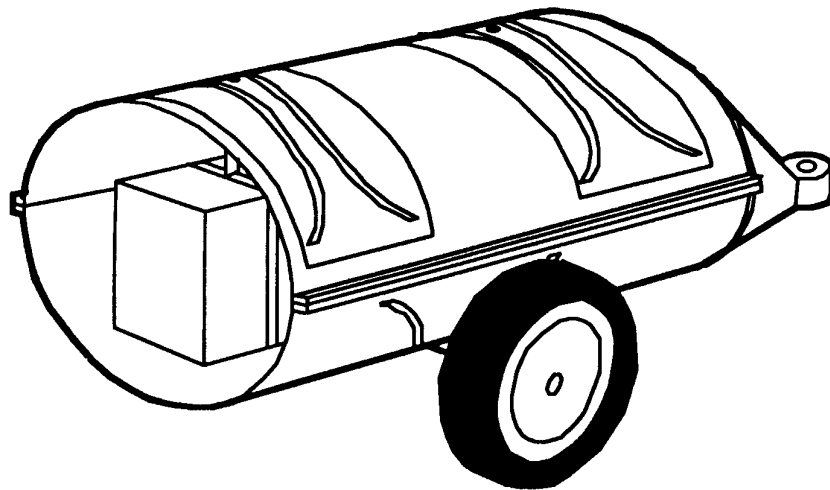


Compact Camera

Trailer Example: Modular Architecture



Trailer Example: Integral Architecture



Choosing the Product Architecture

Architecture decisions (e.g., how to divide into chunks, how much modularity to impose) relate to product planning and concept development decisions.

- Product Change
 - Upgrade (e.g., process board in printer)
 - Add-ons (e.g., USB memories)
 - Adaptation (e.g., gasoline engine to propane engine)
 - Wear (e.g., razors, tires)
 - Consumption (e.g., copier toner)
 - Flexibility in use (e.g., camera lenses)
 - Reuse (e.g., minor change of consumer electronics)

- Product Variety (computers, automobiles)
- Standardization (movement for Swatch, motors, bearings, fasteners)
- Performance (racing bikes, fighter planes)
- Manufacturing Cost (disk drives, razors)
- Project Management (team capacity, skills)
- System Engineering (decomposition, integration)

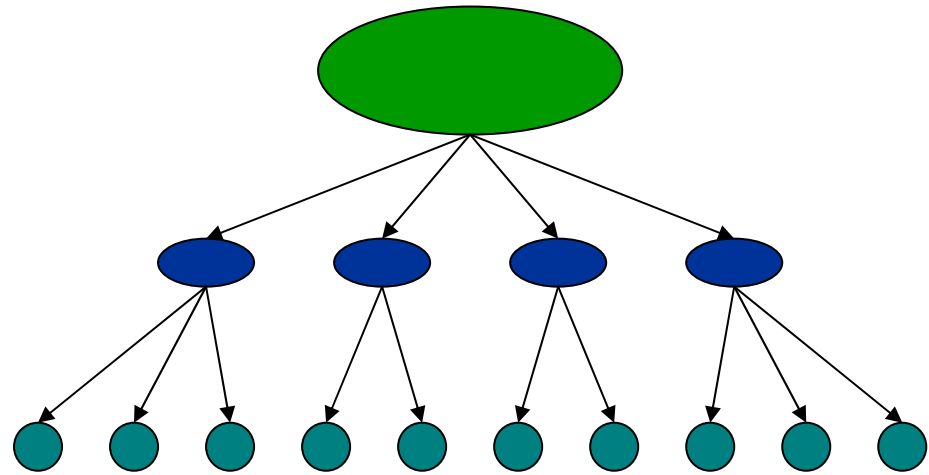
Ford Taurus Integrated Control Panel



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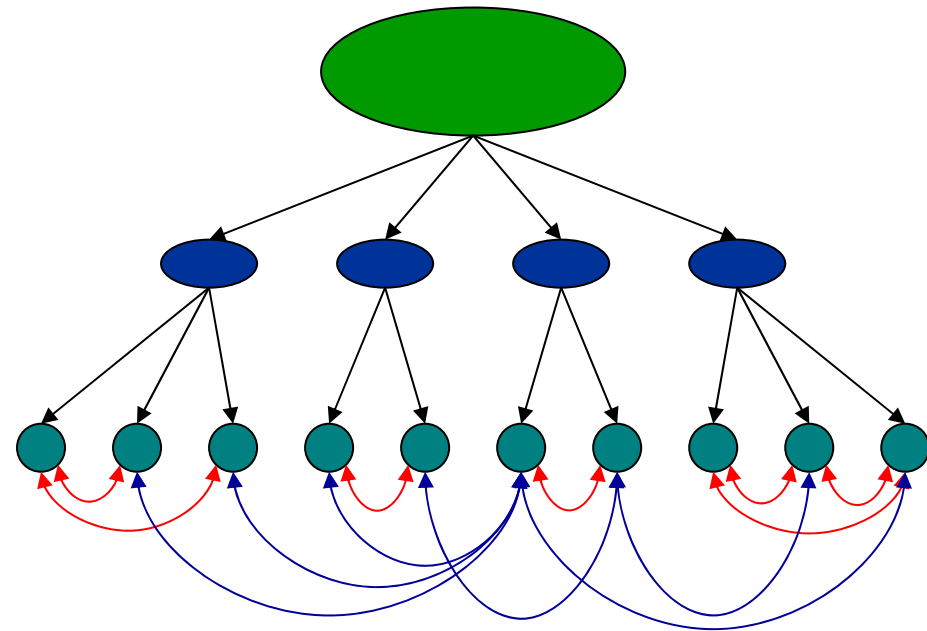
The concepts of integral and modular apply at several levels:

- system
- sub-system
- component



Product Architecture = Decomposition + Interactions

- ↔ Interactions
within chunks
- ↔ Interactions
across chunks

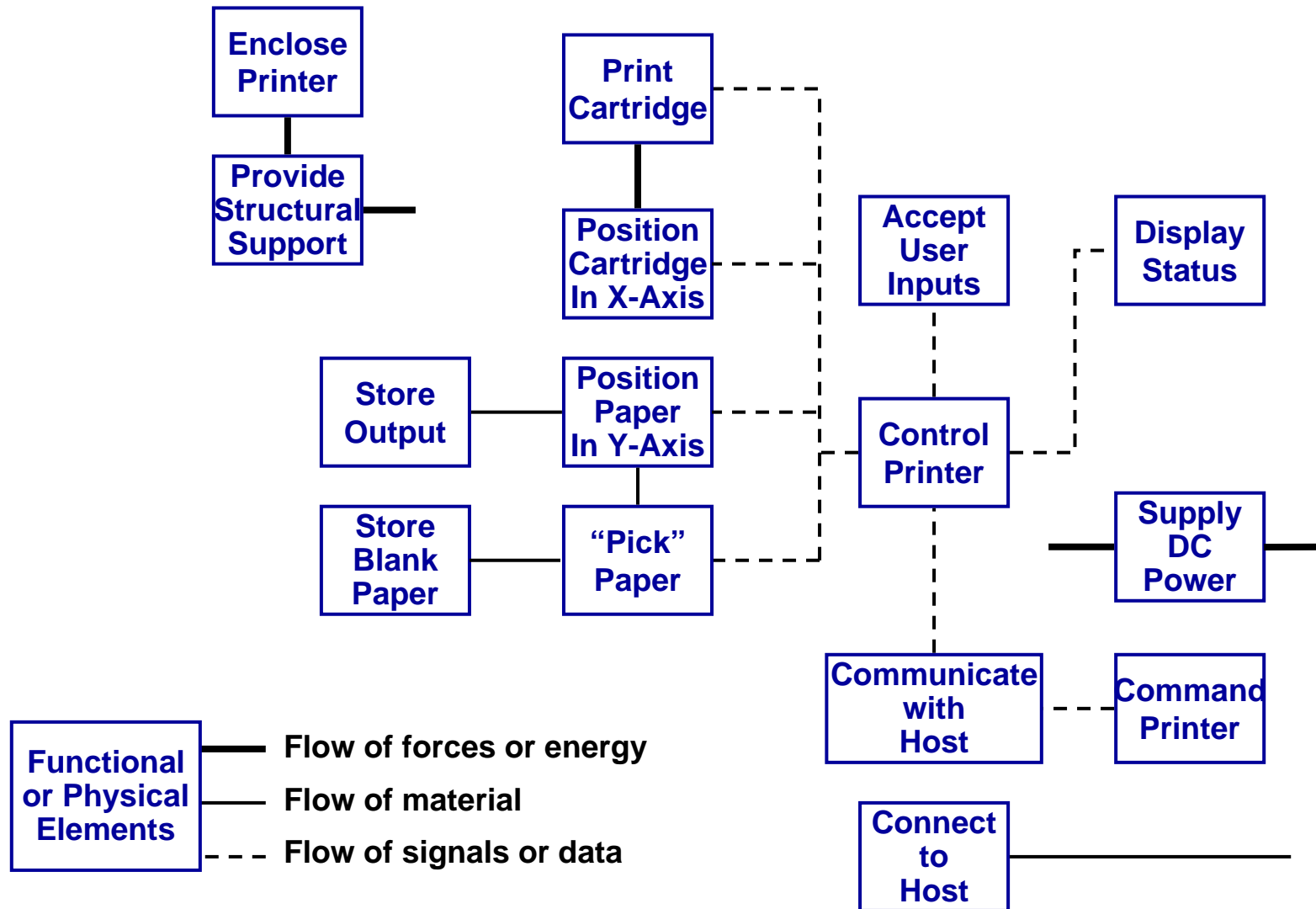


Establishing the Architecture

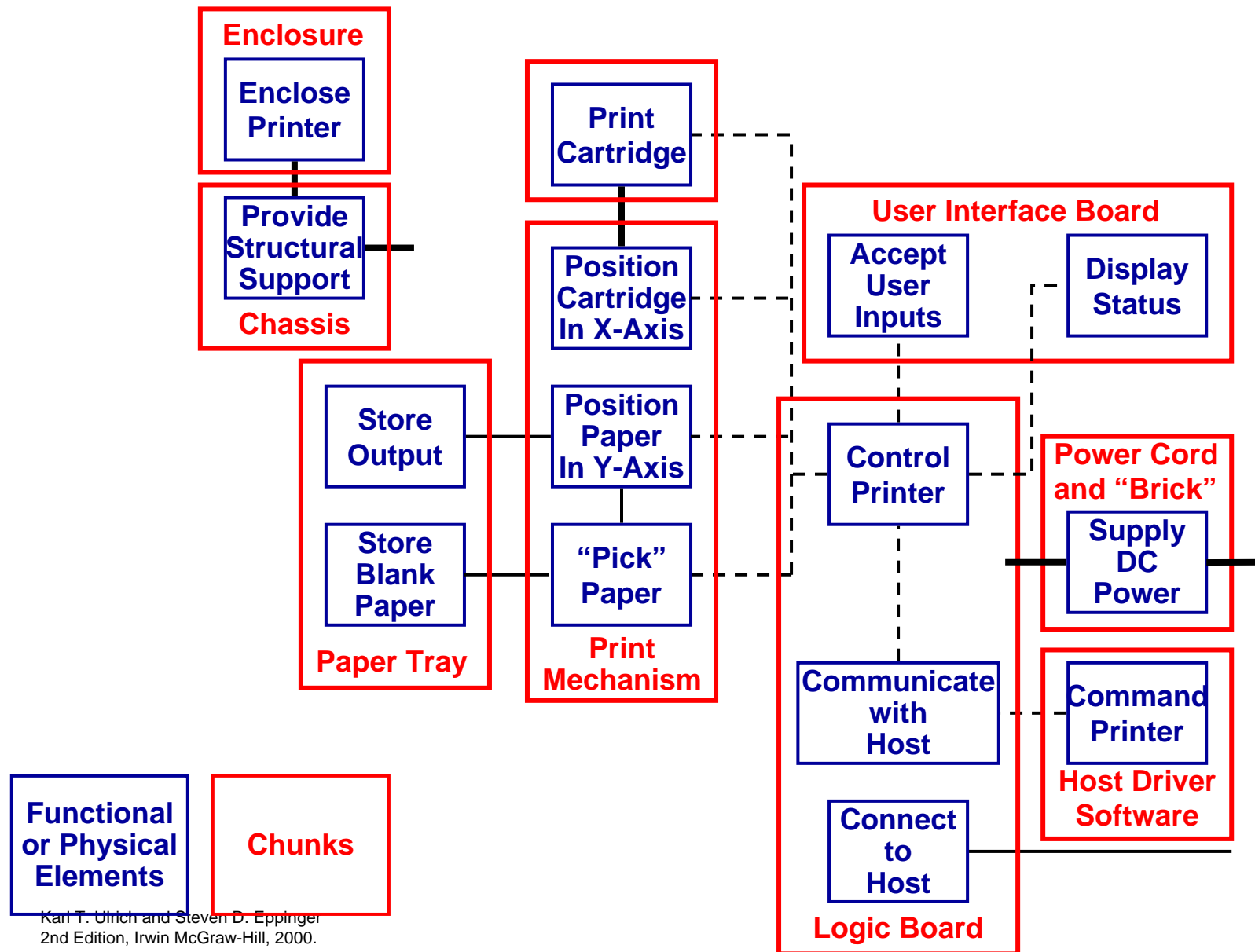
To establish a modular architecture, create a schematic of the product, and cluster the elements of the schematic to achieve the types of product variety desired.

A schematic is a diagram representing the team's understanding of the constituent elements of the product

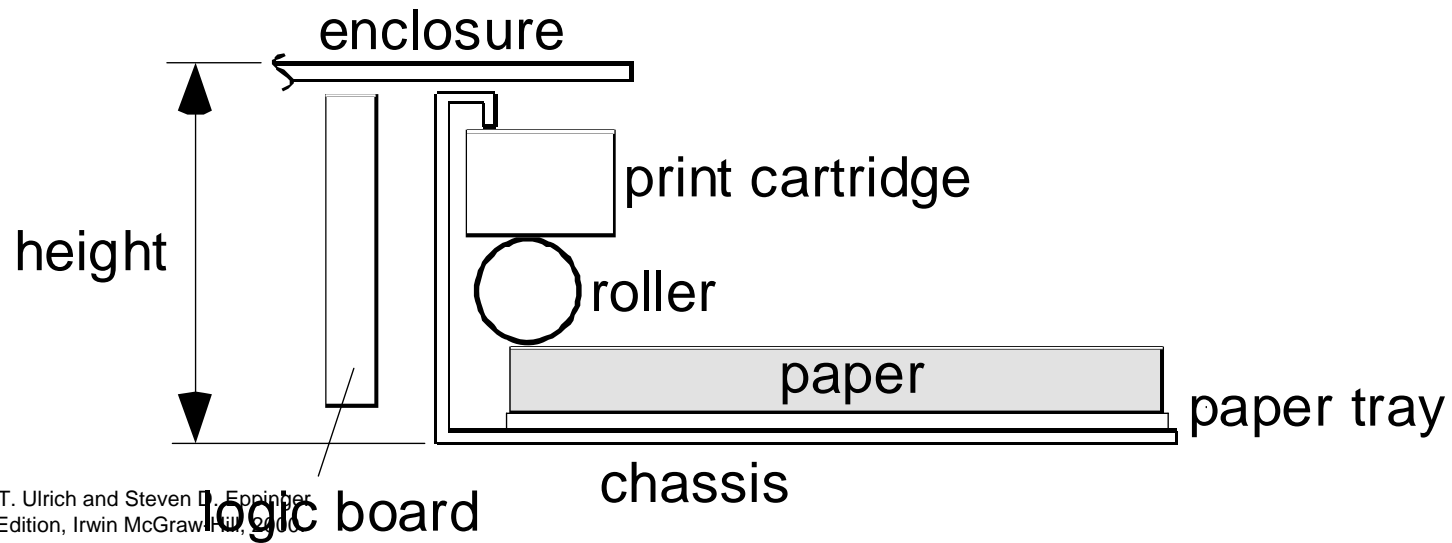
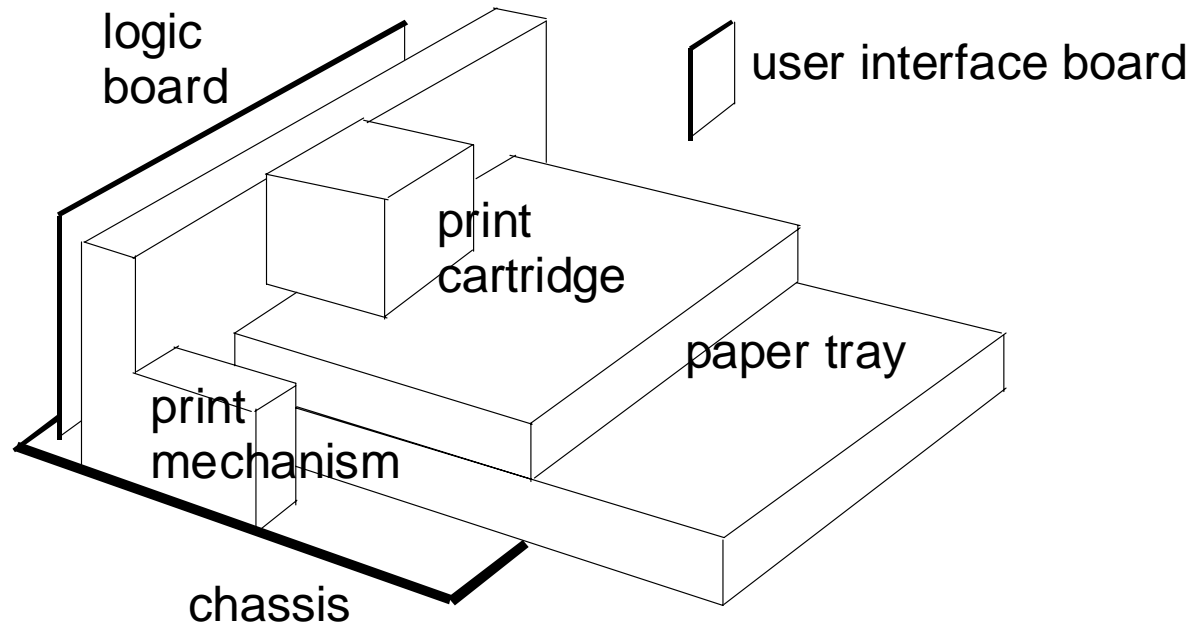
DeskJet Printer Schematic



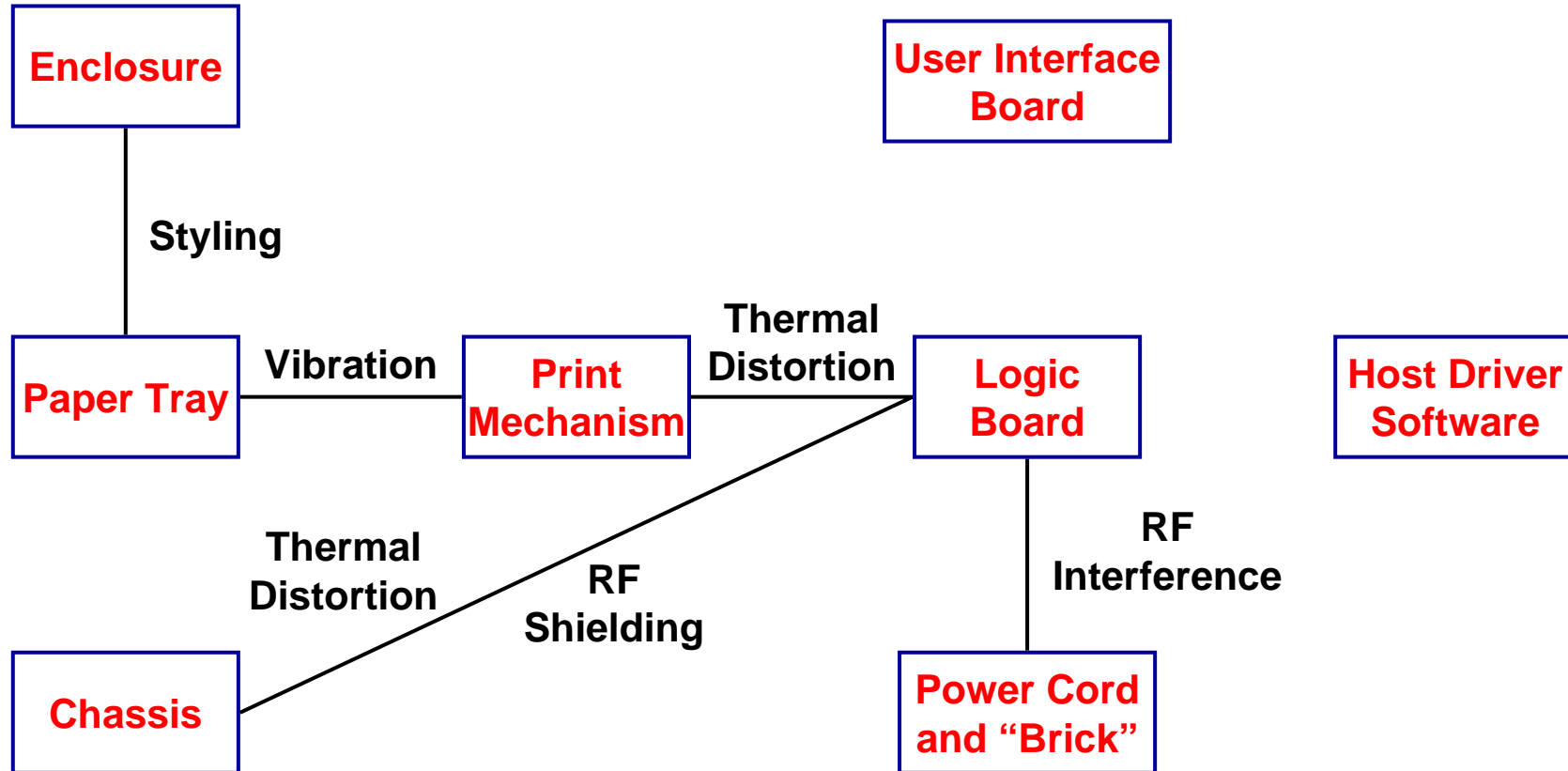
Cluster Elements into Chunks



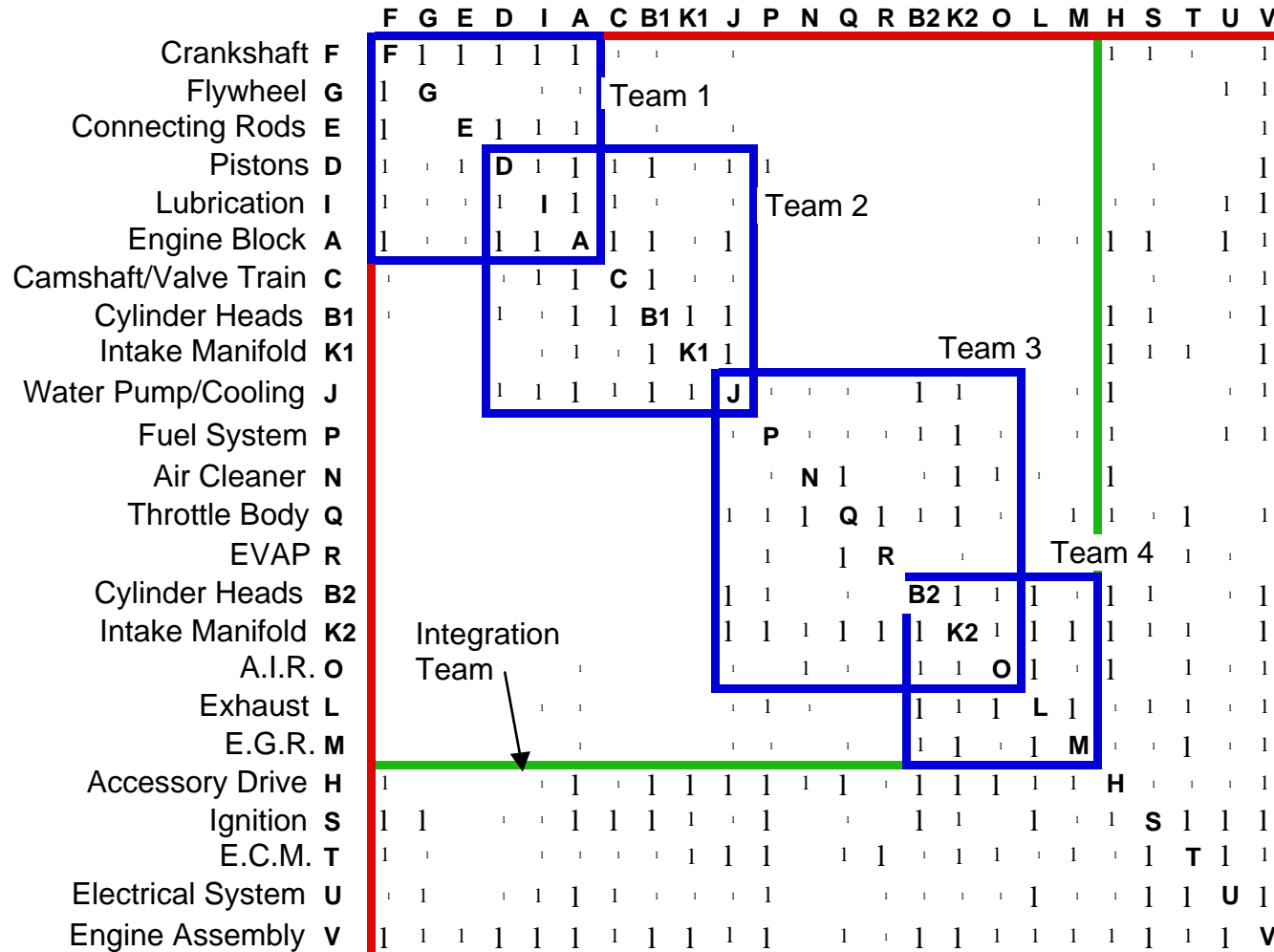
Geometric Layout



Incidental Interactions



System Team Assignment Based on Product Architecture

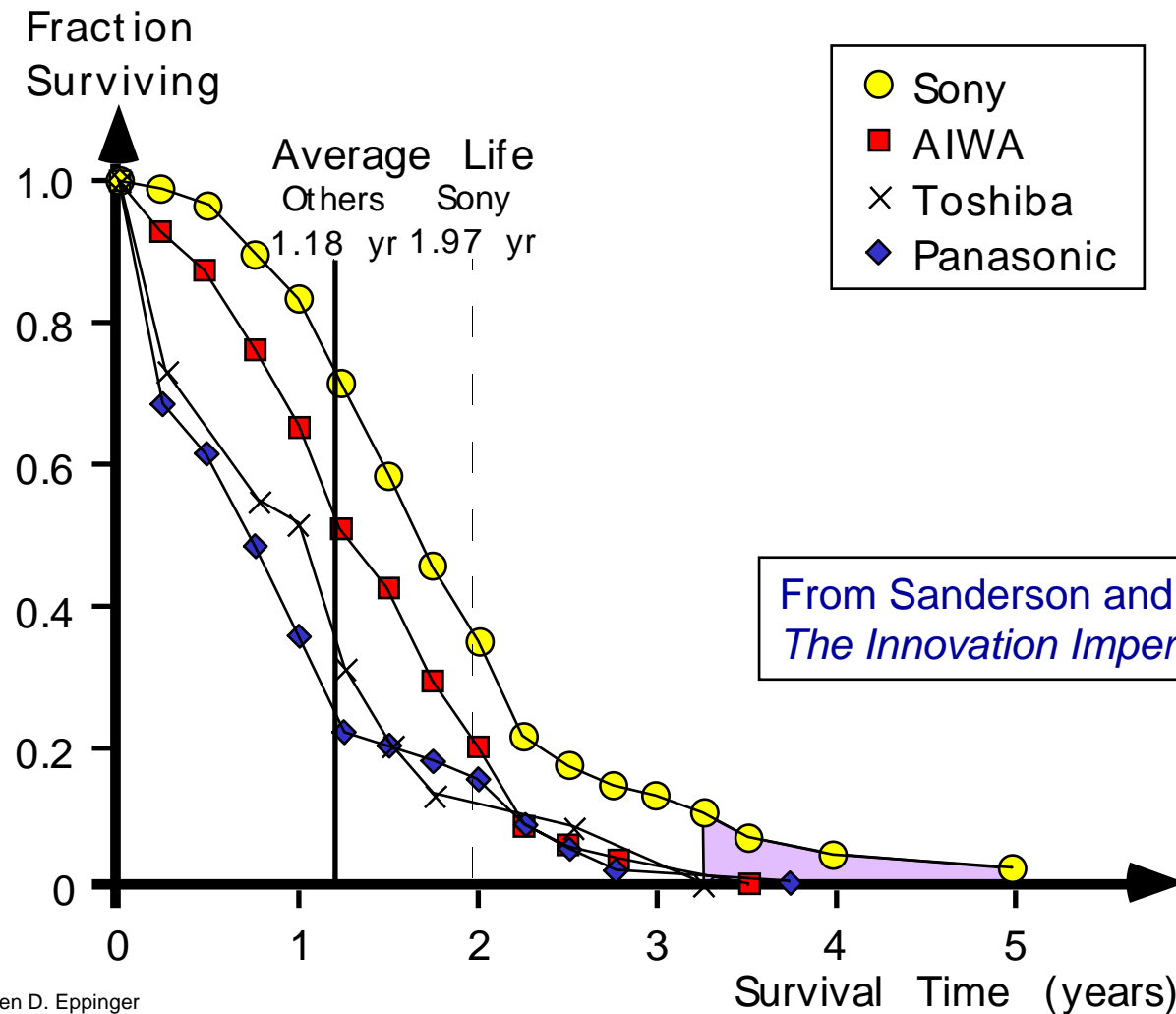


Frequency of PDT Interactions
 1 Daily 1 Weekly 1 Monthly

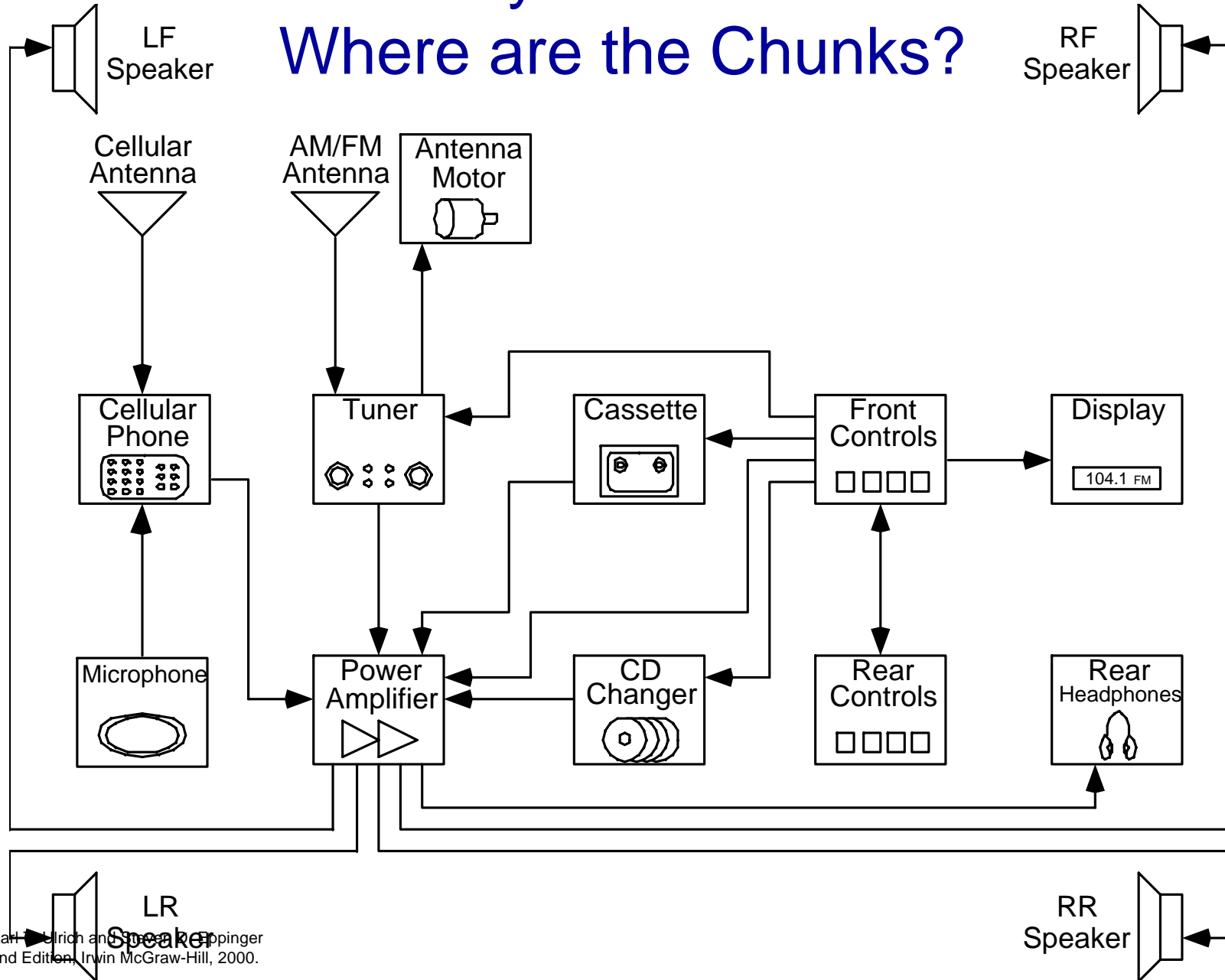
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From "Innovation at the Speed of Information", S. Eppinger, *HBR*, January 2001.

Product Model Lifetime



Audio System Exercise: Where are the Chunks?



Fundamental Decisions

- Integral vs. modular architecture?
- What type of modularity?
- How to assign functions to chunks?
- How to assign chunks to teams?
- Which chunks to outsource?

Practical Concerns

- Planning is essential to achieve the desired variety and product change capability.
- Coordination is difficult, particularly across teams, companies, or great distances.
- Special attention must be paid to handle complex interactions between chunks (system engineering methods).

Product Architecture: Conclusions

- Architecture choices define the sub-systems and modules of the product platform or family.
- Architecture determines:
 - ease of production variety
 - feasibility of customer modification
 - system-level production costs
- Key Concepts:
 - modular vs. integral architecture
 - clustering into chunks
 - planning product families

Design for Manufacturing

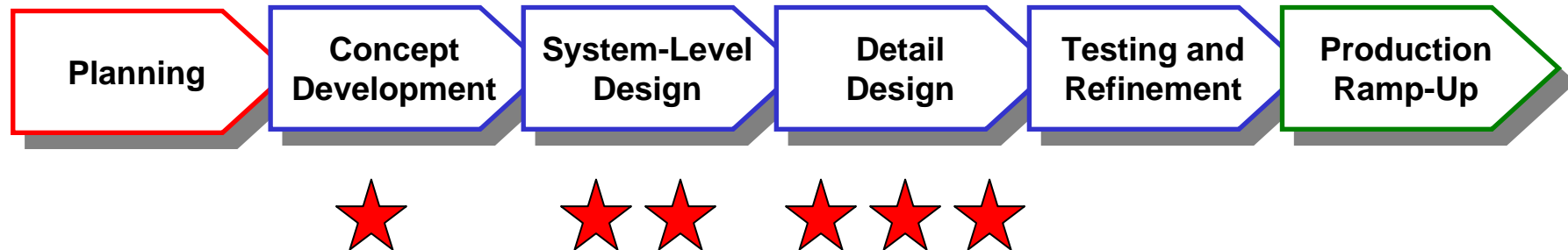
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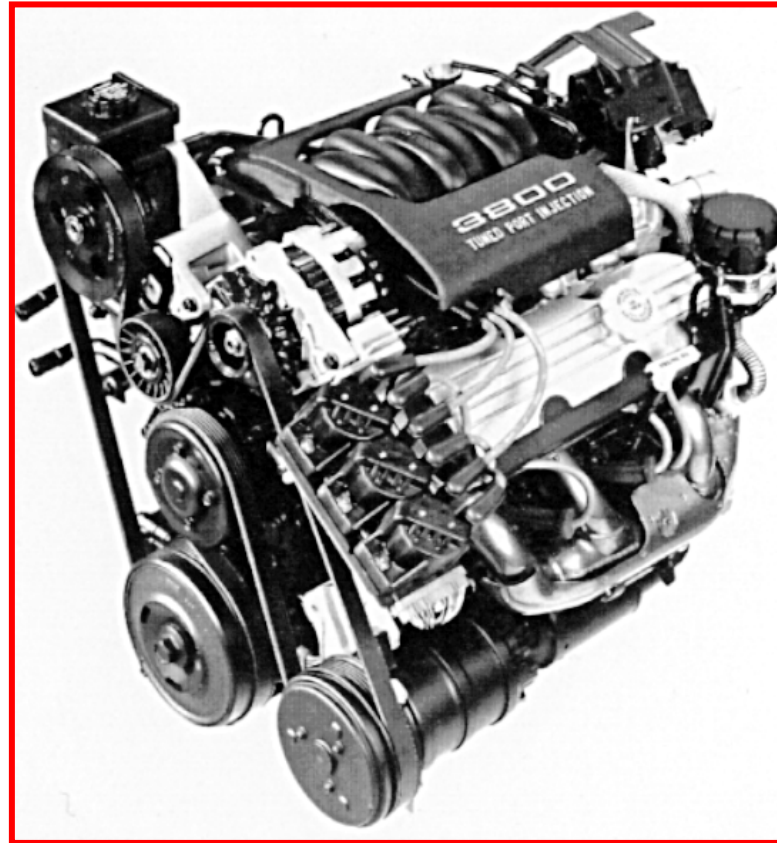
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Product Development Process

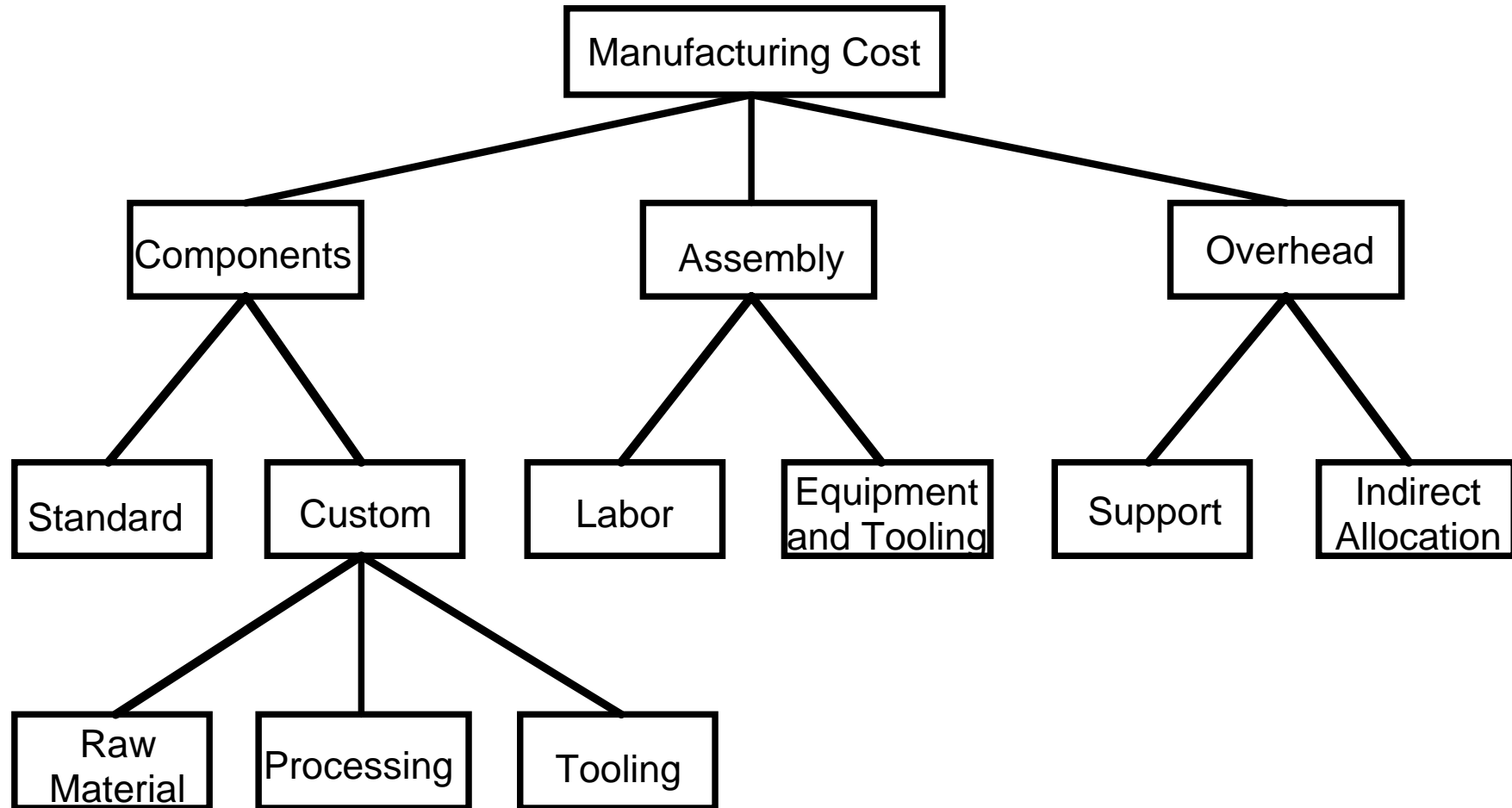


How can we emphasize manufacturing issues throughout the development process?

Design for Manufacturing Example: GM 3.8-liter V6 Engine



Understanding Manufacturing Costs



Definition

- **Design for manufacturing (DFM) is a development practice emphasizing manufacturing issues throughout the product development process.**
- **Successful DFM results in lower production cost without sacrificing product quality.**

Three Methods to Implement DFM

1. Organization: Cross-Functional Teams
2. Design Rules: Specialized by Firm
3. CAD Tools: Boothroyd-Dewhurst Software

Design for Assembly Rules

Example set of DFA guidelines
from a computer manufacturer.

1. Minimize parts count.
2. Encourage modular assembly.
3. Stack assemblies.
4. Eliminate adjustments.
5. Eliminate cables.
6. Use self-fastening parts.
7. Use self-locating parts.
8. Eliminate reorientation.
9. Facilitate parts handling.
10. Specify standard parts.

Design for Assembly

- Key ideas of DFA:
 - Minimize parts count
 - Maximize the ease of **handling** parts
 - Maximize the ease of **inserting** parts
- Benefits of DFA
 - Lower labor costs
 - Other indirect benefits
- Popular software developed by Boothroyd and Dewhurst.

– <http://www.dfma.com>

To Compute Assembly Time

$$\begin{array}{r} \text{Handling Time} \\ + \text{Insertion Time} \\ \hline \text{Assembly Time} \end{array}$$

Method for Part Integration

- Ask of each part in a candidate design:
 1. Does the part need to move relative to the rest of the device?
 2. Does it need to be of a different material because of fundamental physical properties?
 3. Does it need to be separated from the rest of the device to allow for assembly, access, or repair?
- If not, combine the part with another part in the device.

Videocassette DFM Exercise

- 2 billion worldwide annual volume
- 7 major producers of 1/2" cassette shells
- JVC licenses the VHS standard
 - dimensions, interfaces, light path, etc
- VHS cassette shells cost ~\$0.25 each
- What is a \$0.01 cost reduction worth?

DFM Strategy is Contingent

