Concept Selection

One of the existing outpatient syringes.

To summarize the needs of its client and of the intended end users, the team established seven criteria on which the choice of a product concept would be based:

- Ease of handling.
- Ease of use.
- Readability of dose settings.
- Dose metering accuracy.
- Durability.
- Ease of manufacture.
- Portability.

The need to select one syringe concept from many raises several questions:

- How can the team choose the best concept, given that the designs are still quite abstract?
- How can a decision be made that is embraced by the whole team?
- How can desirable attributes of otherwise weak concepts be identified and used?
- How can the decision-making process be documented?

Concept Selection Is an Integral Part of the Product Development Process

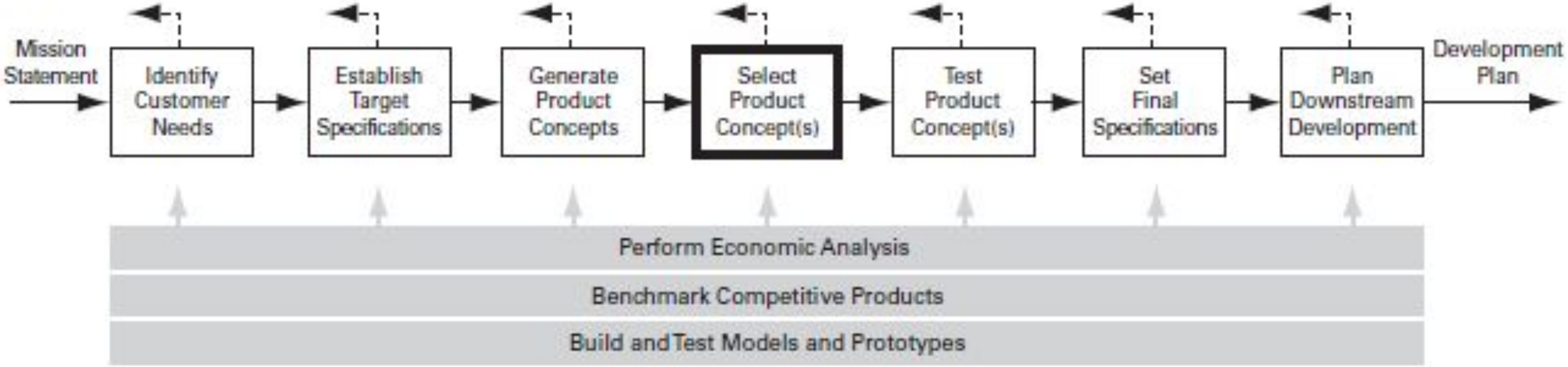


EXHIBIT 8-2 Concept selection is part of the overall concept development phase.

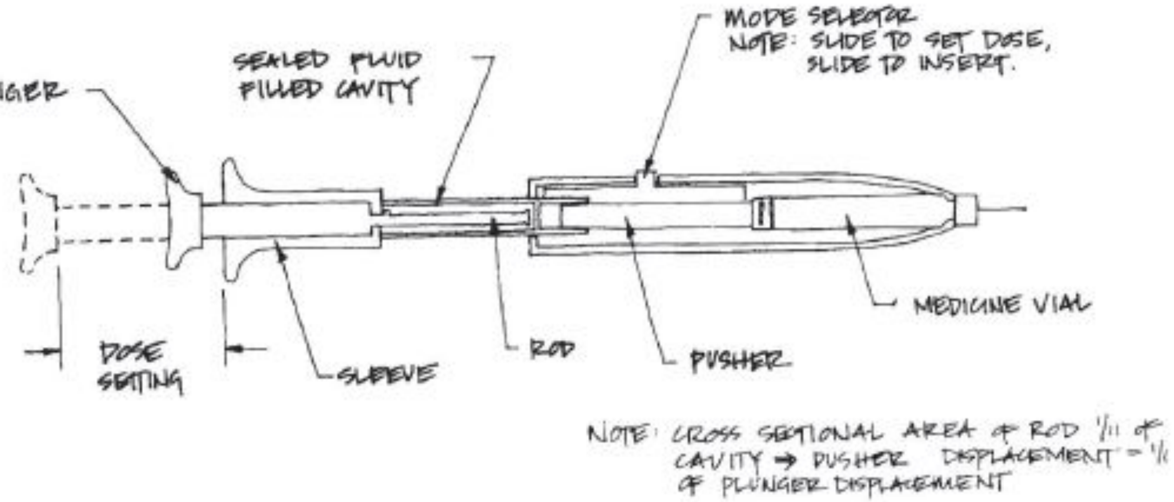
All Teams Use Some Method for Choosing a Concept

The methods vary in their effectivenessand include the following:

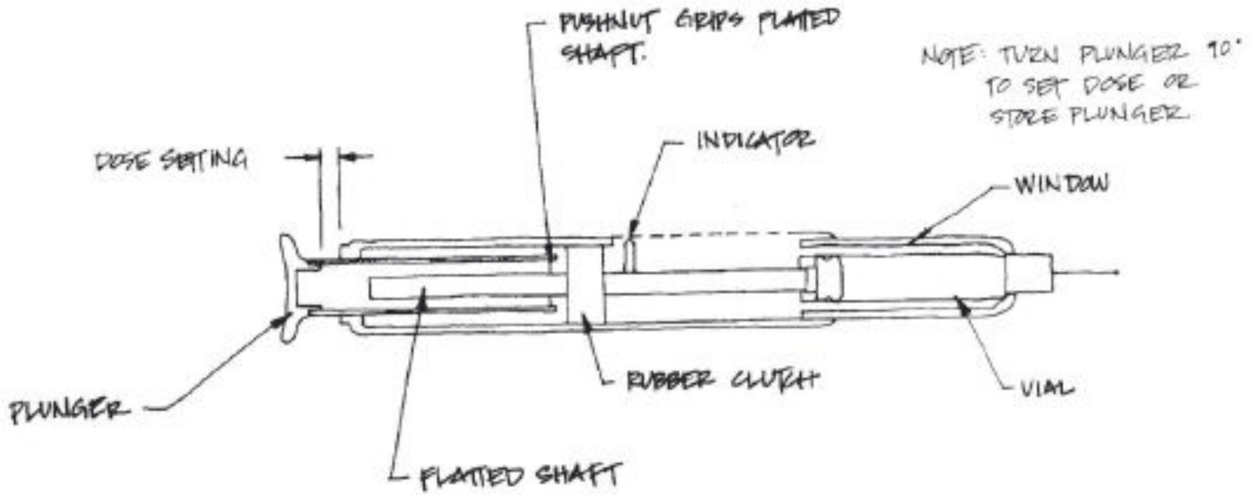
- ***External decision:*** Concepts are turned over to the customer, client, or some other external entity for selection.
- ***Product champion:*** An influential member of the product development team chooses a concept based on personal preference.
- ***Intuition:*** The concept is chosen by its feel. Explicit criteria or trade-offs are not used. The concept just *seems* better.
- ***Multivoting:*** Each member of the team votes for several concepts. The concept with the most votes is selected.
- ***Web-based survey:*** Using an online survey tool, each concept is rated by many people to find the best ones.
- ***Pros and cons:*** The team lists the strengths and weaknesses of each concept and makes a choice based upon group opinion.
- ***Prototype and test:*** The organization builds and tests prototypes of each concept, making a selection based upon test data.
- ***Decision matrices:*** The team rates each concept against prespecified selection criteria, which may be weighted.

Seven concepts for the outpatient syringe. The product development team generated the seven sketches to describe the basic concepts under consideration.

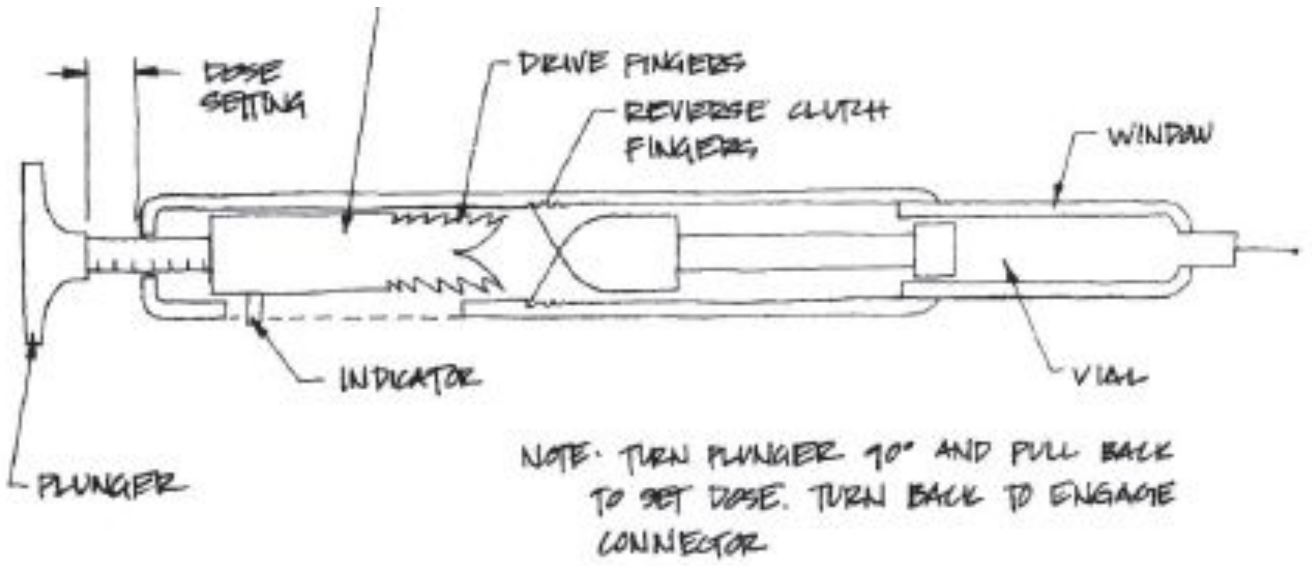
Concept A:
Master Cylinder



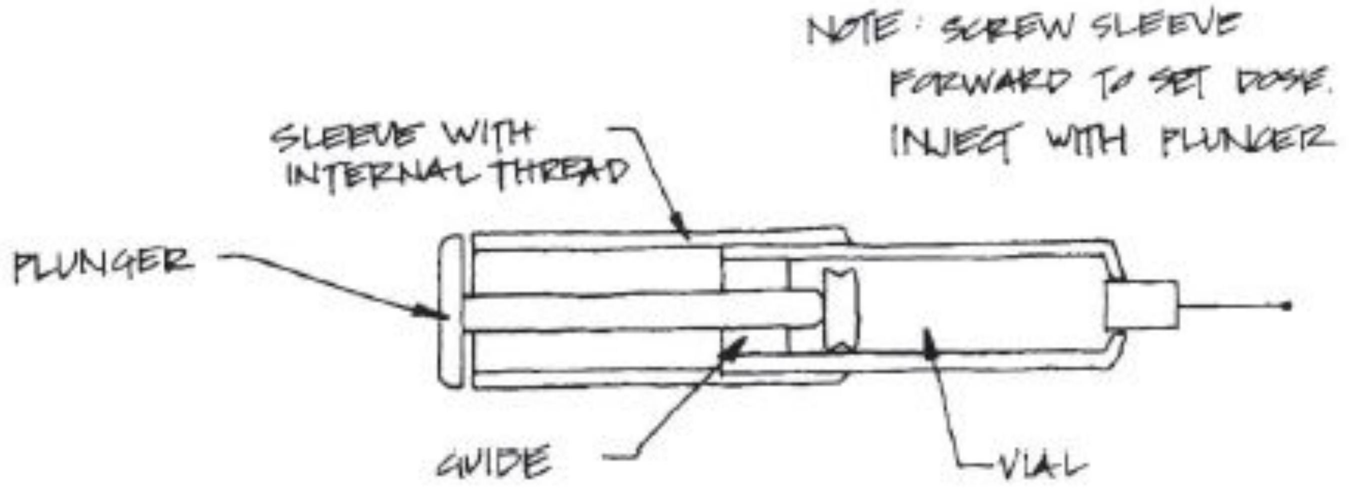
Concept B:
Rubber Brake



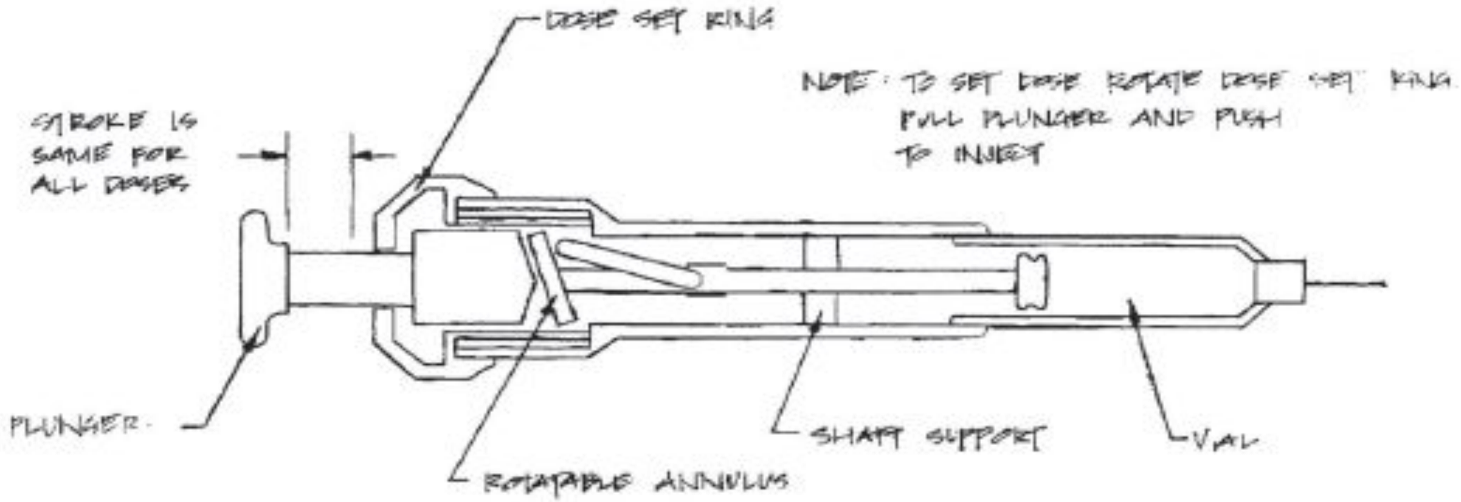
Concept C:
Ratchet



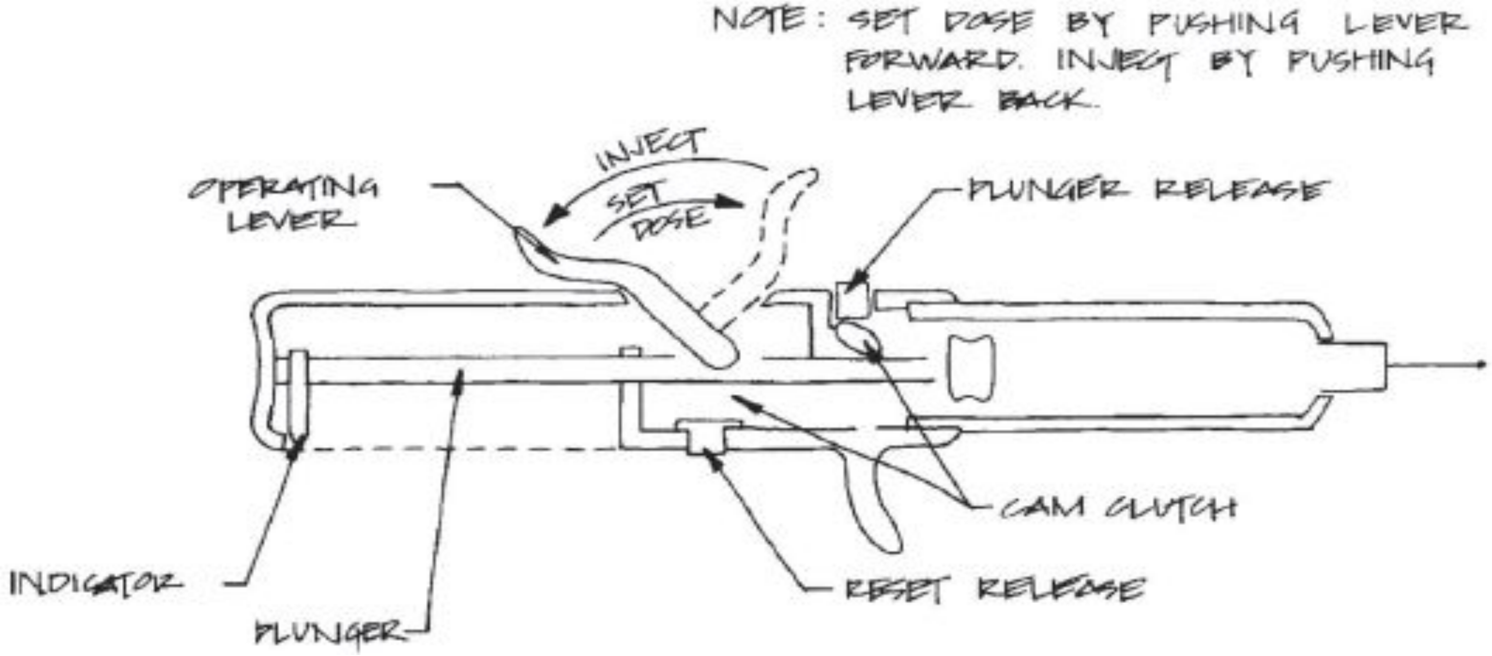
Concept D:
Plunge Stop



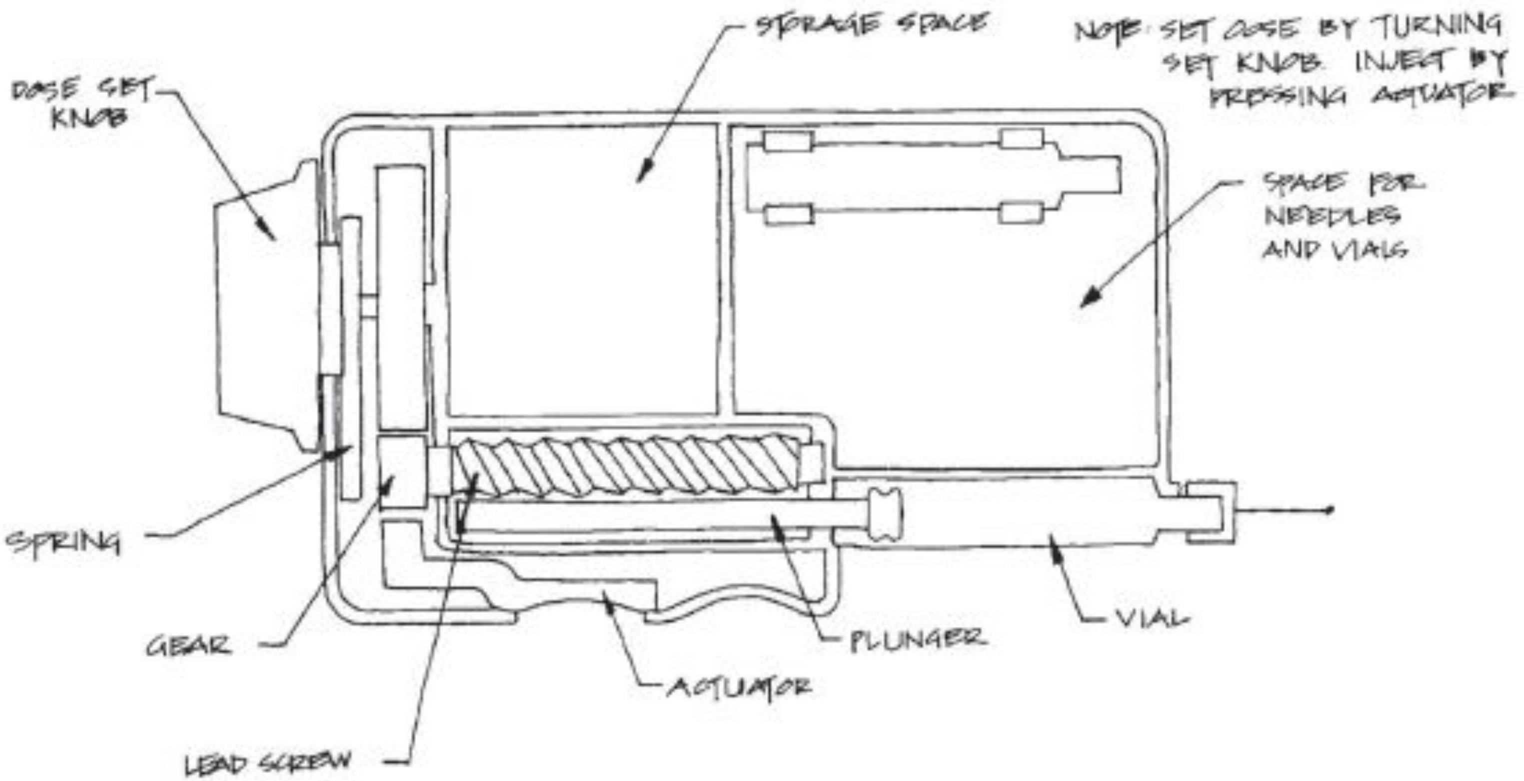
Concept E:
Swash Ring



Concept F:
Lever Set



Concept G:
Dial Screw



A Structured Method Offers Several Benefits

Specifically, a structured concept selection method offers the following potential benefits:

- ***A customer-focused product:***
- ***A competitive design***
- ***Better product-process coordination***
- ***Reduced time to product introduction***
- ***Effective group decision making***
- ***Documentation of the decision process***

Overview of Methodology

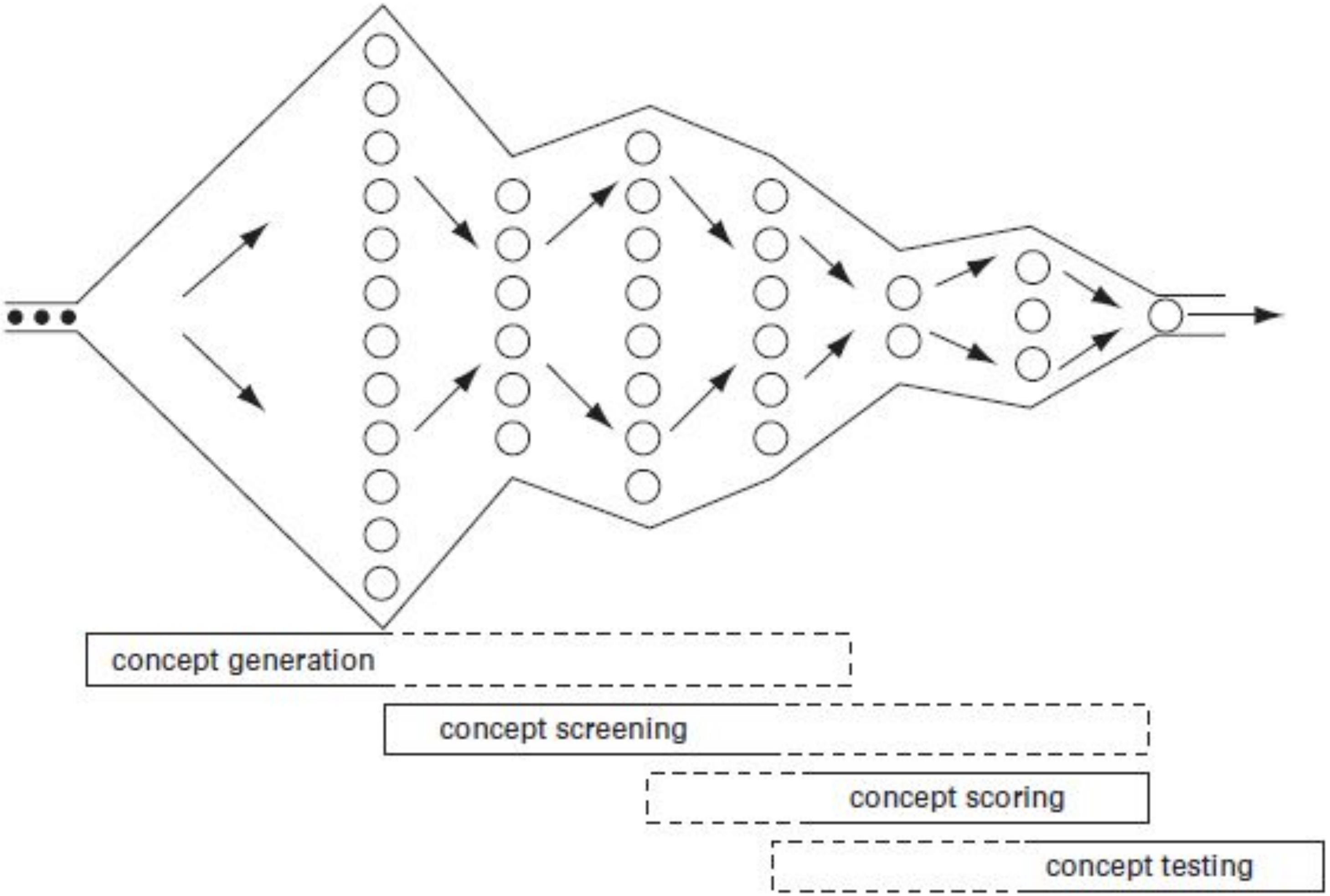


EXHIBIT 8-4 Concept selection is an iterative process closely related to concept generation and testing. The concept screening and scoring methods help the team refine and improve the concepts, leading to one or more promising concepts upon which further testing and development activities will be focused.

Both stages, concept screening and concept scoring, follow a six-step process that leads the team through the concept selection activity. The steps are:

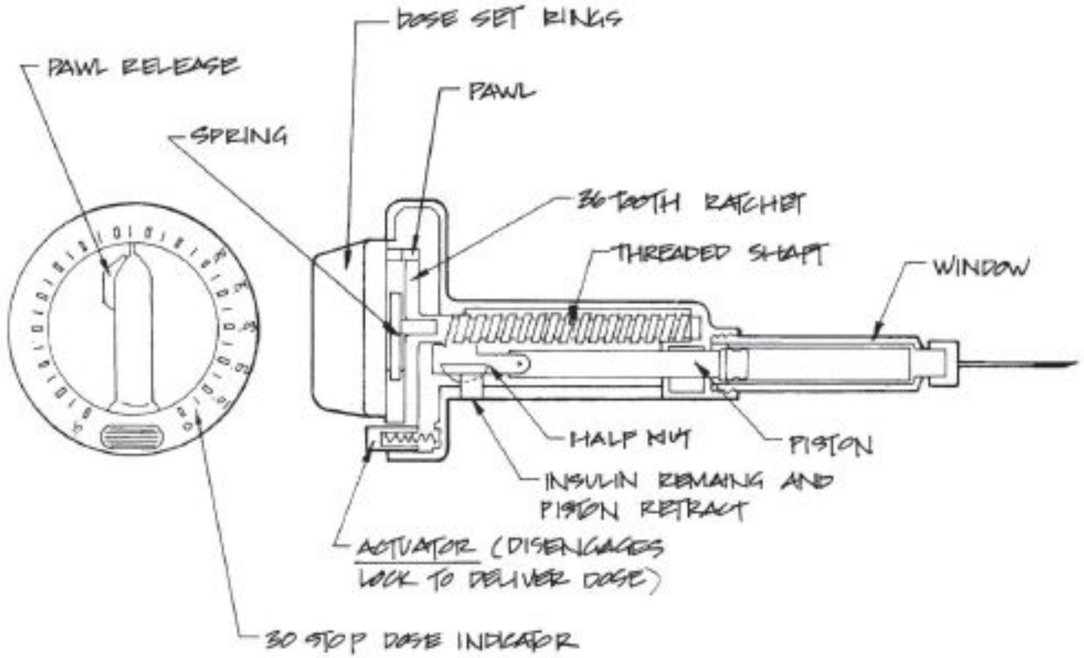
1. Prepare the selection matrix.
2. Rate the concepts.
3. Rank the concepts.
4. Combine and improve the concepts.
5. Select one or more concepts.
6. Reflect on the results and the process.

Concept Screening

	Concepts						
Selection Criteria	A Master Cylinder	B Rubber Brake	C Ratchet	D (Reference) Plunge Stop	E Swash Ring	F Lever Set	G Dial Screw
Ease of handling	0	0	–	0	0	–	–
Ease of use	0	–	–	0	0	+	0
Readability of settings	0	0	+	0	+	0	+
Dose metering accuracy	0	0	0	0	–	0	0
Durability	0	0	0	0	0	+	0
Ease of manufacture	+	–	–	0	0	–	0
Portability	+	+	0	0	+	0	0
Sum +'s	2	1	1	0	2	2	1
Sum 0's	5	4	3	7	4	3	5
Sum –'s	0	2	3	0	1	2	1
Net Score	2	–1	–2	0	1	0	0
Rank	1	6	7	3	2	3	3
Continue?	Yes	No	No	Combine	Yes	Combine	Revise

EXHIBIT 8-5 The concept-screening matrix. For the syringe example, the team rated the concepts against the reference concept using a simple code (+ for "better than," 0 for "same as," – for "worse than") in order to identify some concepts for further consideration. Note that the three concepts ranked "3" all received the same net score.

Concept G+:
Dial Screw+



Concept DF:
Lever Stop

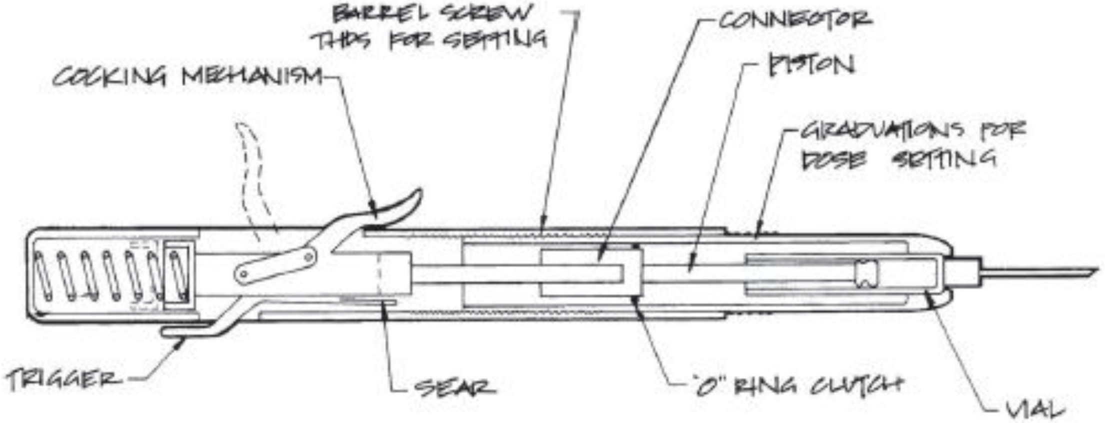


EXHIBIT 8-6 New and revised concepts for the syringe. During the selection process, the syringe team revised concept G and generated a new concept, DF, arising from the combination of concepts D and F.

Concept Scoring

Step 1: Prepare the Selection Matrix

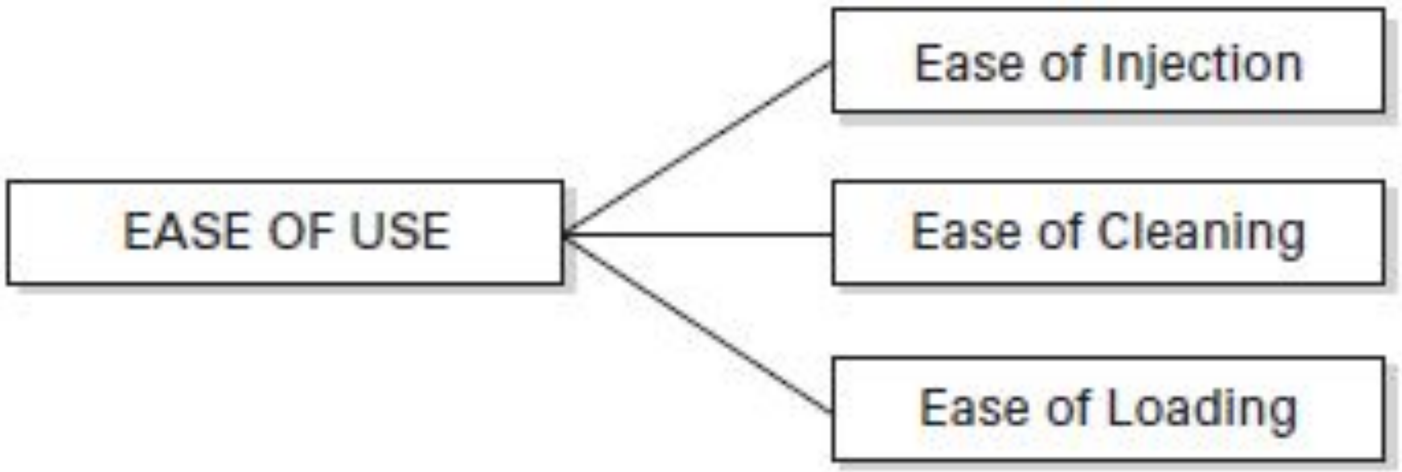


EXHIBIT 8-8 Hierarchical decomposition of selection criteria. In conjunction with more detailed concepts, the team may choose to break down criteria to the level of detail necessary for meaningful comparison.

Step 2: Rate the Concepts

Relative Performance	Rating
Much worse than reference	1
Worse than reference	2
Same as reference	3
Better than reference	4
Much better than reference	5

Step 3: Rank the Concepts

Once the ratings are entered for each concept, weighted scores are calculated by multiplying the raw scores by the criteria weights. The total score for each concept is the sum of the weighted scores:

$$S_j = \sum_{i=1}^{n} r_{ij} w_i$$

where

r_{ij} = raw rating of concept j for the ith criterion
w_i = weighting for ith criterion
n = number of criteria
S_j = total score for concept j

Finally, each concept is given a rank corresponding to its total score, as shown in Exhibit 8-7.

Step 4: Combine and Improve the Concepts

Step 5: Select One or More Concepts

Step 6: Reflect on the Results and the Process

		Concept							
		A (Reference) Master Cylinder		DF Lever Stop		E Swash Ring		G+ Dial Screw+	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Ease of handling	5%	**3**	0.15	3	0.15	4	0.2	4	0.2
Ease of use	15%	**3**	0.45	4	0.6	4	0.6	3	0.45
Readability of settings	10%	2	0.2	**3**	0.3	5	0.5	5	0.5
Dose metering accuracy	25%	**3**	0.75	3	0.75	2	0.5	3	0.75
Durability	15%	2	0.3	5	0.75	4	0.6	**3**	0.45
Ease of manufacture	20%	**3**	0.6	3	0.6	2	0.4	2	0.4
Portability	10%	**3**	0.3	3	0.3	3	0.3	3	0.3
	Total Score	2.75		3.45		3.10		3.05	
	Rank	4		1		2		3	
	Continue?	No		Develop		No		No	

EXHIBIT 8-7 The concept-scoring matrix. This method uses a weighted sum of the ratings to determine concept ranking. While concept A serves as the overall reference concept, the separate reference points for each criterion are signified by **bold** rating values.

Concept Testing

A prototype of empower Corporation's electric scooter product concept.

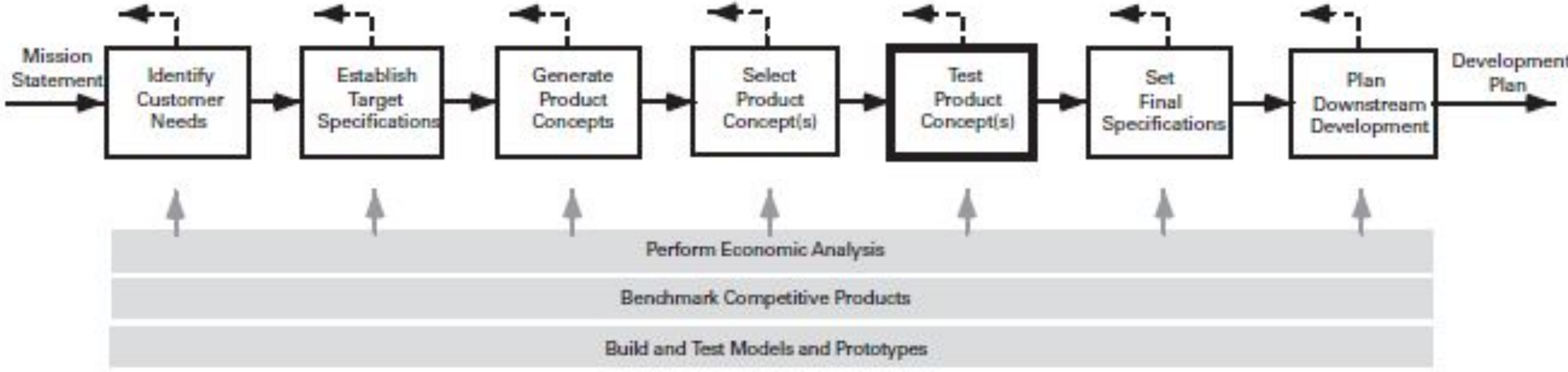


EXHIBIT 9-2 Concept testing in relation to other concept development activities.

Seven-step method for testing product concepts:

1. Define the purpose of the concept test.
2. Choose a survey population.
3. Choose a survey format.
4. Communicate the concept.
5. Measure customer response.
6. Interpret the results.
7. Reflect on the results and the process.

Step 1: Define the Purpose of the Concept Test

The primary questions addressed in concept testing are typically:

- Which of several alternative concepts should be pursued?
- How can the concept be improved to better meet customer needs?
- Approximately how many units are likely to be sold?
- Should development be continued?

Step 2: Choose a Survey Population

EXHIBIT 9-3
Factors leading to relatively smaller or larger survey sample sizes.

Factors Favoring a Smaller Sample Size	Factors Favoring a Larger Sample Size
• Test occurs early in concept development process. • Test is primarily intended to gather qualitative data. • Surveying potential customers is relatively costly in time or money. • Required investment to develop and launch the product is relatively small. • A relatively large fraction of the target market is expected to value the product (i.e., many positively inclined respondents can be found without a large sample).	• Test occurs later in concept development process. • Test is primarily intended to assess demand quantitatively. • Surveying customers is relatively fast and inexpensive. • Required investment to develop and launch the product is relatively high. • A relatively small fraction of the target market is expected to value the product (i.e., many people have to be sampled to reliably estimate the fraction that values the product).

Step 3: Choose a Survey Format

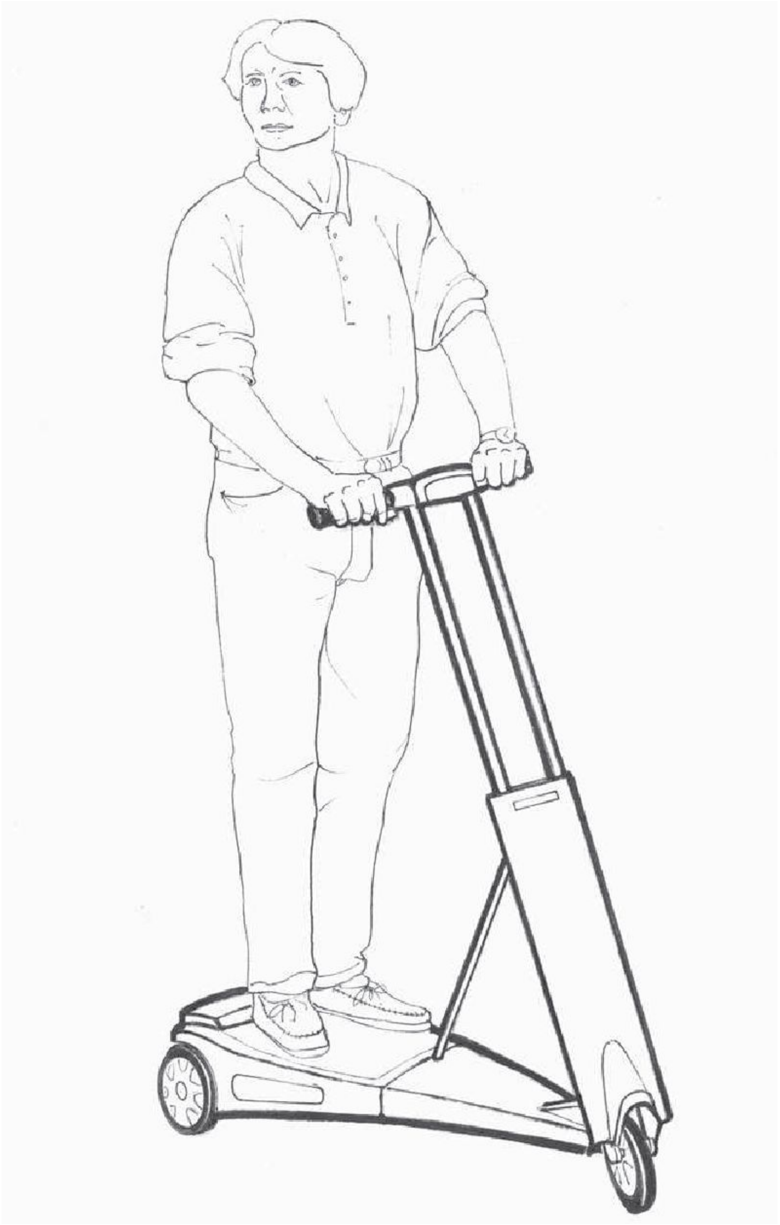
The following formats are commonly used in concept testing:

- ***Face-to-face interaction***
- ***Telephone***
- ***Postal mail***
- ***Electronic mail***
- ***Internet***

Step 4: Communicate the Concept

- ***Verbal description***
- ***Sketch:***
- ***Photos and renderings:***
- ***Storyboard***
- ***Video***
- ***Simulation***
- ***Interactive multimedia***
- ***Physical appearance models***
- ***Working prototypes:***

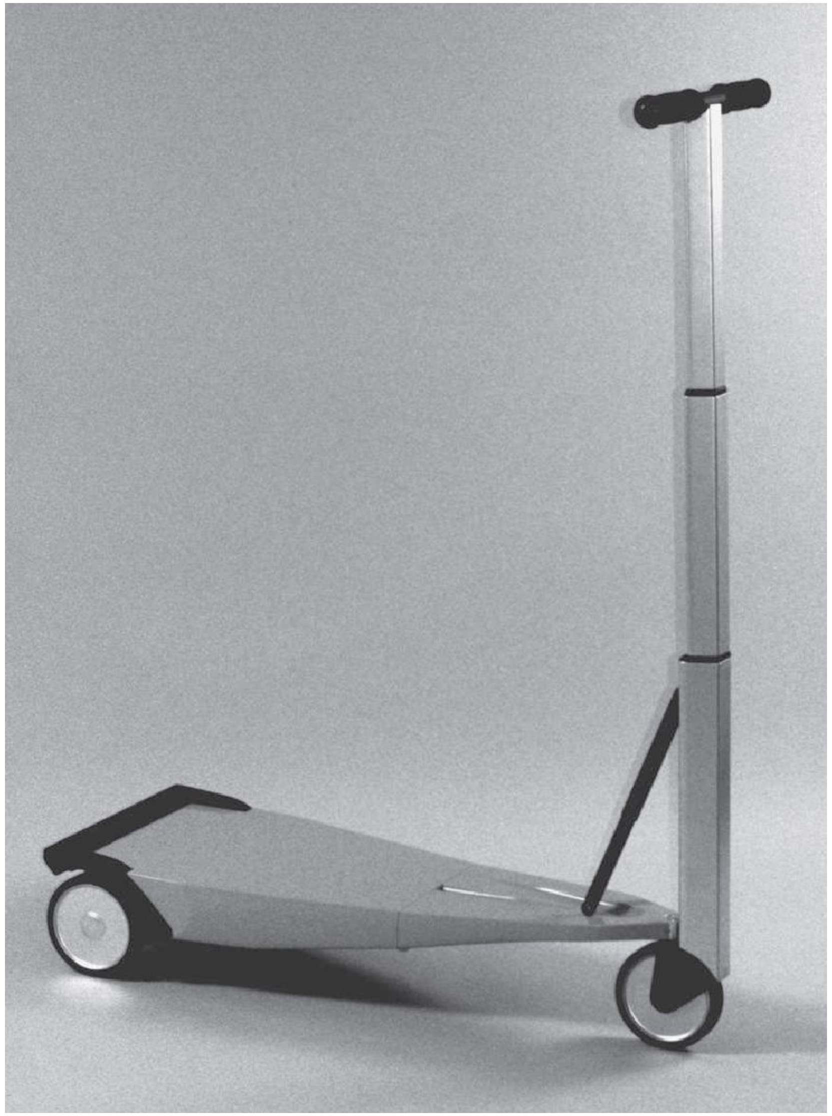
Sketch of
scooter concept



Rendering of the scooter from computer-aided design software.

Storyboard illustrating storage, transportation, and use scenarios.

Appearance model of the scooter concept.



Working prototype of the scooter concept

EXHIBIT 9-9
Appropriateness of different survey formats for different ways of communicating the product concept.

	Telephone	Electronic Mail	Postal Mail	Internet	Face-to-Face
Verbal description	•	•	•	•	•
Sketch		•	•	•	•
Photo or rendering		•	•	•	•
Storyboard		•	•	•	•
Video				•	•
Simulation				•	•
Interactive multimedia				•	•
Physical appearance model					•
Working prototype					•

Step 5: Measure Customer Response

The most commonly used purchase-intent scale has five response categories:

- Definitely would buy.
- Probably would buy.
- Might or might not buy.
- Probably would not buy.
- Definitely would not buy.

CONCEPT TEST SURVEY— Electric Powered Personal Transportation Device

I am gathering information for a new transportation product and am hoping that you would be willing to share your opinions with me.

Are you a college student?__________

<If the response is no, thank the respondent and end the survey.>

Do you live between one and three miles from campus?____________

Do you travel distances of one to three miles between classes or other activities during your day?________

<If the response is no to this ***and*** *the previous question, thank the respondent and end the survey.>*

How do you currently get to campus from your home: ______________

How do you currently get around campus during the day: ______________

Here is a brochure for the product. *<Show the brochure.>*

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.

If the product were priced at $689 and were available from a dealer on or near campus, how likely would you be to purchase the scooter within the next year?

❑	❑	❑	❑	❑
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

Would you be interested in test riding a prototype of the product?

<Provide operating instructions and fit the helmet.>

Based on your experience with the product, how likely would you be to purchase the product within the next year?

❑	❑	❑	❑	❑
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

How might this product be improved?
<Ask open-ended questions to elicit feedback on the concept.>

EXHIBIT 9-10 Example interview guide (abridged) for a concept test of the electric scooter.

Step 6: Interpret the Results

Estimate Q, the quantity of the product expected to be sold during a time period, as

$$Q = N \cdot A \cdot P$$

N is the number of potential customers expected to make purchases during the time period. For an existing and stable product category (e.g., bicycles) N is the expected number of purchases to be made of existing products in the category over the time period.

A is the fraction of these potential customers or purchases for which the product is *available* and the customer is *aware* of the product. (In situations where awareness and availability are assumed to be separate independent factors, they are multiplied together to generate A.)

P is the probability that the product is purchased if available and if the customer is aware of it. P is estimated in turn by

$$P = C_{\text{definitely}} \cdot F_{\text{definitely}} + C_{\text{probably}} \cdot F_{\text{probably}}$$

$F_{\text{definitely}}$ is the fraction of survey respondents indicating in the concept test survey that they would *definitely purchase* (often called the "top box" score).

F_{probably} is the fraction of survey respondents indicating that they would *probably purchase* (often called the "second box" score).

$C_{\text{definitely}}$ and C_{probably} are calibration constants usually established based on the experience of a company with similar products in the past. Generally the values of $C_{\text{definitely}}$ and C_{probably} fall in these intervals: $0.10 < C_{\text{definitely}} < 0.50$, $0 < C_{\text{probably}} < 0.25$. Absent prior history, many teams use values of $C_{\text{definitely}} = 0.4$ and $C_{\text{probably}} = 0.2$. Note that these values reflect the typical bias of respondents to *overestimate* the probability that they would actually purchase the product.

Step 7: Reflect on the Results and the Process

The team benefits from thinking about the impact of the three key variables in the forecasting model: (1) the overall size of the market,
(2) the availability and awareness of the product, and
(3) the fraction of customers who are likely to purchase.

Product Architecture

Courtesy of Hewlett-Packard Company

Three Hewlett-Packard printers from the same product platform: an office model, a photo model, and a model including scanning capability.

In considering their next steps, the team members asked:

- How would the architecture of the product impact their ability to offer product variety?
- What would be the cost implications of different product architectures?
- How would the architecture of the product impact their ability to complete the design within 12 months?
- How would the architecture of the product influence their ability to manage the development process?

What Is Product Architecture?

A product can be thought of in both functional and physical terms.

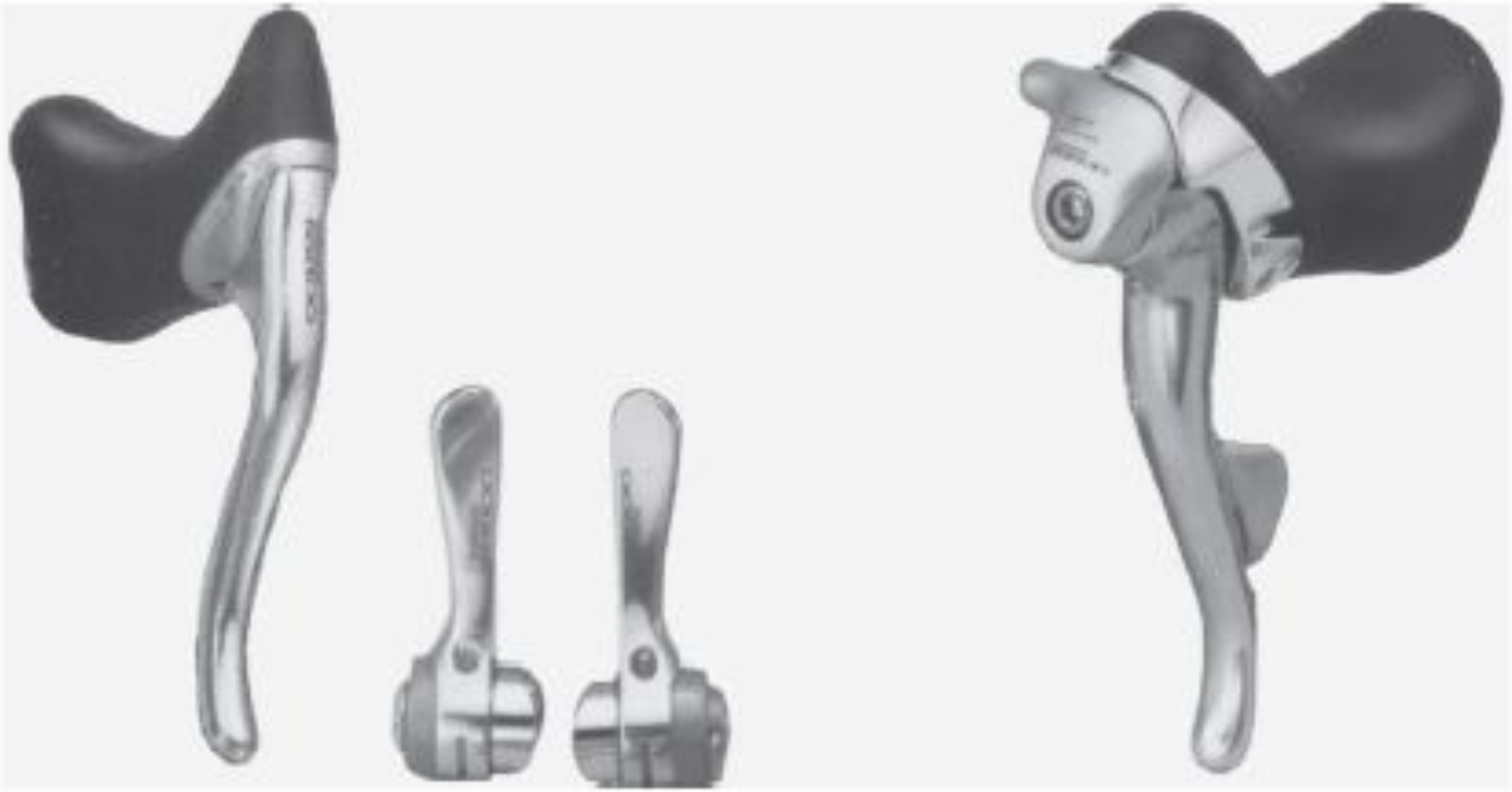
The *functional elements* of a product are the individual operations and transformations that contribute to the overall performance of the product.

The *physical elements* of a product are the parts, components, and subassemblies that ultimately implement the product's functions.

The physical elements of a product are typically organized into several major physical building blocks, which we call *chunks*.

A *modular architecture* has the following two properties:
• Chunks implement one or a few functional elements in their entirety.
• The interactions between chunks are well defined and are generally fundamental to the
primary functions of the product.

EXHIBIT 10-2
Two models of bicycle brake and shifting controls. The product on the left exemplifies a modular architecture; the product on the right has a more integral architecture.



Courtesy of Shimano

The opposite of a modular architecture is an *integral architecture*. An integral architecture exhibits one or more of the following properties:

• Functional elements of the product are implemented using more than one chunk.
• A single chunk implements many functional elements.
• The interactions between chunks are ill defined and may be incidental to the primary functions of the products.

A product embodying an integral architecture will often be designed with the highest possible performance in mind.

Types of Modularity

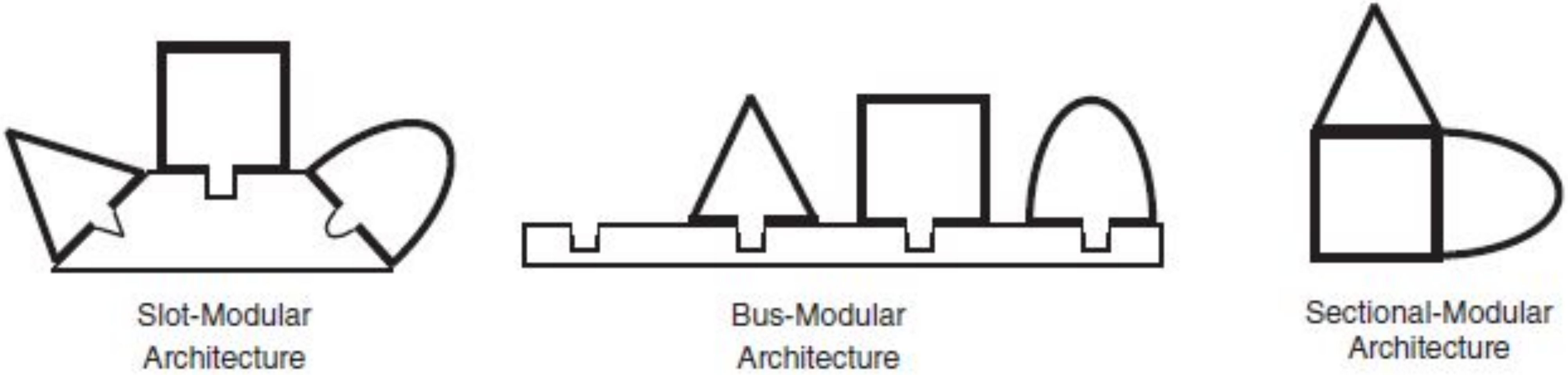


EXHIBIT 10-3 Three types of modular architectures.

When Is the Product Architecture Defined?

A product's architecture begins to emerge during concept development. This happens informally—in the sketches, function diagrams, and early prototypes of the concept development phase.

Implications of the Architecture

Some of the motives for product change are:

- ***Upgrade:***
- ***Add-ons:***
- ***Adaptation:***
- ***Wear:***
- ***Consumption:***
- ***Flexibility in use:***
- ***Reuse:***

Product Variety

Variety refers to the range of product models the firm can produce within a particular time period in response to market demand.

Swatch uses a modular architecture to enable high-variety manufacturing.

Component Standardization

Component standardization is the use of the same component or chunk in multiple products.

Product Performance

We define *product performance* as how well a product implements its intended functions.

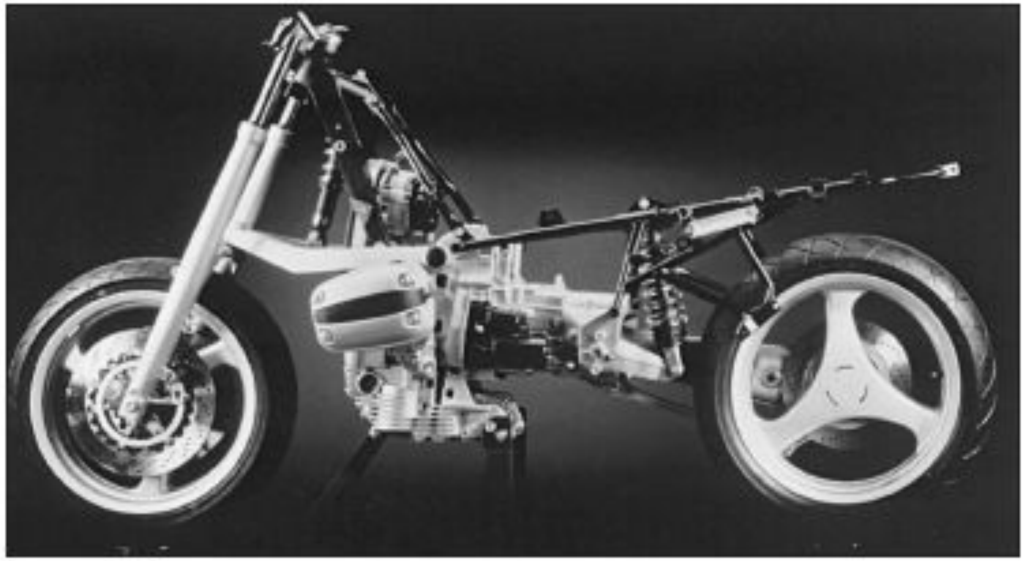
Typical product performance characteristics are speed, efficiency, life, accuracy, and noise.

Manufacturability

In addition to the cost implications of product variety and component standardization described above, the product architecture also directly affects the ability of the team to design each chunk to be produced at low cost.

Product Development Management

EXHIBIT 10-5
The BMW R1100RS motorcycle. This product exhibits function sharing and an integral architecture with the design of its transmission chunk.



Courtesy of BMW Motorcycle Group

Establishing the Architecture

The steps are:

1. Create a schematic of the product.
2. Cluster the elements of the schematic.
3. Create a rough geometric layout.
4. Identify the fundamental and incidental interactions.

Step 1: Create a Schematic of the Product

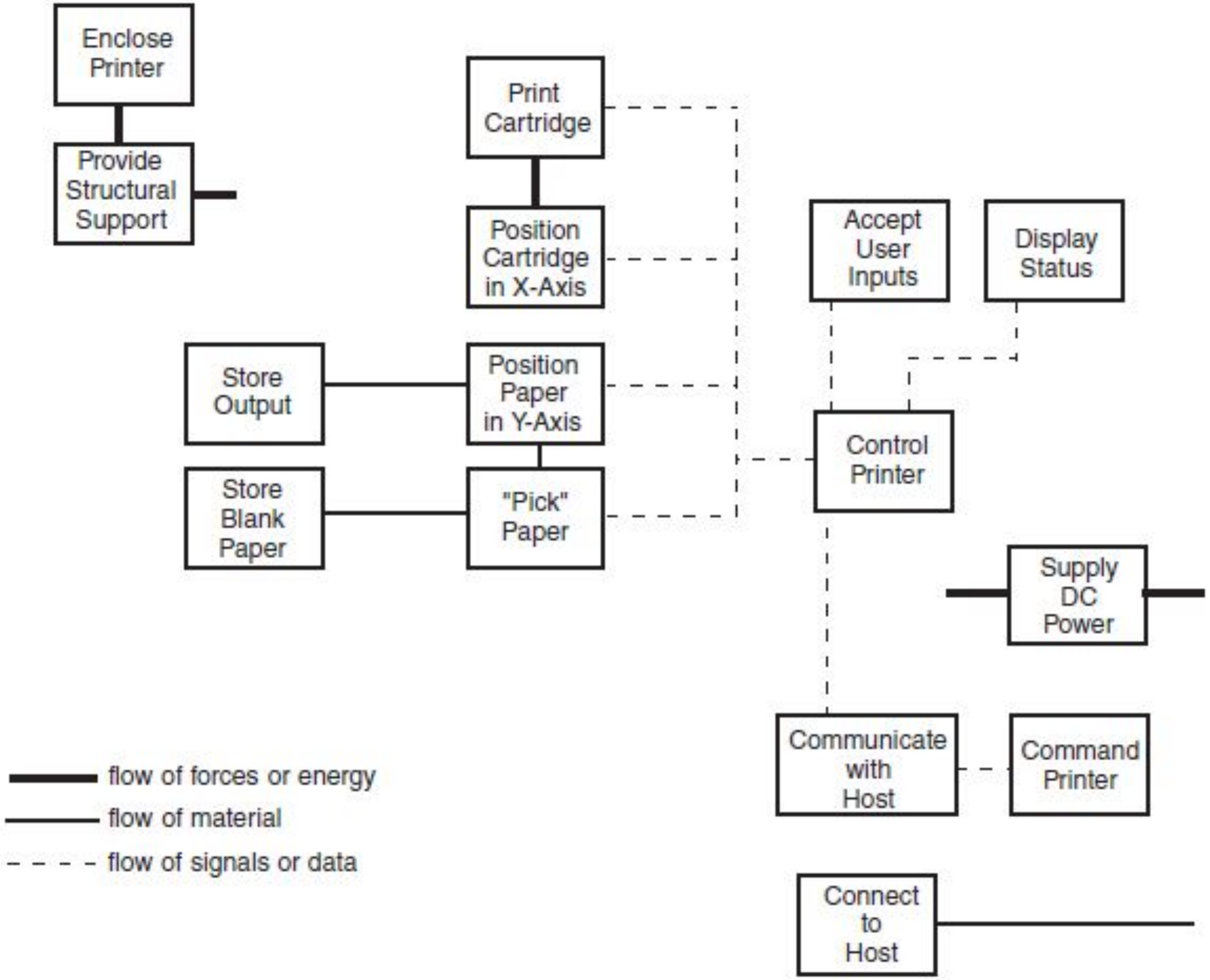


EXHIBIT 10-6 Schematic of the DeskJet printer. Note the presence of both functional elements (e.g., "Store Output") and physical elements (e.g., "Print Cartridge"). For clarity, not all connections among elements are shown.

Step 2: Cluster the Elements of the Schematic

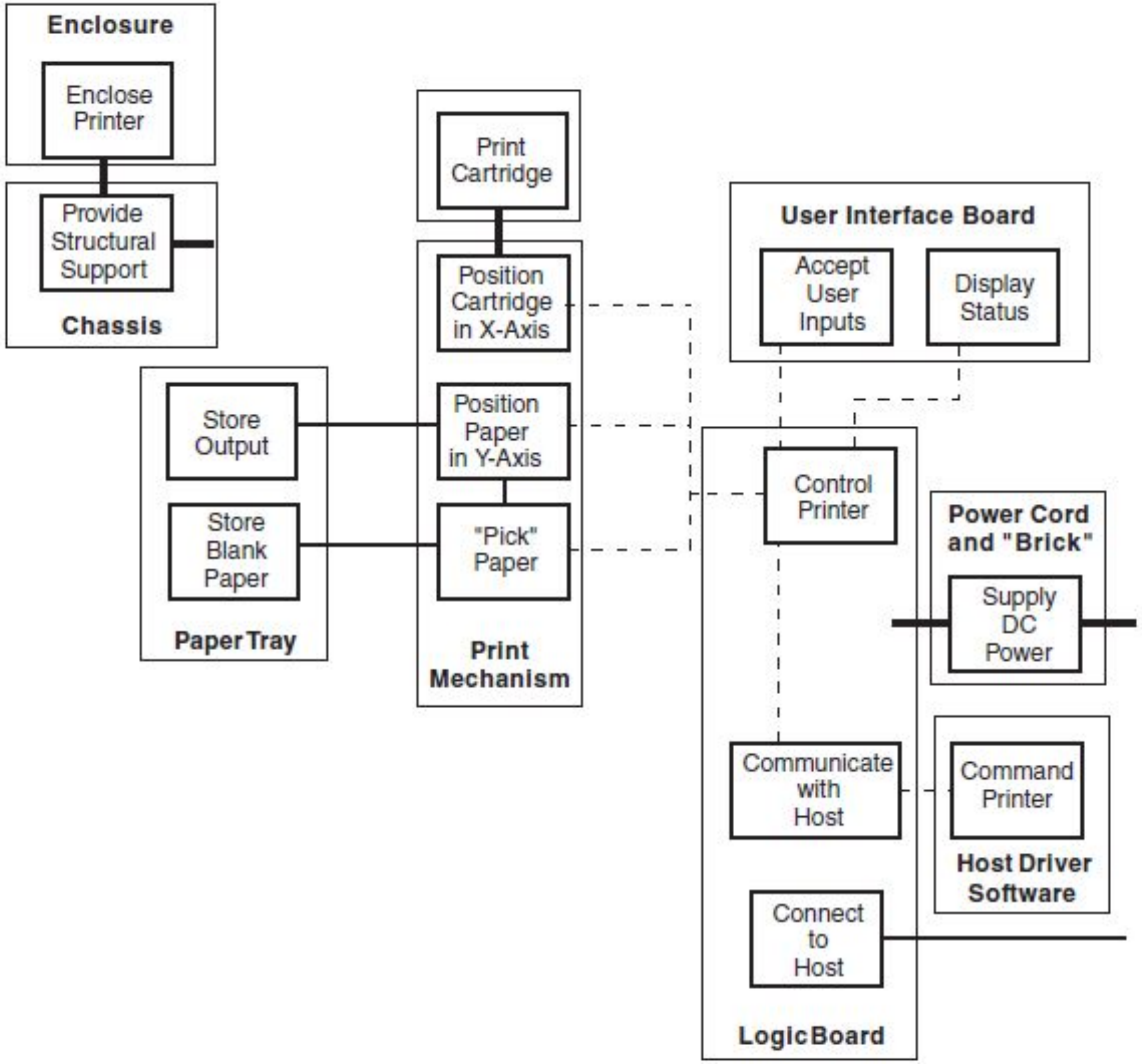


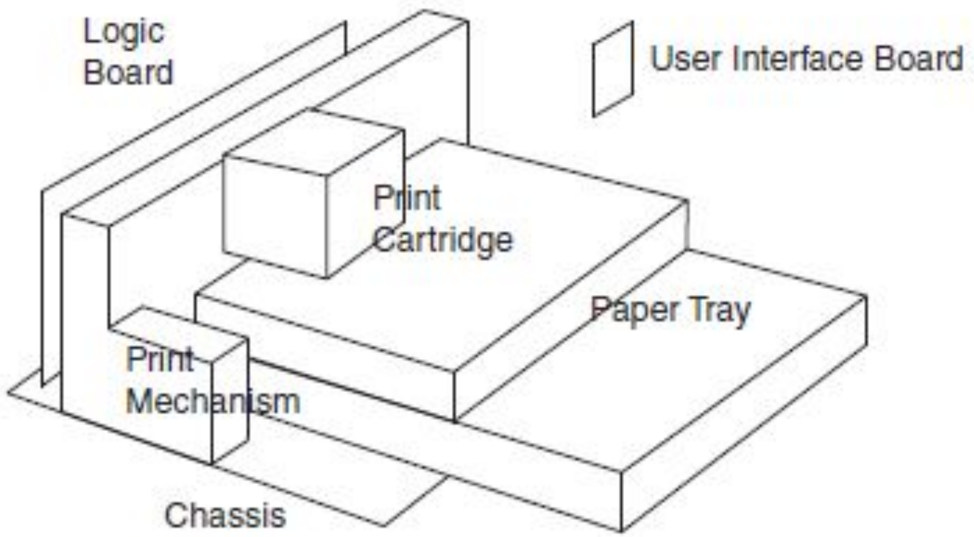
EXHIBIT 10-7 Clustering the elements into chunks. Nine chunks make up this proposed architecture for the DeskJet printer.

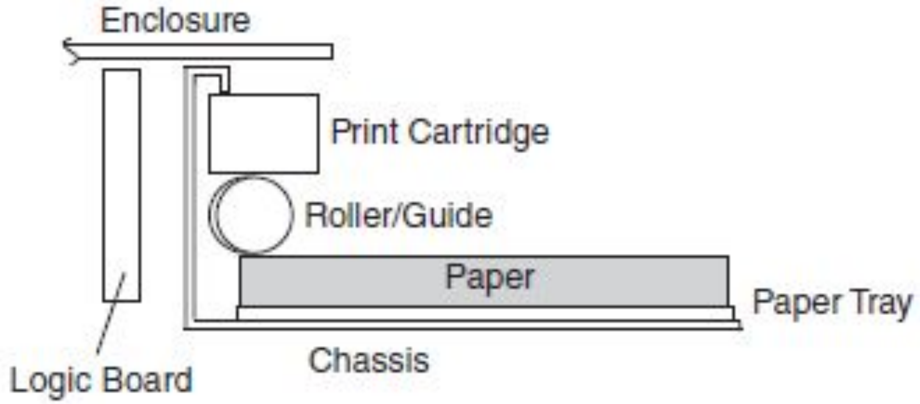
Clustering factors:

- Geometric integration and precision
- Function sharing
- Capabilities of vendors
- Similarity of design or production technology
- Localization of change
- Accommodating variety
- Enabling standardization
- Portability of the interface

Step 3: Create a Rough Geometric Layout

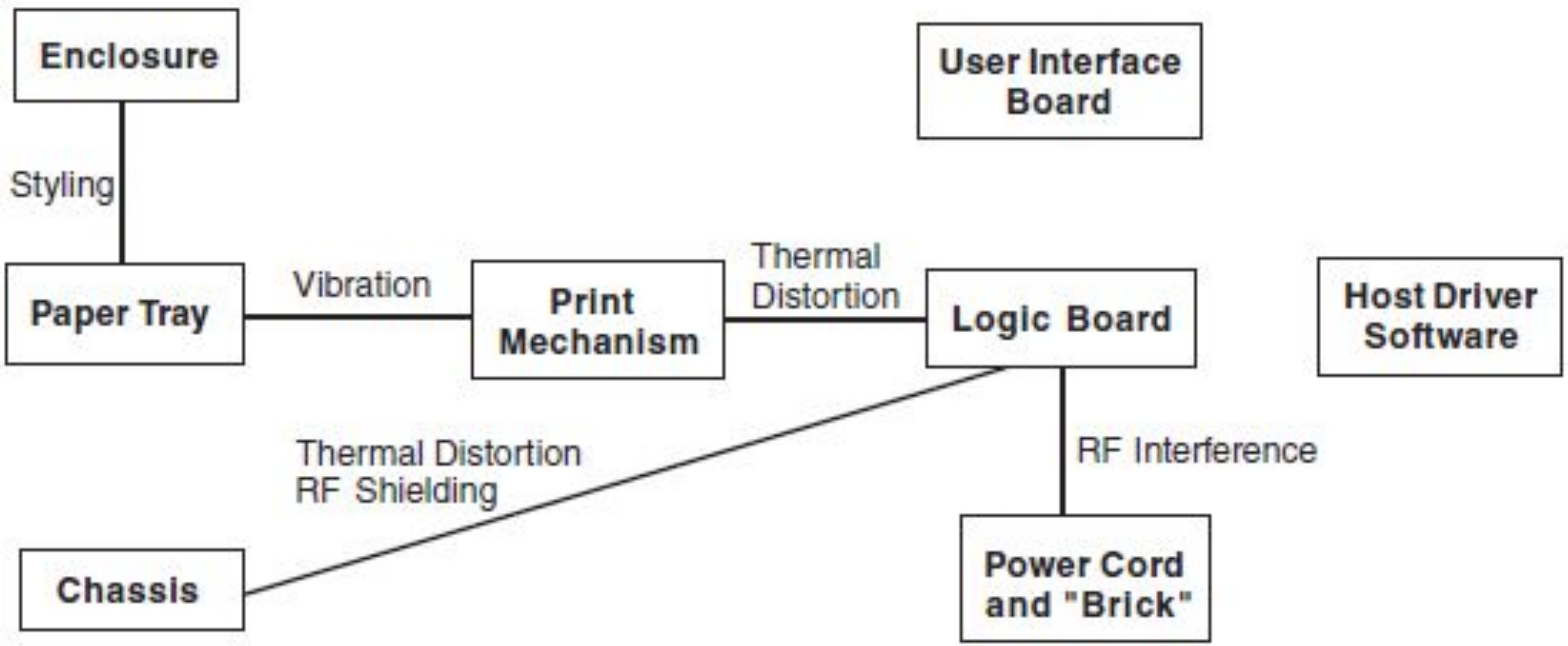
EXHIBIT 10-8
Geometric layout of the printer.



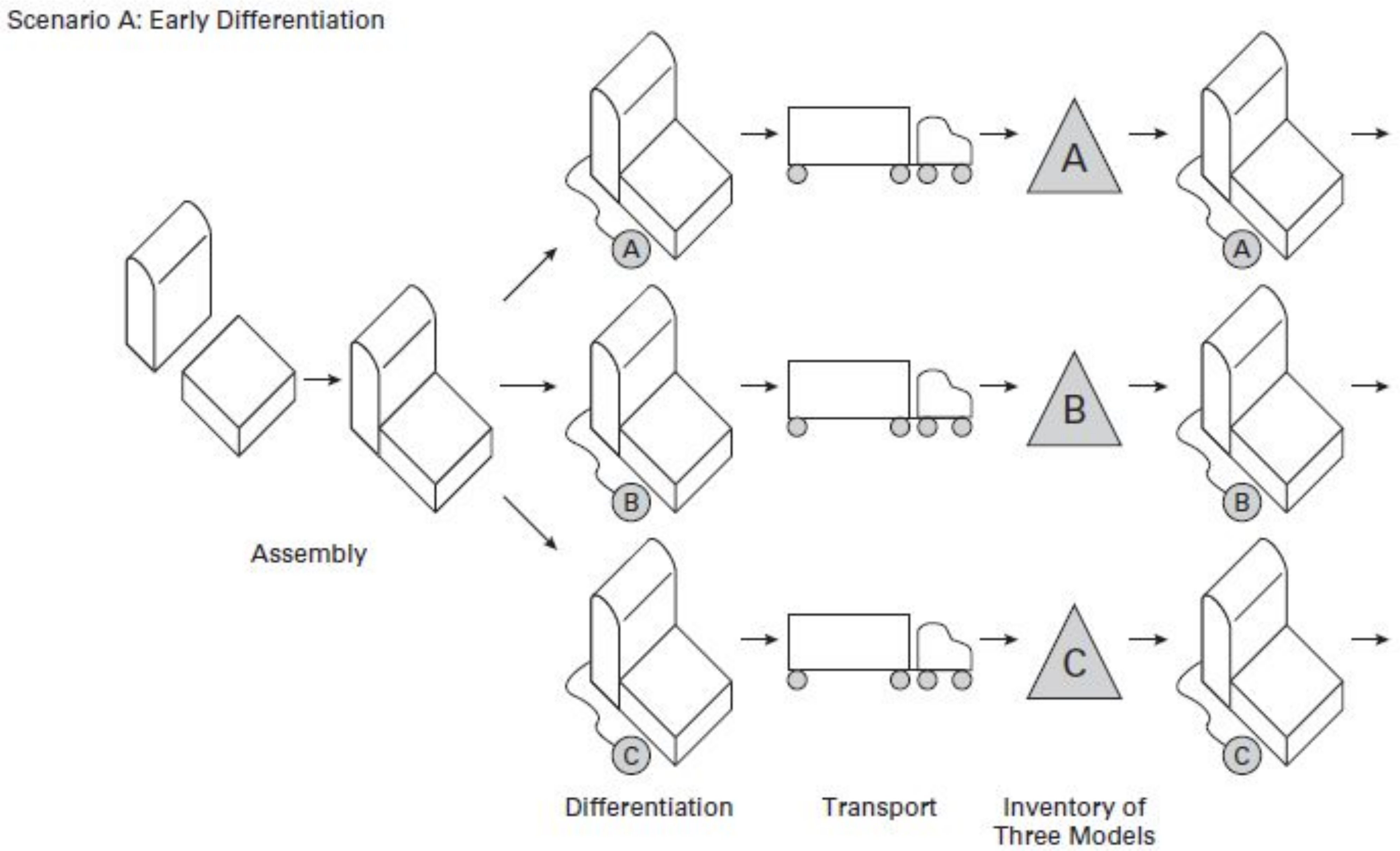


Step 4: Identify the Fundamental and Incidental Interactions

EXHIBIT 10-9
Incidental interaction graph.



Delayed Differentiation



Scenario B: Postponement

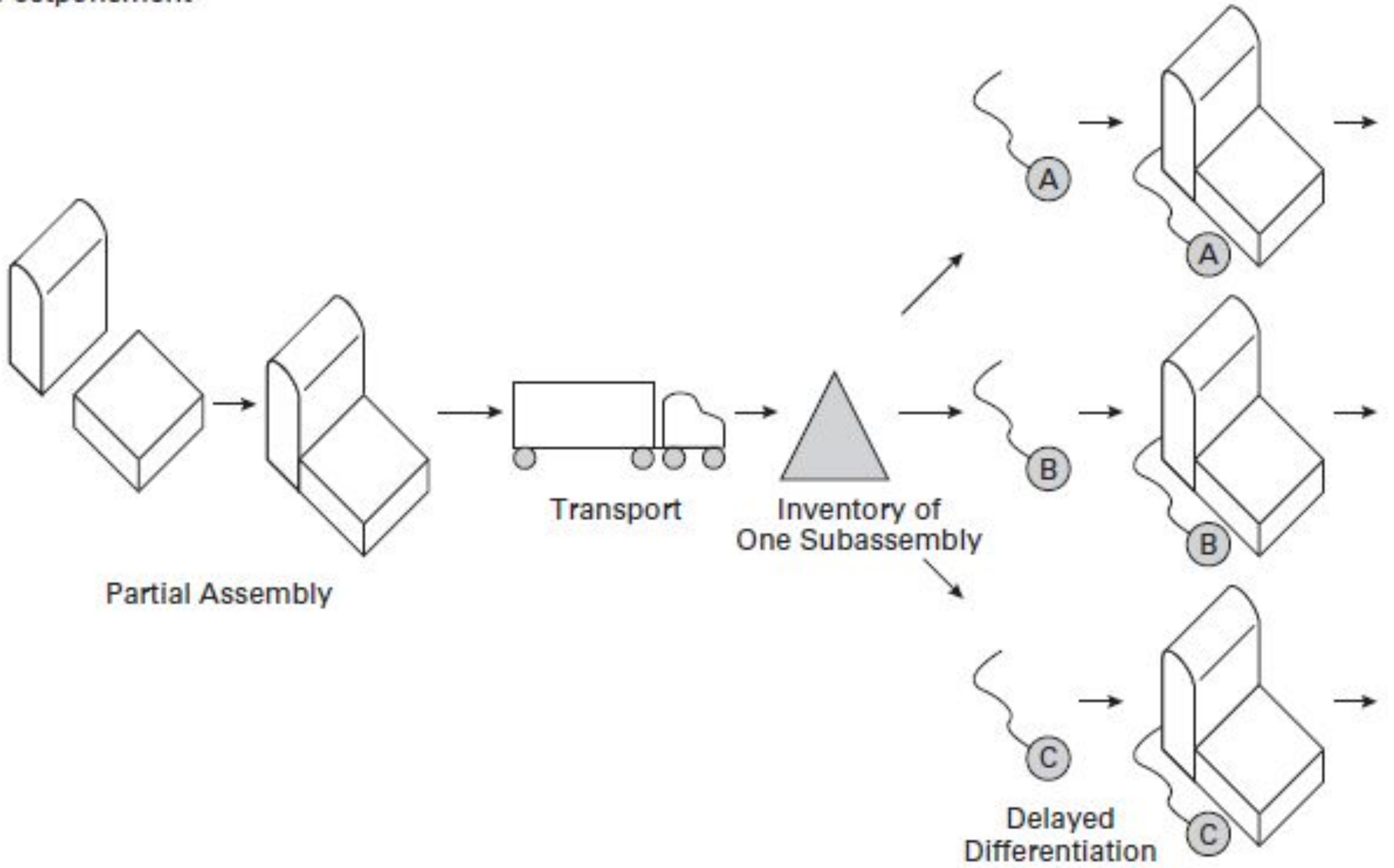


EXHIBIT 10-10 Postponement involves delaying differentiation of the product until late in the supply chain. In scenario A, three versions of the product are created during assembly and before transportation. In scenario B, the three versions of the product are not created until after transportation.

Two design principles are necessary conditions for postponement.

1. The differentiating elements of the product must be concentrated in one or a few chunks.

2. The product and production process must be designed so that the differentiating chunk(s) can be added to the product near the end of the supply chain.

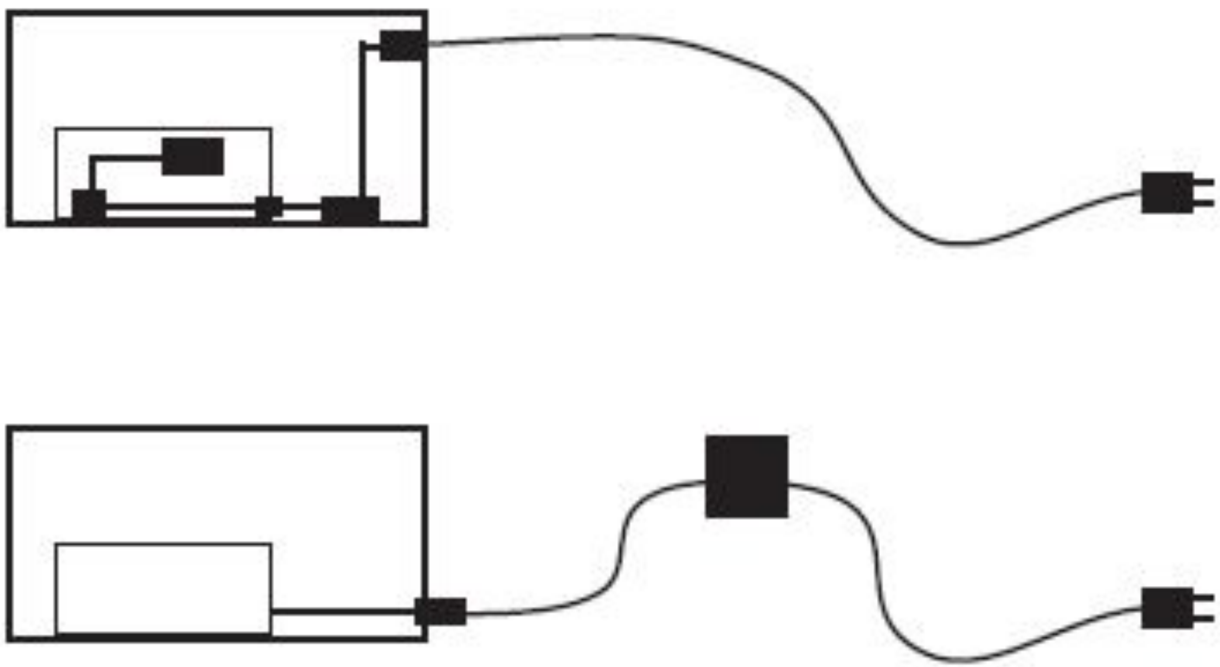


EXHIBIT 10-11 To enable postponement, the differentiating attributes of the product must be concentrated in one or a few chunks. In the top case, the power supply is distributed across the cord, enclosure, chassis, and logic board. In the bottom case, the power supply is confined to the cord and a power supply "brick."

- **Platform Planning**

Differentiation Plan

Differentiating Attributes	Family	Student	SOHO (Small Office, Home Office)
Black print quality	"Near Laser" quality 300dpi	"Laser" quality 600dpi	"Laser" quality 600dpi
Color print quality	"Near photo" quality	Equivalent to DJ600	Equivalent to DJ600
Print speed	6 pages/minute	8 pages/minute	10 pages/minute
Footprint	360mm deep × 400mm wide	340mm deep × 360mm wide	400mm deep × 450mm wide
Paper storage	100 sheets	100 sheets	150 sheets
Style	"Consumer"	"Youth consumer"	"Commercial"
Connectivity to computer	USB and parallel port	USB	USB
Operating system compatibility	Macintosh and Windows	Macintosh and Windows	Windows

EXHIBIT 10-12 An example differentiation plan for a family of three printers.

Commonality Plan

Chunks	Number of Types	Family	Student	SOHO (Small Office, Home Office)
Print cartridge	2	"Manet" cartridge	"Picasso" cartridge	"Picasso" cartridge
Print mechanism	2	"Aurora" series	Narrow "Aurora" series	"Aurora" series
Paper tray	2	Front-in front-out	Front-in front-out	Tall front-in front-out
Logic board	2	"Next gen" board with parallel port	"Next gen" board	"Next gen" board
Enclosure	3	Home style	Youth style	Soft office style
Driver software	5	Version A-PC, Version A-Mac	Version B-PC, Version B-Mac	Version C

EXHIBIT 10-13 An example commonality plan for a family of three printers.

Managing the Trade-Off between Differentiation and Commonality

We offer several guidelines for managing this tension.

- ***Platform planning decisions should be informed by quantitative estimates of costand revenue implications:***

- ***Iteration is beneficial:***

- ***The product architecture dictates the nature of the trade-off between differentiation and commonality:***

Related System-Level Design Issues

Establishing the Architecture of the Chunks

EXHIBIT 10-14
Specification of interface between black print cartridge and logic board.

Line	Name	Properties
1	PWR-A	+12VDC, 5mA
2	PWR-B	+5VDC, 10mA
3	STAT	TTL
4	LVL	100KΩ-1MΩ
5	PRNT1	TTL
6	PRNT2	TTL
7	PRNT3	TTL
8	PRNT4	TTL
9	PRNT5	TTL
10	PRNT6	TTL
11	GND