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DI BERGAMO

Dipartimento
di Ingegneria Gestionale,
dell'Informazione e della Produzione

PBL 5: Design and Economics

COURSE:
Laboratory Digital Innovation and Management

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Agenda

Design For Manufacturing:

Product Development Economics

Business Case

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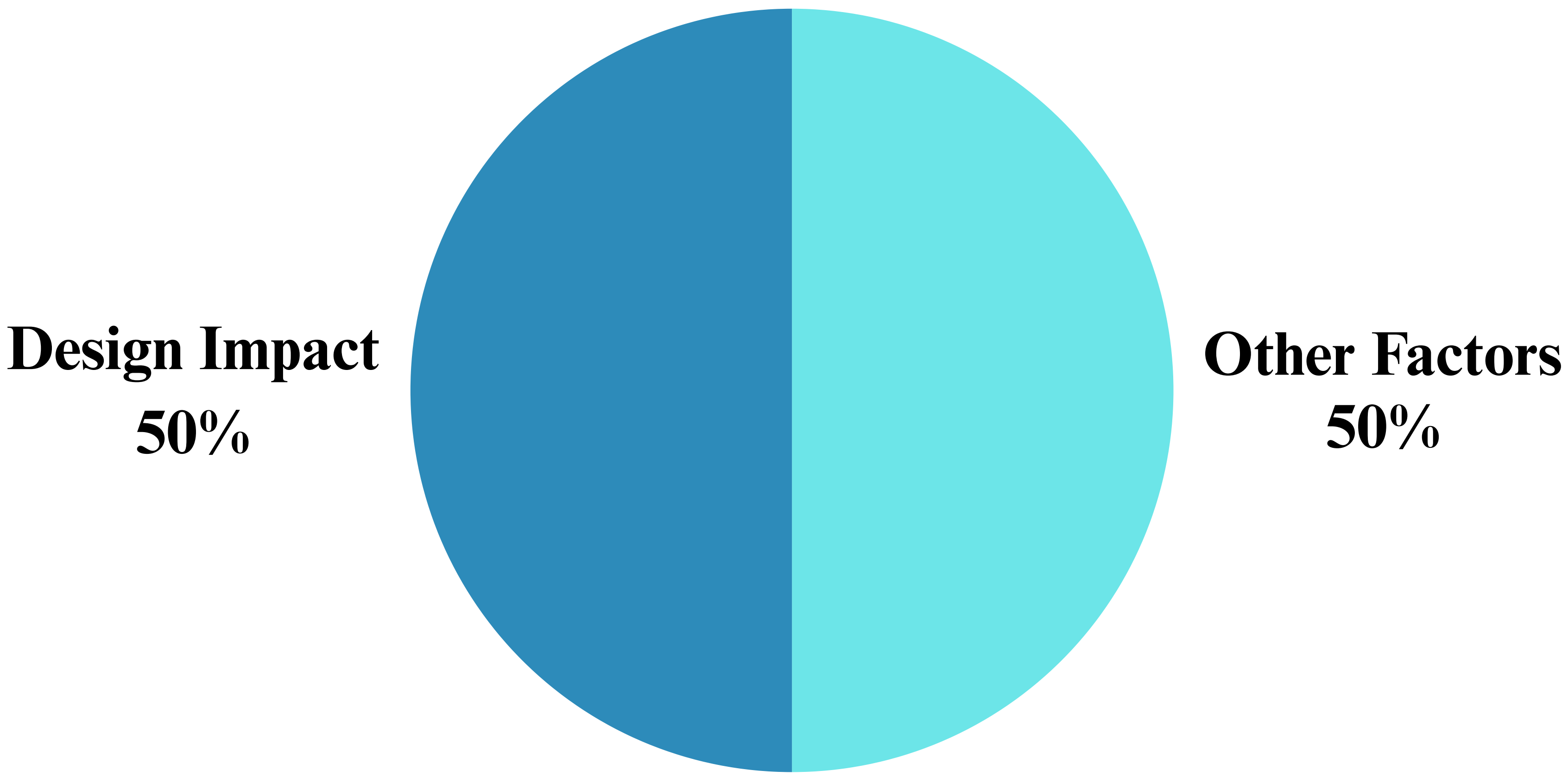
1-Introduction

The Design-Economics Nexus

Did you know? Design decisions account for approximately 50% of manufacturing cost variations.

"Significance of Variation in Manufacturing Content in Influencing Manufacturing Cost
The significant variation in manufacturing content of the products translates into significant variation in manufacturing costs for the hypothetical manufacturing system. The average estimated cost for the products is $7.37. We estimate the cost of the least costly product, the Rowenta FG22-O, to be $5.92; and the most costly product, the Krups 178, to be $9.28, a range of $3.36. We view the magnitude of this range as large and highly significant relative to the size of profit margins that are typical in the small appliance business. For example, Mr. Coffee earned gross margins of 28.5% in 1991, or $4.28 on a coffee maker with a factory price of $15.00 (SEC 1993)."



Our goal:

Optimize TenAlpina Tools' climbing hammer through customer-driven design and economic analysis.
To enhance manufacturing efficiency for Giulia Ferrato's expanding business.

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2-Design for Manufacturing (DFM)

What is New Product Development (NPD)?

New Product Development (NPD) is the process of transforming a market opportunity into a product available for sale, involving stages from idea generation to commercialization.

(Ulrich & Eppinger, 2017)

Phases of NPD (between strategy and design)

Planning

- Starts with opportunity identification **guided by corporate strategy**
- Ends with project mission statement (target market for the product, business goals)

→

Concept development

- Identification of the needs of the target market
- Generation, evaluation, selection, testing of alternative product concepts (description of the form, function, and features of a product)

→

Design

- System-level design (definition of the product architecture, decomposition in subsystems, preliminary design of key components)
- Detail design (complete specification of the product parts and process)

→

Testing and refinement

- Construction and validation through prototypes

What is Design for Manufacturing (DFM)?

Is methodology that optimizes product design to reduce manufacturing costs while maintaining or improving quality.

Focus Areas:

- Material selection

- Process optimization

- Assembly efficiency

- Cost reduction

Good design is not just about aesthetics; it's about making products easier and cheaper to produce.

- **(Hertenstein et al., 2005)**

Why DFM Matters?

- Reduces production costs by up to 50% through optimized design.

- Enhances product quality and reliability.

- Shortens time-to-market by simplifying manufacturing processes.

Aligns with TenAlpina's goal of producing high-quality, cost-effective climbing tools .

DFM in Action

DFM connects customer needs to manufacturing realities across the product lifecycle.

TenAlpina's hammer: Lightweight titanium must be affordable to produce.

- Customer Need: Durability and weight.

- Manufacturing Goal: Minimize machining costs

Sketch ⟶ Prototypes ⟶ Final Hammers

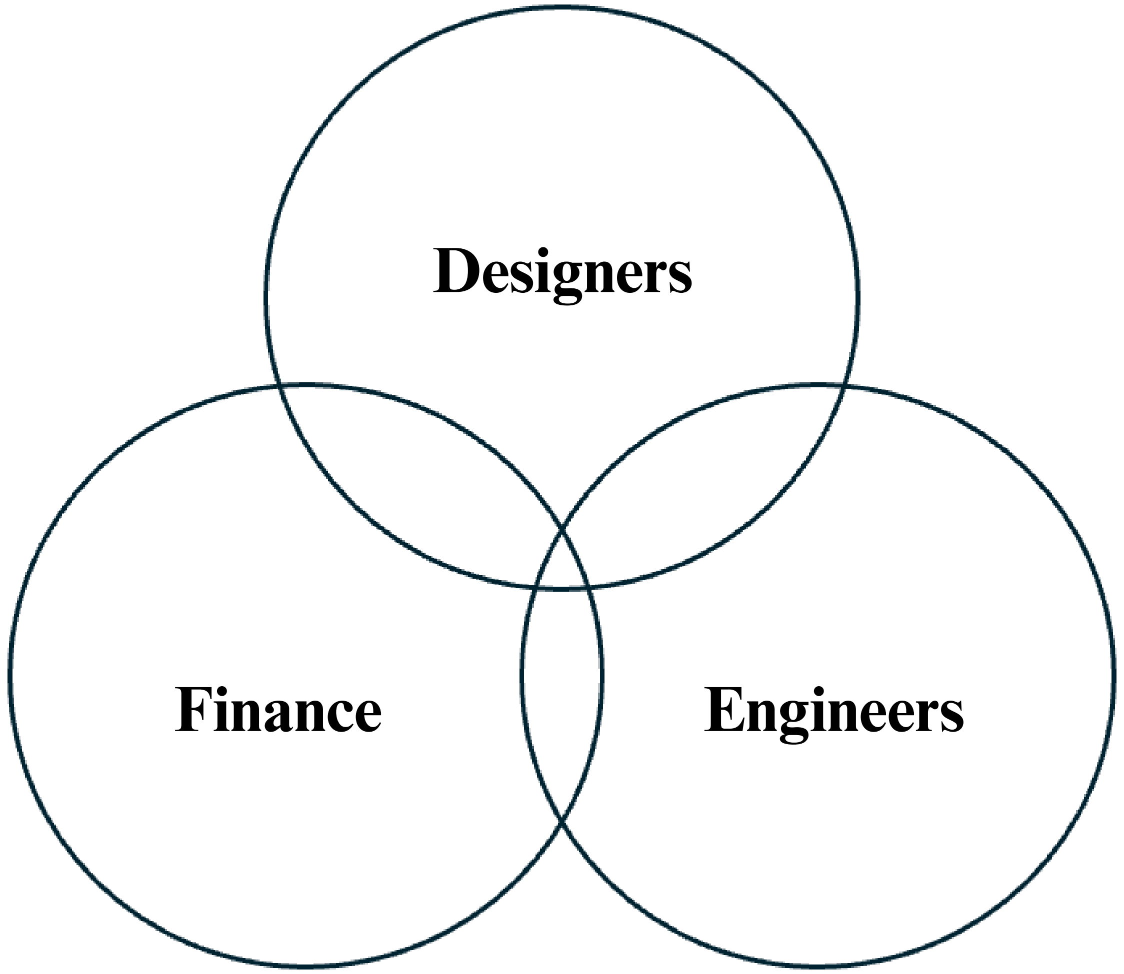
The DFM Team

DFM thrives on cross-functional collaboration:

- Designers: Create initial concepts and sketches.

- Engineers: Define process constraints and feasibility.

- Finance: Calculate costs and ensure profitability.



DFM Process Overview

A structured 5-step approach to cost-effective design:

1. Estimate Manufacturing Costs

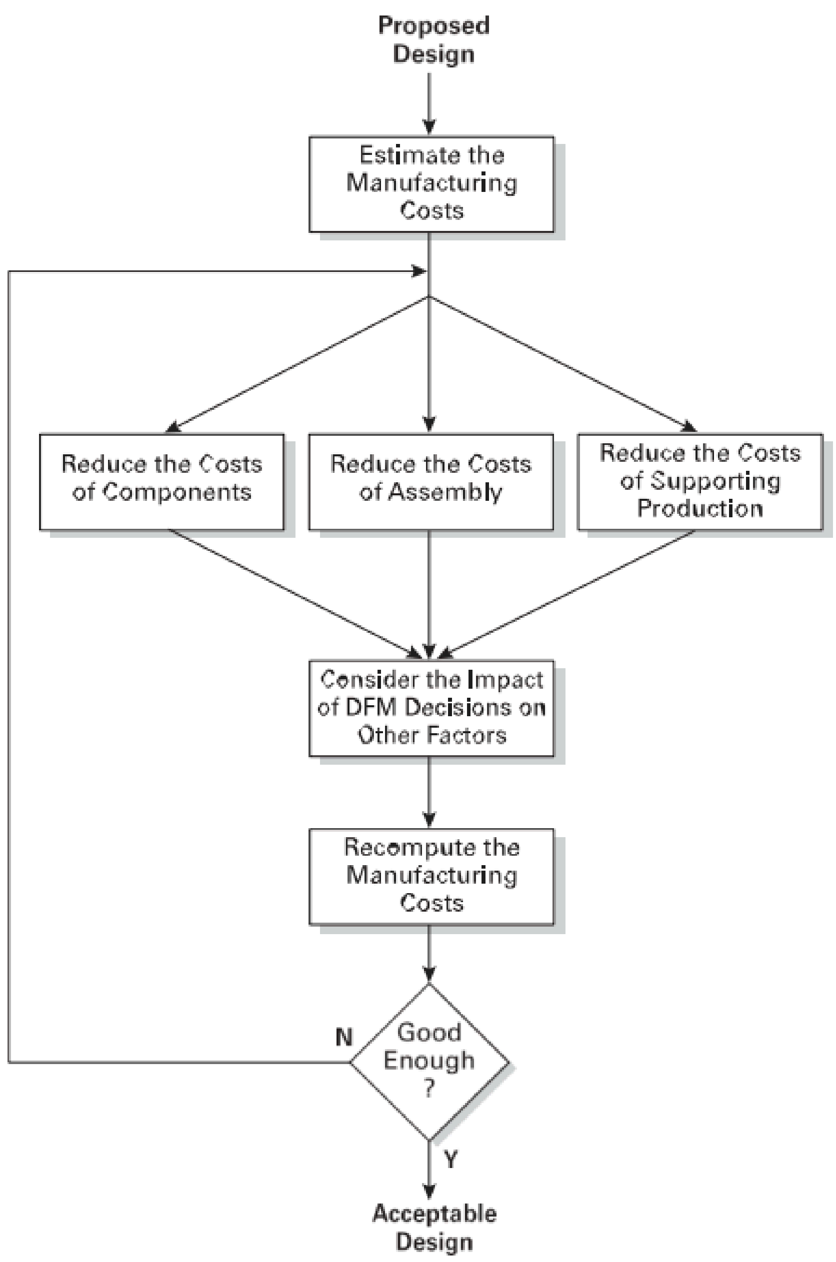
2. Reduce the Cost of Components and Materials

3. Reduce the Cost of Assembly

4. Reduce the Cost of Supporting Production

5. Consider the Impact of DFM Decisions on Other Factors

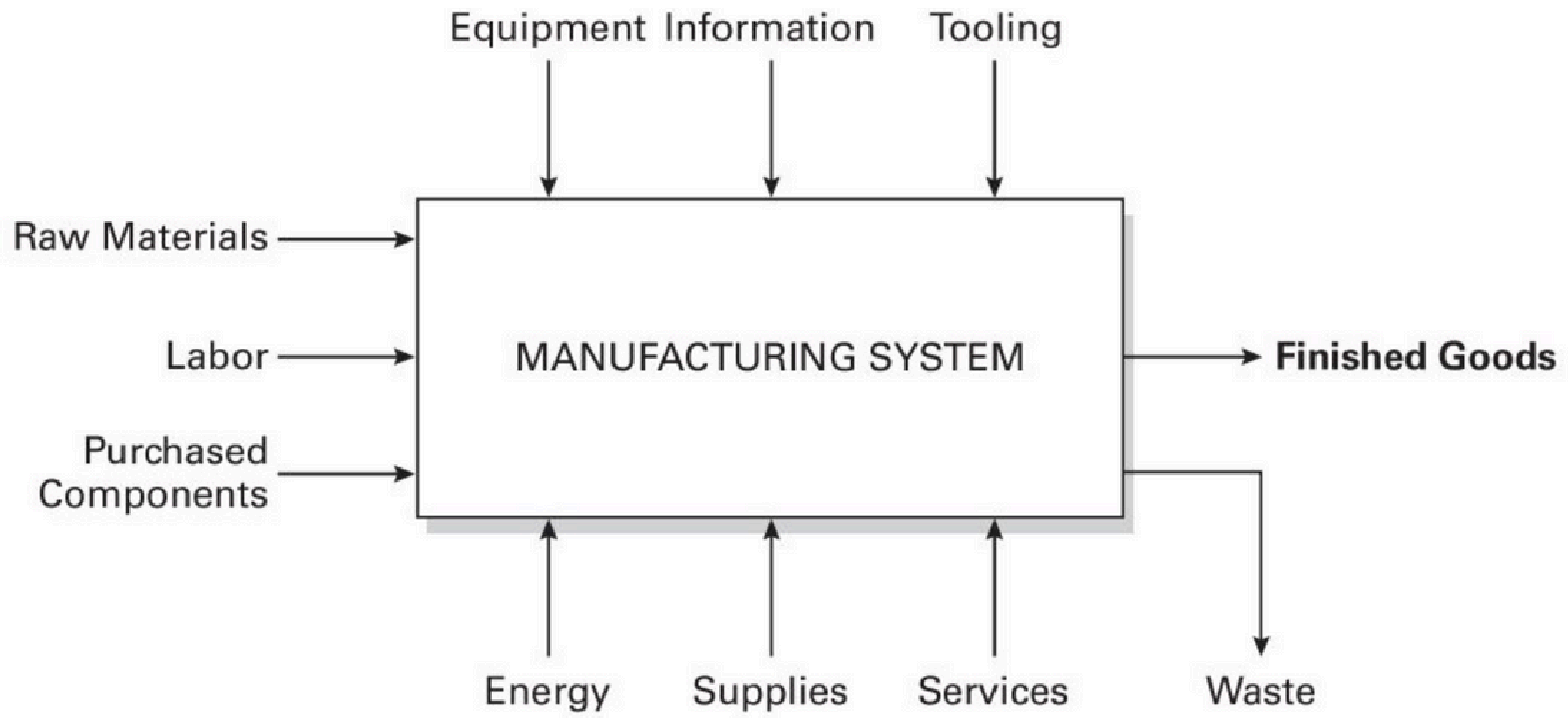
- Iterative process to optimize design and economics.



Step 1 - Estimating Costs

- Purpose:
Understand the total cost to manufacture the product.

- Challenges:
- **- Defining system boundaries**
- **- Allocating shared costs**
- **- Estimating overhead**

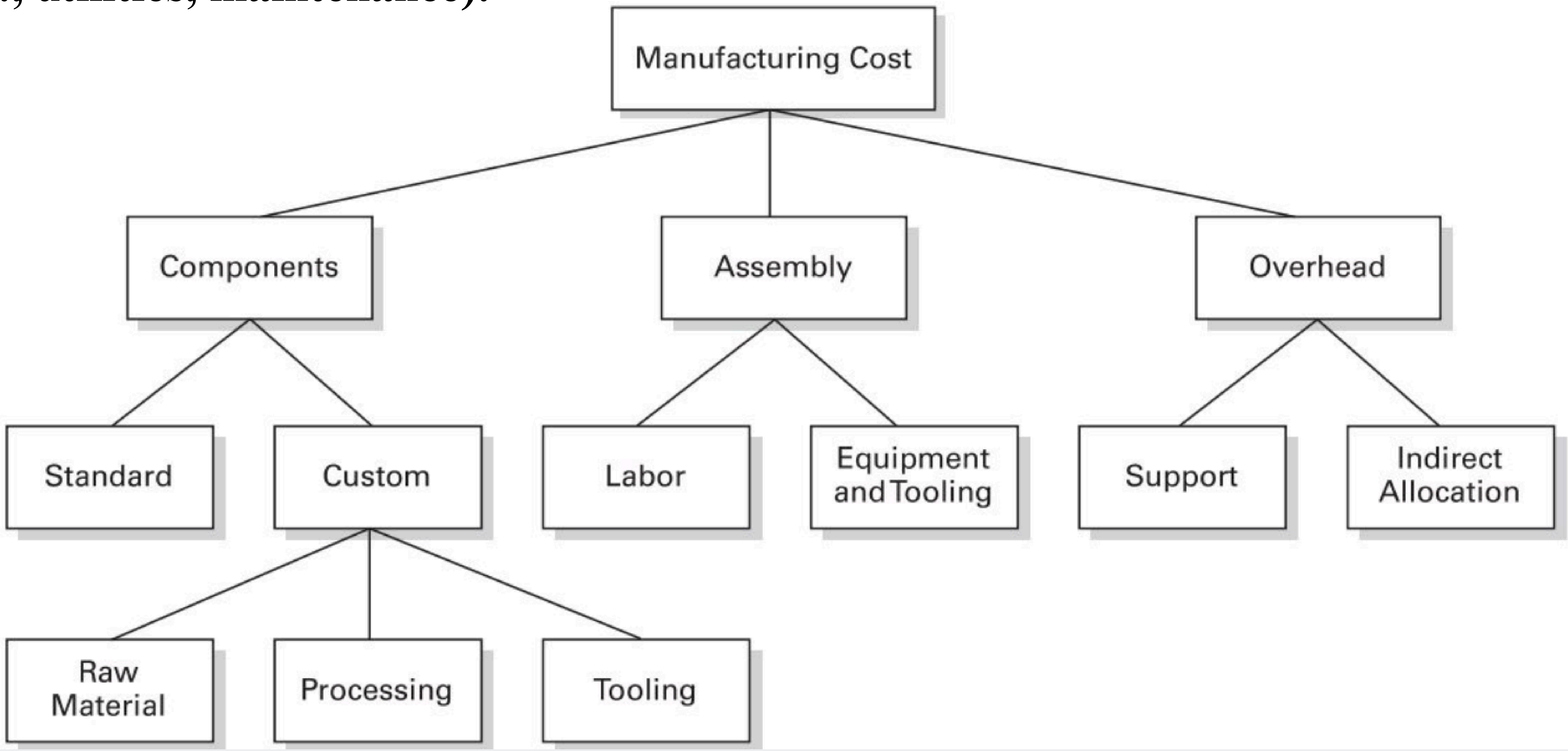


Step 1: Categorizing Manufacturing Costs

- Fixed Costs: Incurred regardless of volume (e.g., machinery, tooling).

- Variable Costs: Scale with production (e.g., materials).

- Overhead Costs: Indirect costs (e.g., utilities, maintenance).



Step 1: Bill of Materials (BOM)

- Definition: A comprehensive list of all components and materials needed.

- Importance: Tracks costs and ensures accurate estimation.

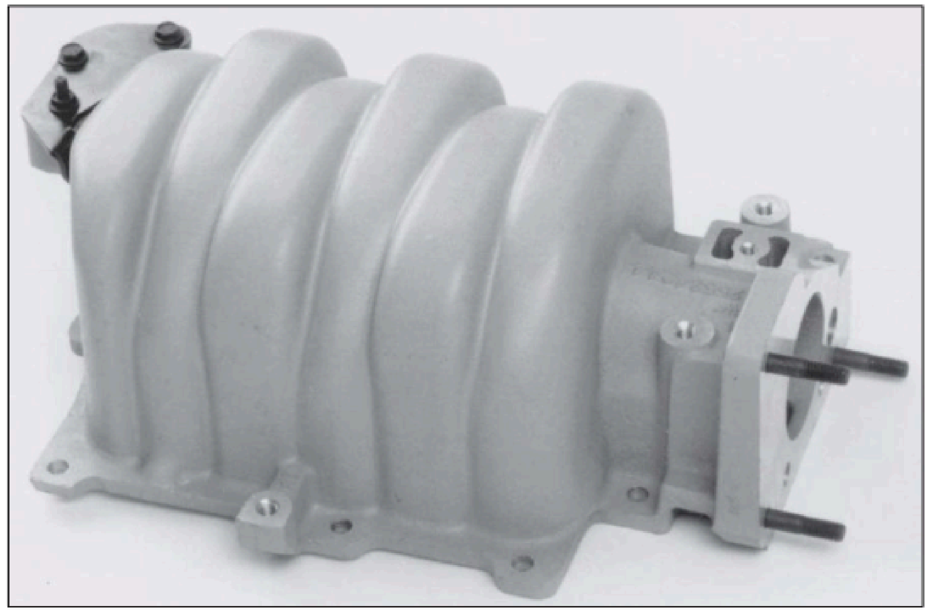
- Example: BOM for TenAlpina's hammer (titanium alloy, plastic resin, etc.)

Component	Material	Cost per Unit ($)
Hammer Head Shaft	Titanium Alloy	7.5
Handle (Plastic)	Plastic Resin	2.44
Padded Handle	Foam/Rubber	0.5
Total Material Cost		**10.94**

Costs likely come from the TenAlpina Tools: Product Line Expansion Case Study (BAB279 / MAY 2015) by Nanni and Juras (2015a)

Step 1: Bill of Materials (BOM)

- **Cost estimation plays a key role in DFM (Design for Manufacturability).**
- **Organizing information efficiently proves to be beneficial.**
- **Development of the Bill of Materials (BOM) is crucial.**



Component	Purchased Materials	Processing (Machine + Labor)	Assembly (Labor)	Total Unit Variable Cost	Tooling and Other NRE, K$	Tooling Lifetime, K units	Total Unit Fixed Cost	Total Cost
Manifold machined casting	12.83	5.23		18.06	1960	500+	0.50	18.56
EGR return pipe	1.30		0.15	1.45				1.45
PCV assembly								
Valve	1.35		0.14	1.49				1.49
Gasket	0.05		0.13	0.18				0.18
Cover	0.76		0.13	0.89				0.89
Screws (3)	0.06		0.15	0.21				0.21
Vacuum source block assembly								
Block	0.95		0.13	1.08				1.08
Gasket	0.03		0.05	0.08				0.08
Screw	0.02		0.09	0.11				0.11
Total Direct Costs	17.35	5.23	0.95	23.53	1960		0.50	24.03
Overhead Charges	2.60	9.42	1.71				0.75	14.48
Total Cost								**38.51**

Step 1: Estimating Costs for Standard and Custom Components

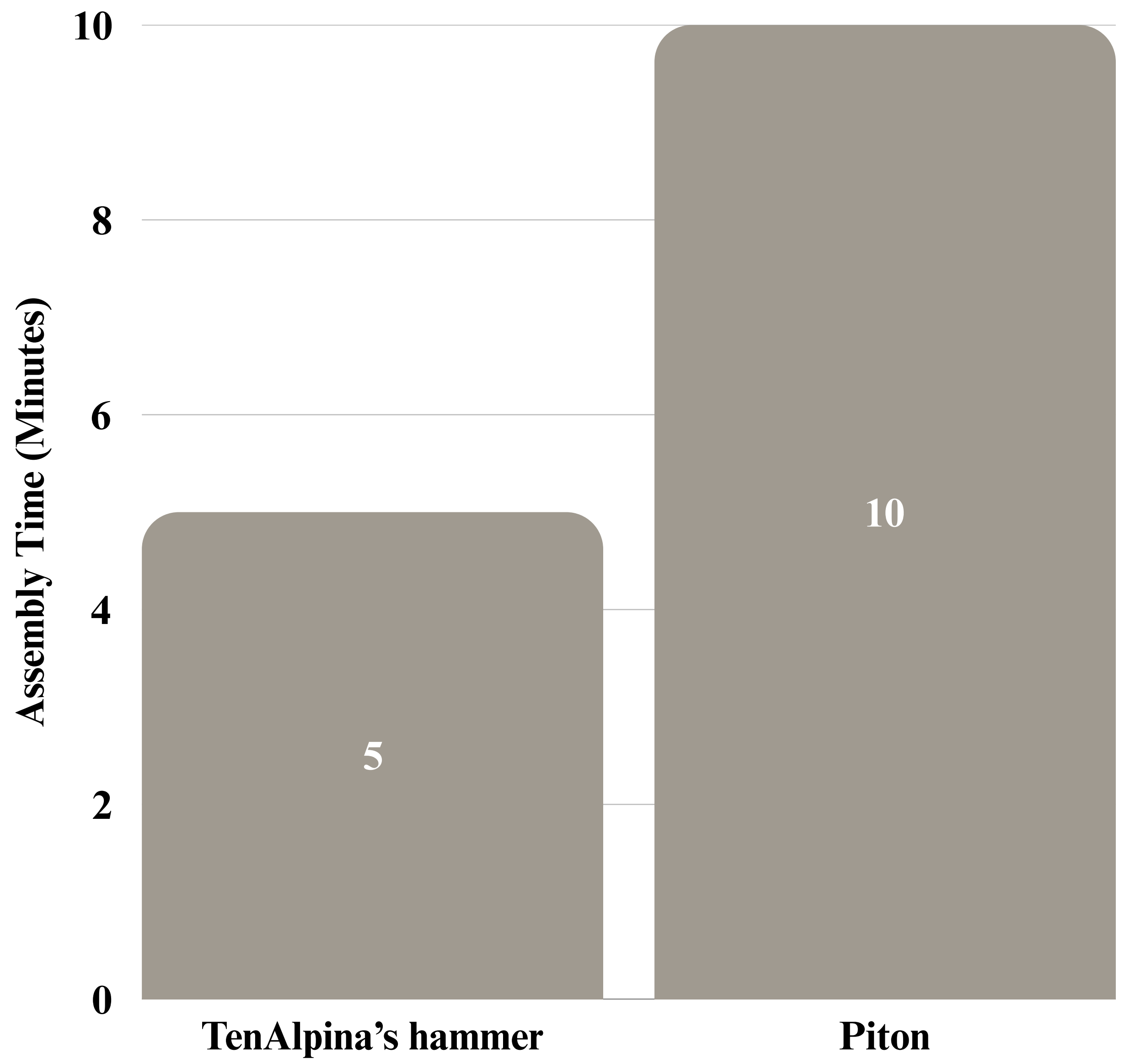
- Standard Components: Use supplier quotes or historical data.

- Custom Components: Estimate based on raw materials, processing, and tooling.

- Example: Titanium alloy for TenAlpina hammer haft

Step 1: Estimating Assembly Costs

- **Method: Sum the time for each operation × labor rate.**
- **Labor Rates: Vary globally (e.g., \$1–\$40/hour) .**
- **Hypothetical example: Assembly time for TenAlpina's hammer vs. piton.**



Step 1: Estimating Overhead Costs

- Overhead Rates Method: Allocates costs based on drivers (e.g., labor hours).

- Activity-Based Costing (ABC): More accurate using multiple drivers.

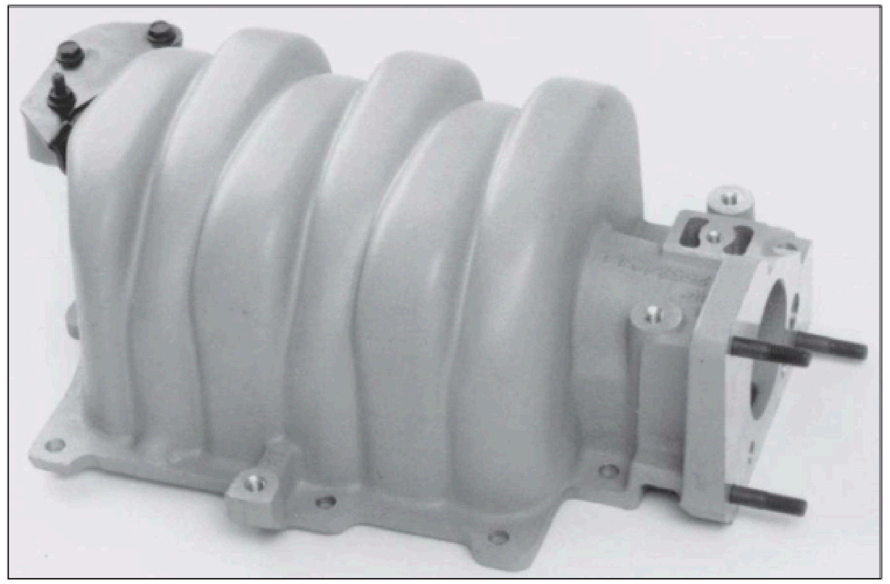
- Challenge: Proportional allocation to cost drivers.

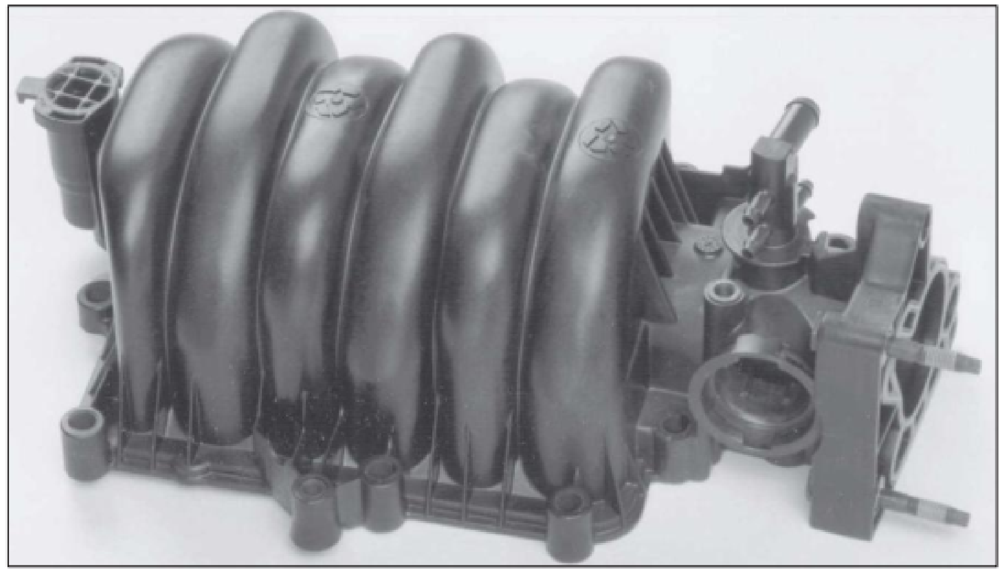
Step 2: Reduce the Cost of Components and Materials - Introduction

-Goal: Minimize material and processing costs without compromising quality.

- Strategies:

- **Eliminate unnecessary steps**
- **Reduce material usage**
- **Standardize components**





Step 2: Understanding Process Constraints

Designers must identify costly or complex processes.

Example: Avoid high-cost machining for hidden parts.

-Benefit: Reduces unnecessary expenses.

Identify Process **Assess Cost** **Redesign to Avoid**

Step 2: Redesigning Components to Eliminate Processing Steps

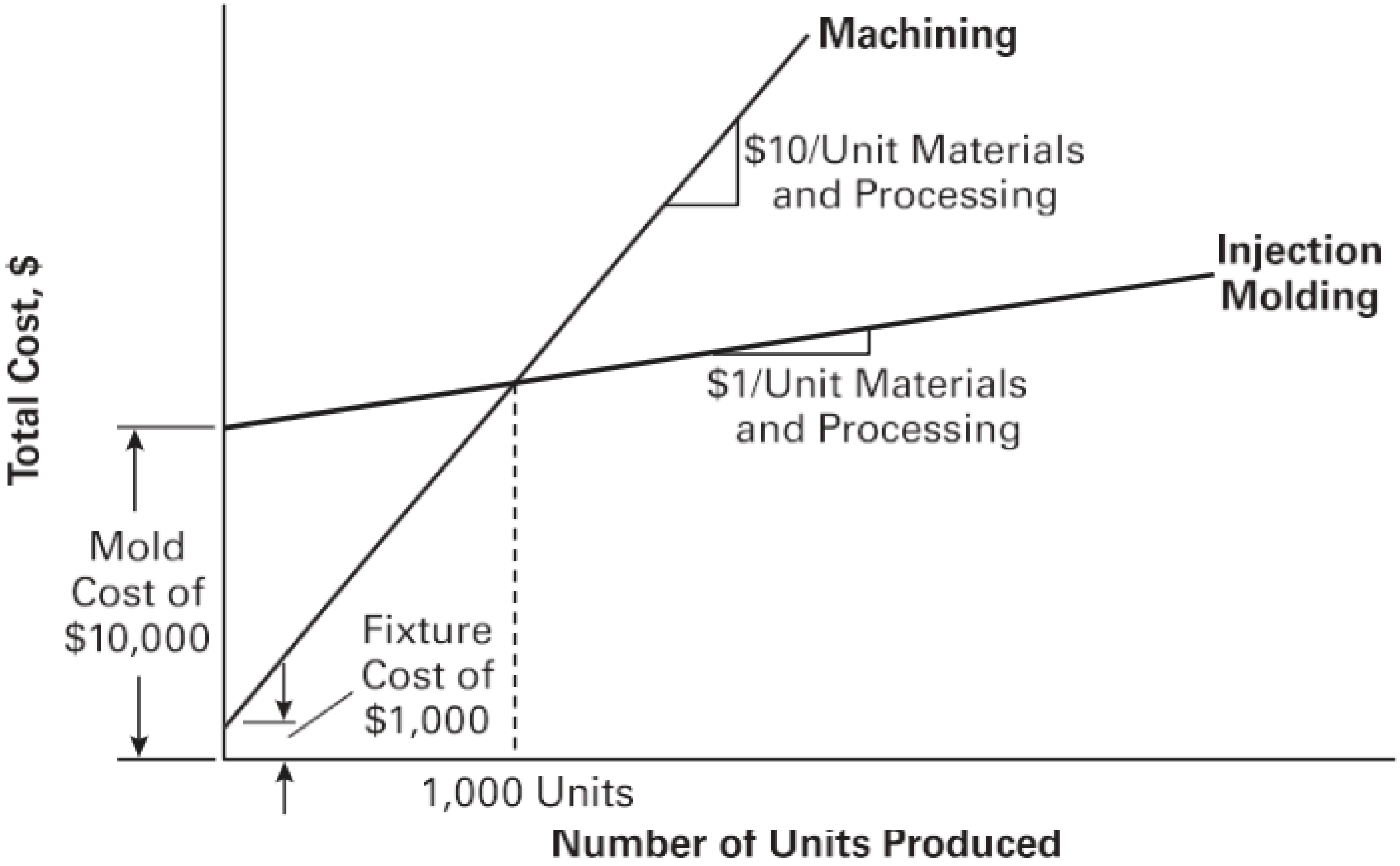
- **Strategy: Use net-shape processes (e.g., injection molding) or integrate parts.**
- **Example: Redesigning the GM V6 intake manifold to use injection-molded pieces, eliminating post-casting machining.**
- **Savings: Reduced component costs by 65% .**

Variable Cost		
Materials	5.7 kg aluminum at $2.25/kg	$12.83
Processing (casting)	150 units/hr at $530/hr	3.53
Processing (machining)	200 units/hr at $340/hr	1.70
Fixed Cost		
Tooling for casting	$160,000/tool at 500K units/tool (lifetime)	0.32
Machine tools and fixtures	$1,800,000/line at 10M units (lifetime)	0.18
Total Direct Cost		**$18.56**
Overhead charges		$12.09
Total Unit Cost		**$30.65**

→

Variable Cost		
Materials (manifold housing)	1.4 kg glass-filled nylon at $2.75/kg	$ 3.85
Materials (intake runner insert)	0.3 kg glass-filled nylon at $2.75/kg	0.83
Molding (manifold housing)	80 units/hr at $125/hr	1.56
Molding (intake runner insert)	100 units/hr at $110/hr	1.10
Fixed Cost		
Mold tooling (manifold housing)	$350,000/tool at 1.5M units/tool	$ 0.23
Mold tooling (intake runner insert)	$150,000/tool at 1.5M units/tool	0.10
Total Direct Cost		**$ 7.67**
Overhead charges		$ 5.99
Total Unit Cost		**$13.66**

Step 2: Redesigning Components to Eliminate Processing Steps

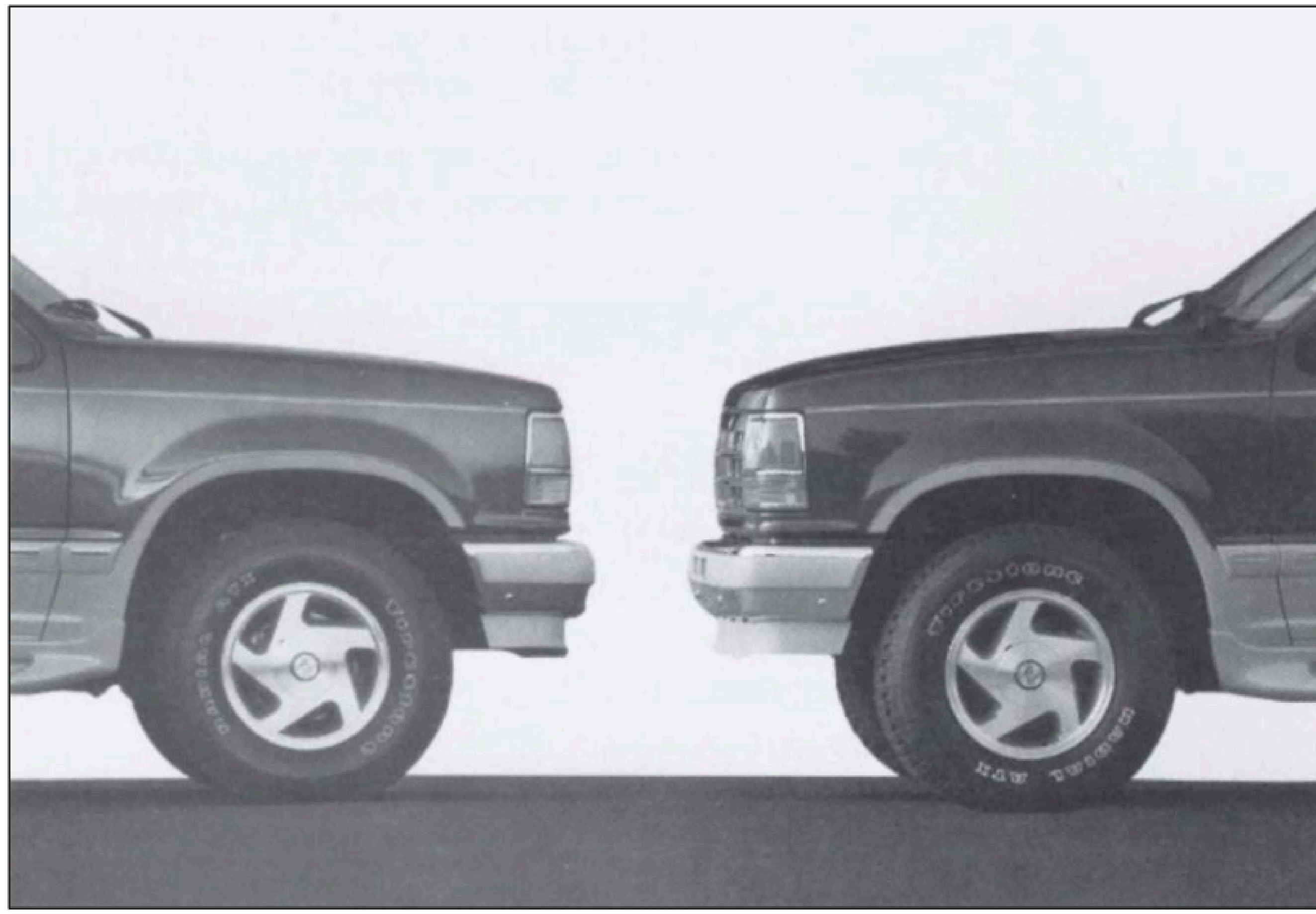


Step 2: Standardizing Components

Benefits:

- **Economies of Scale: Bulk purchasing reduces material costs by 10–15%**
- **Reduced Inventory Costs: Fewer unique parts lower storage needs**
- **Simplified Supply Chain: Streamlined procurement and logistics.**

Example: Auto industry using the same wheels on both sides of a car to cut production costs.



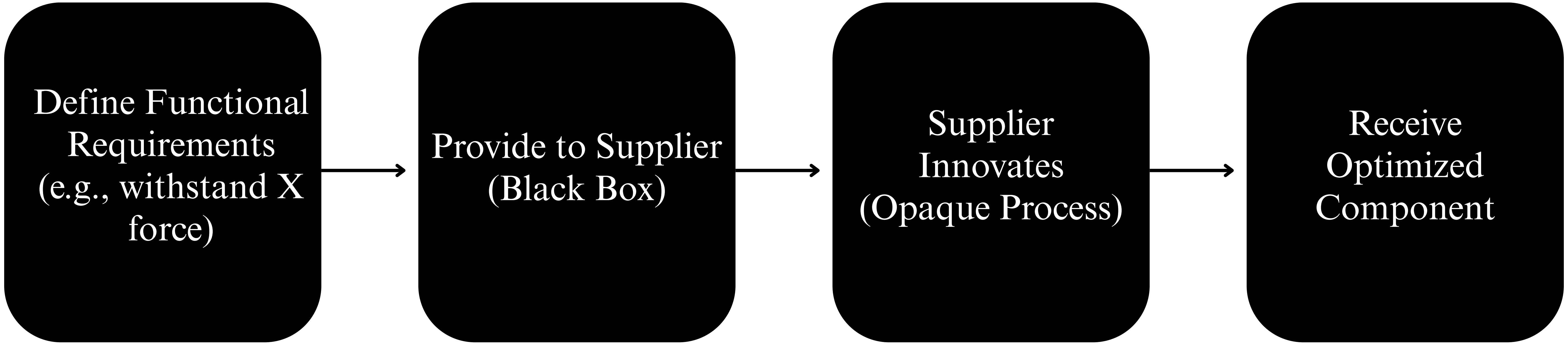
Courtesy of Ford Motor Co.

Step 2: Black Box Component Procurement

Method: Provide suppliers with functional requirements, not specifics.

Advantage: Suppliers optimize for cost and performance.

Example: Japanese automotive industry success.



Step 3: Reduce the Cost of Assembly

Design for Assembly (DFA) focuses on minimizing assembly costs. For most products, assembly costs are a small part of the total cost. However, reducing these costs can lead to significant indirect benefits by lowering parts count and manufacturing complexity.

Goal: Minimize assembly time and complexity.

Subset of DFM: Design for Assembly (DFA).

Focus: Fewer parts, easier assembly.

Step 3: Design for Assembly (DFA) Index

$$\text{DFA index} = \frac{\text{Theoretical minimum number of parts} \times (3 \text{ seconds})}{\text{Estimated total assembly time}}$$

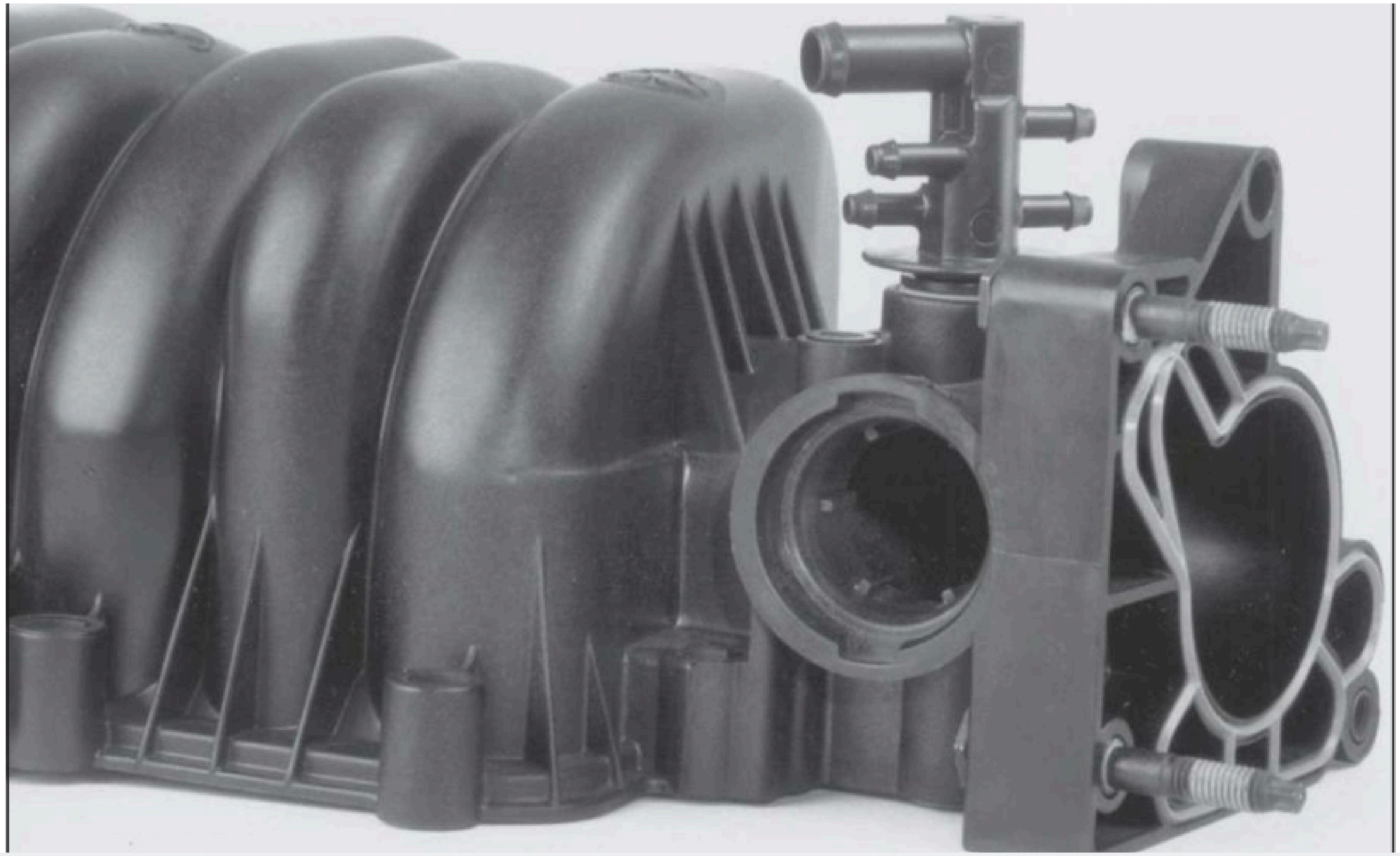
Purpose: Measures assembly efficiency.

Step 3: Integrating Parts

Strategy: Combine multiple parts into one component.

Benefits: Reduces assembly time and costs.

Example: Redesigning the GM V6 intake manifold from a single cast piece to two integrated injection-molded parts, reducing assembly steps

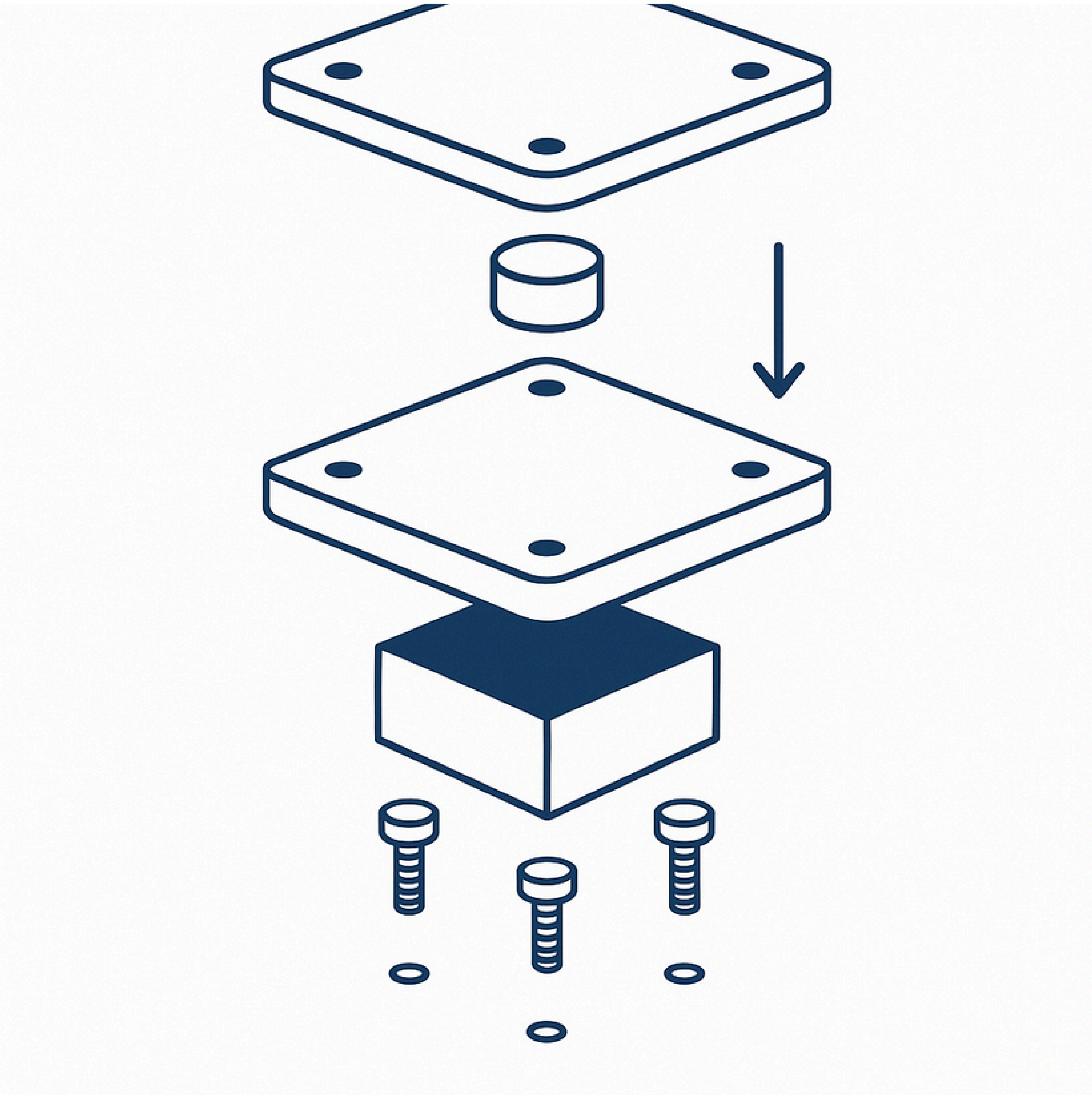


Step 3: Maximizing Ease of Assembly

- Principles:

- **Insert from top (Z-axis)**
- **Self-aligning parts**
- **No tools required**

- Example: Chamfered edges for easy insertion.



Step 3: Considering Customer Assembly

Strategy: Allow customers to assemble parts.

Benefits: Lowers transportation and assembly costs.

Example: IKEA's flat-pack furniture model.

Step 3: DFA in TenAlpina's Hammer

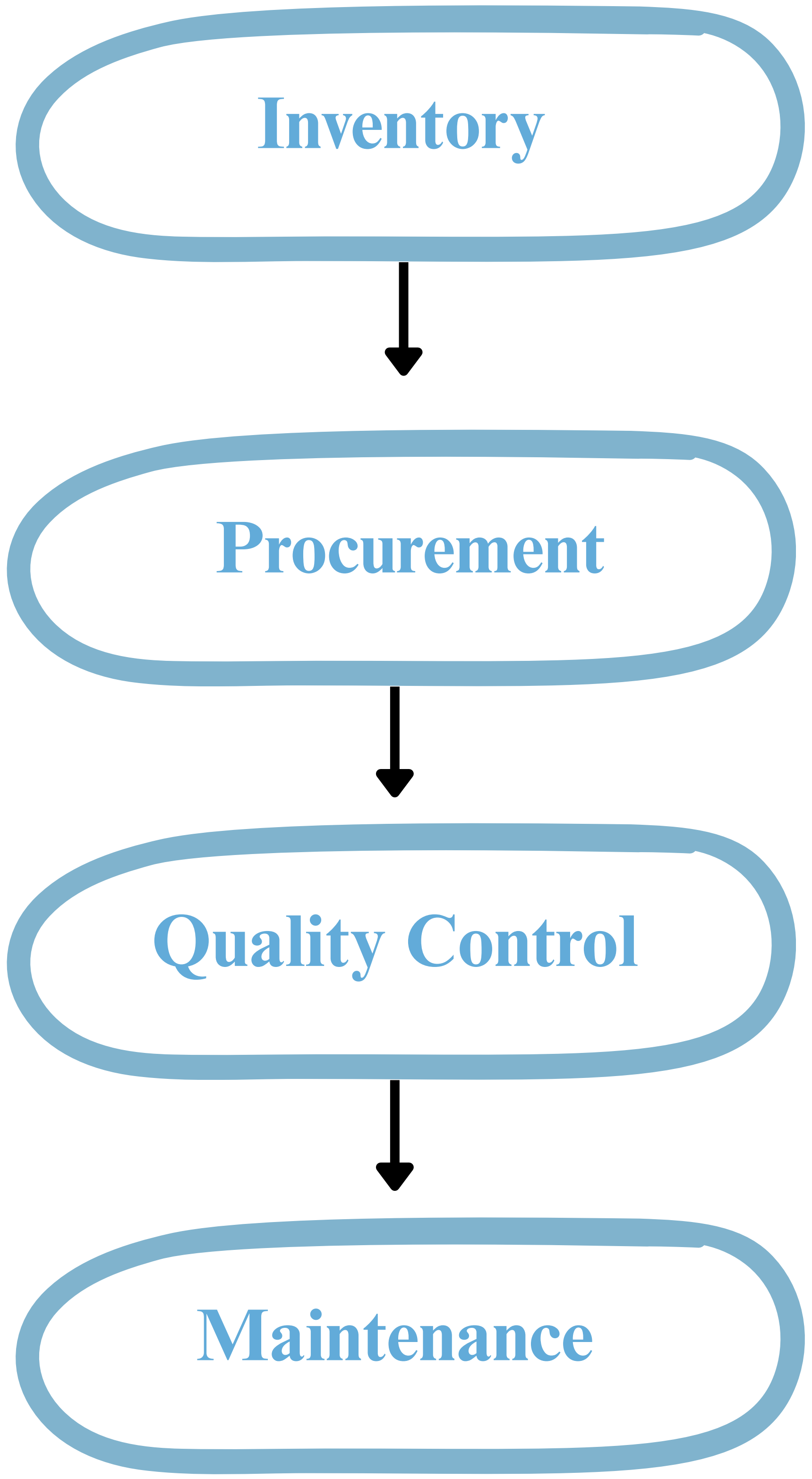
Application: Reduce fasteners, integrate components.

Step 4: Reduce the Cost of Supporting Production

The Goal is to Minimize indirect costs (e.g., inventory, HR).

Strategies:

- Minimize complexity
- Error-proof processes



Step 4: Minimizing Systematic Complexity

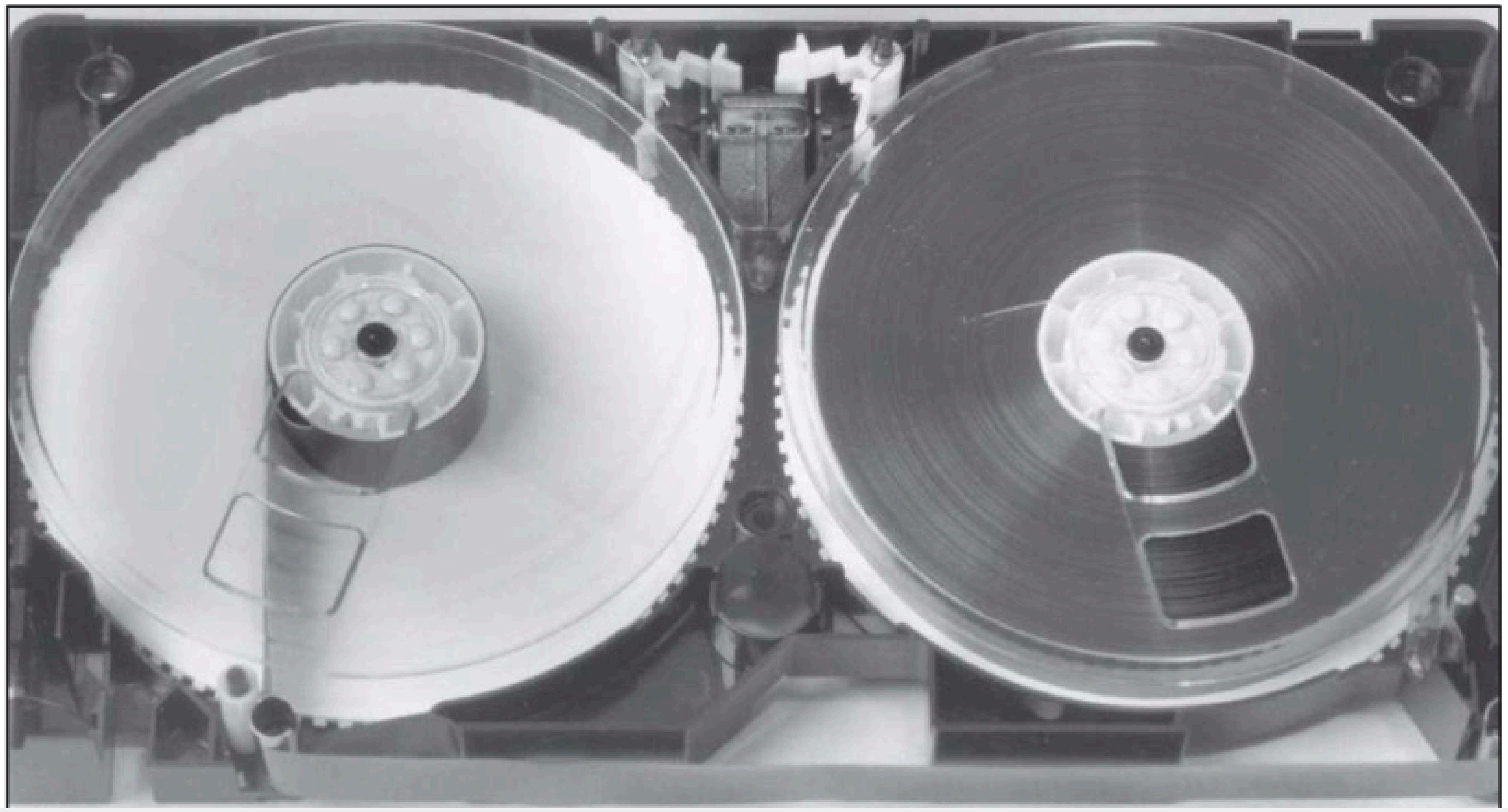
Strategy	Benefits	Example
Reduce variety in inputs, outputs, and processes.	Lower inventory and management costs.	Standardizing packaging for pitons and hammers.

Step 4: Error-Proofing (Poka-Yoke)

Strategy: Design processes to prevent errors (e.g., color-coding, orientation-specific designs).

Benefits: Reduces [green] rework [red] and waste.

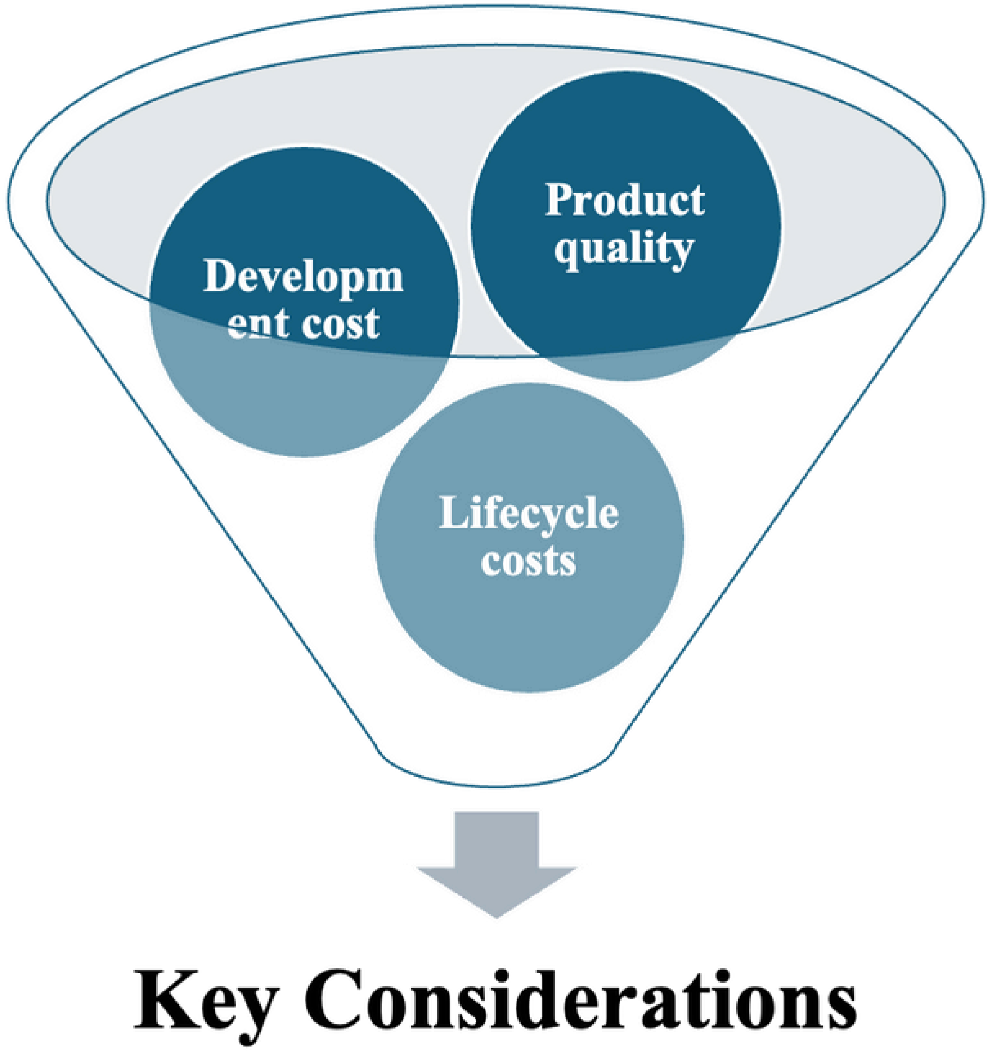
Example: Color-coding the left and right reel locks in a videocassette to prevent assembly errors .



Step 4: Supporting Production in TenAlpina

Application: Streamline inventory for shared components (e.g., titanium alloy).

Step 5: Consider the Impact of DFM Decisions



The Goal is to Balance cost reduction with other factors.

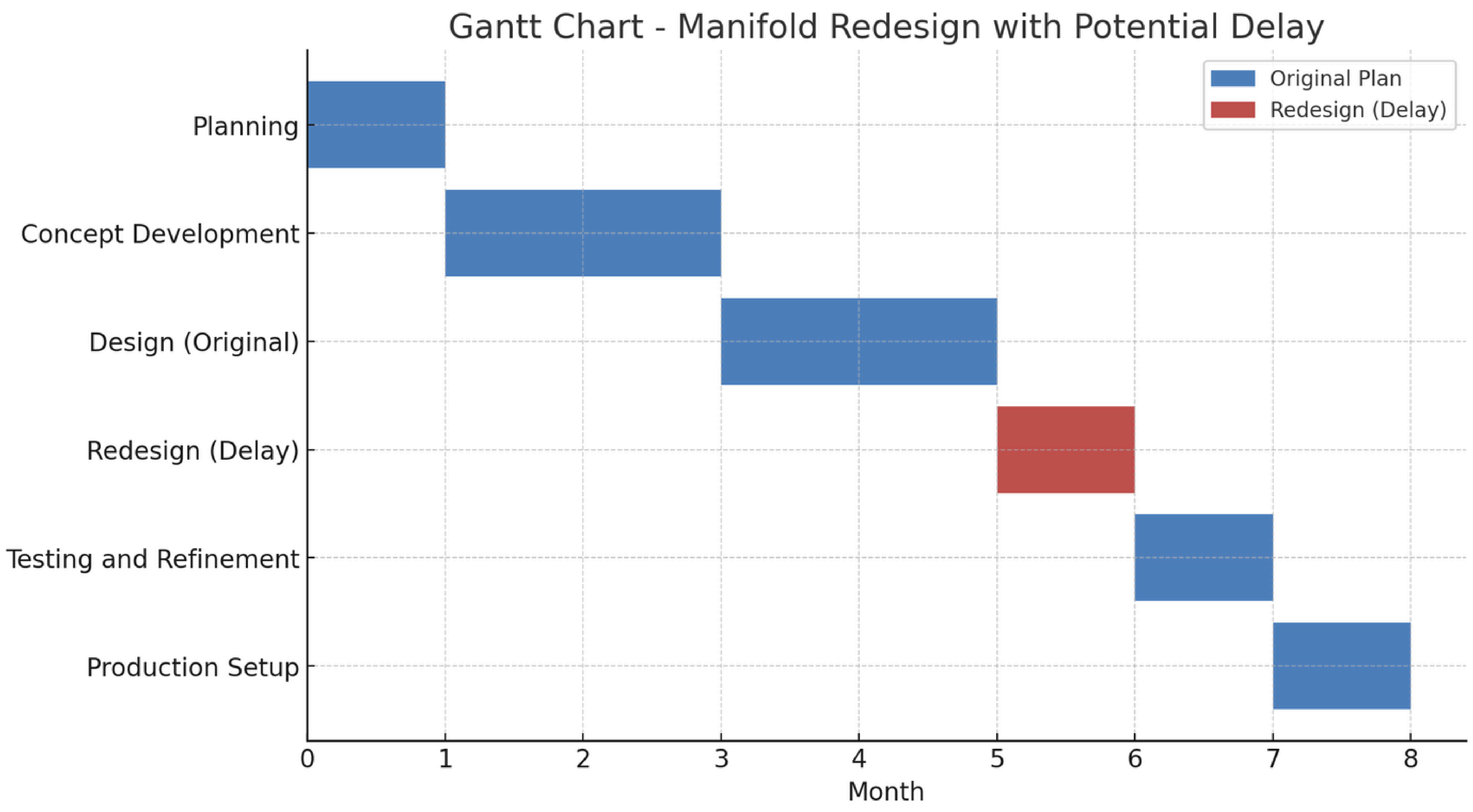
"The Impact of DFM on External Factors

Design decisions may have implications beyond the responsibilities of a single development team. In economic terms, these implications may be viewed as externalities. 2 such externalities are component reuse and life cycle costs.
Component reuse: Taking time and money to create a low-cost component may be of value to other teams designing similar products.
Life cycle costs: Throughout their life cycles, certain products may incur some company or societal costs that are not accounted for in the manufacturing cost. Products may incur service and warranty costs. Although these costs may not appear in the manufacturing cost analysis, they should be considered before adopting a DFM decision. Design for Environment, provides a detailed method of addressing life cycle costs"

Step 5: Impact on Development Time and Cost

Trade-Off: Complex DFM may delay development.

Example: Redesigning the GM V6 intake manifold to use injection-molded parts adds design time.



Step 5: Impact on Product Quality

Trade-Off: DFM may compromise quality.

Example: GM V6 intake manifold's material change (aluminum to nylon) may affect durability.

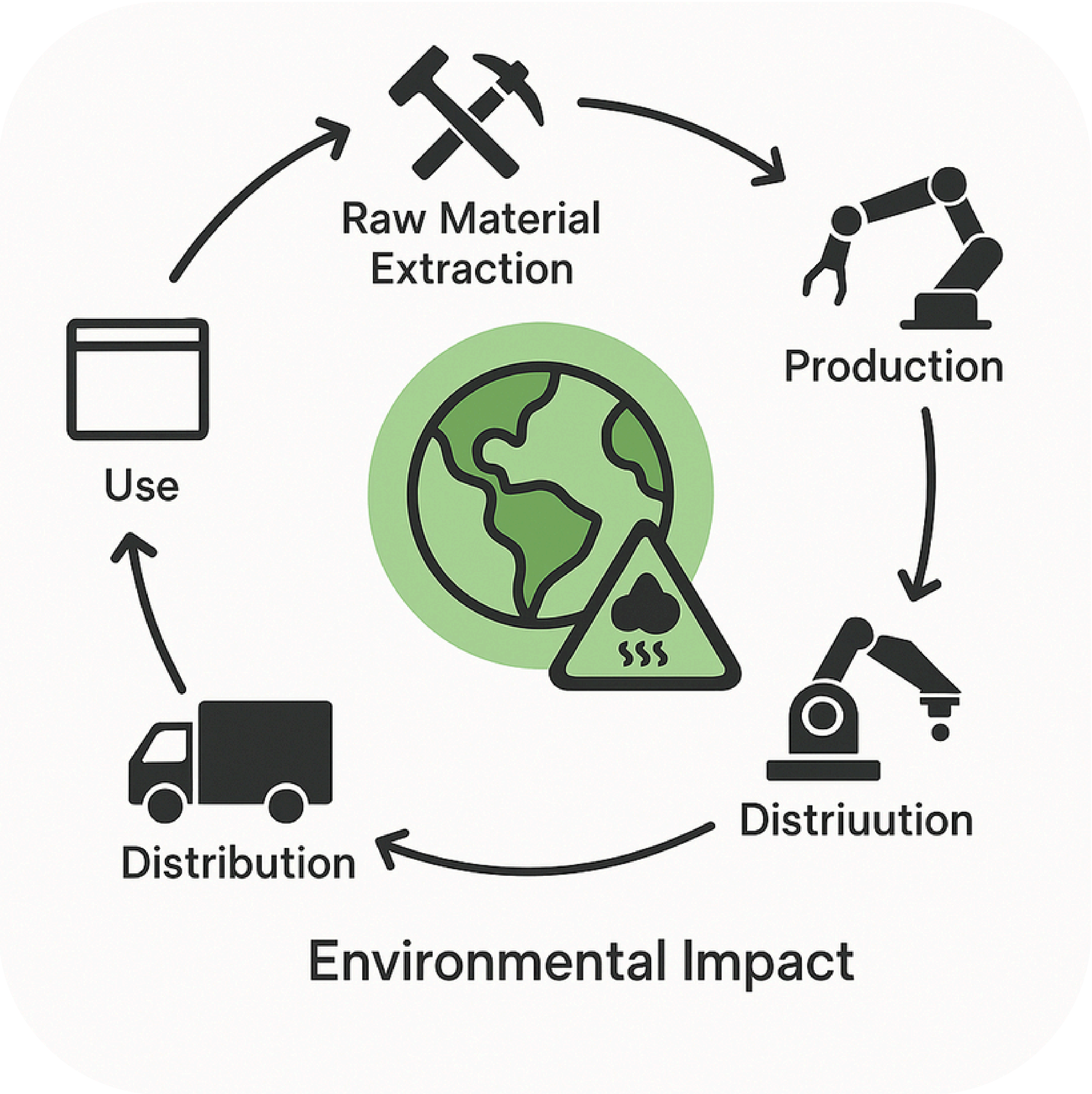
"**The Impact of DFM on Product Quality**
Before proceeding with a DFM decision, the team should evaluate the impact of the decision on product quality. Under ideal circumstances, actions to decrease manufacturing cost would also improve product quality. For example, the new GM manifold resulted in cost reduction, weight reduction, and improved engine performance. It is not uncommon for DFM efforts focused primarily on manufacturing cost reduction to also result in improved serviceability, ease of disassembly, and recycling. However, in some cases actions to decrease manufacturing cost can have adverse effects on product quality (such as reliability or robustness), so it is advisable for the team to keep in mind the many dimensions of quality that are important for the product."

Step 5: Impact on External Factors

Considerations:

- Component reuse
- Lifecycle costs
- Environmental impact

Example: Reusing titanium reduces waste.



Step 5: DFM Impact in TenAlpina

Application: Balance cost savings with safety and reputation.

Recommendation: Prioritize durability in hammer design.

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3-Product development economics

Product Development Team

The primary objective of the team is to deliver value to customers while strengthening the company’s competitive position. To support this goal, the product development team needed effective tools—such as economic analysis methods—to guide decision-making throughout the development process.

Elements of Economic Analysis

Qualitative Analysis

- Focuses on non-measurable factors like market dynamics, timing, and competitive strategy.
- Recognizes risks and opportunities that numbers may miss.
- Considers interactions with:
    a. The firm
    b. The market
    c. The macroeconomic environment

Why It Matters:

- Captures strategic factors that influence long-term success.
- Useful in uncertain, fast-changing environments.
- Quote from a CEO: short-term payback isn't everything—strategic timing matters

When Should Economic Analysis Be Performed?

Economic analysis supports decision-making at two key stages:

1. Go/No-Go Milestones
Decide whether to proceed with development, implement a concept, or launch a product. Typically occurs at the end of each development phase.

2. Operational Decisions
Evaluate trade-offs such as cost vs. time (e.g., outsourcing to speed up development or delaying launch to reduce production costs).

Key Notes:
Analysis should be updated as new information becomes available.
It serves as a dynamic decision-support tool for managing the project.
All team members—not just financial experts—should understand and engage with the analysis process.

Elements of Economic Analysis

Quantitative Analysis

- Focuses on measurable financial data like revenues (cash inflows) and costs (cash outflows).
- Common costs: development, ramp-up, marketing, production (materials, labor, etc.).
- Goal: assess project profitability using Net Present Value (NPV).

Ct = Cash flow at time period t
C0 = initial investment
r = Discount rate
t = Time period
n = Total number of period

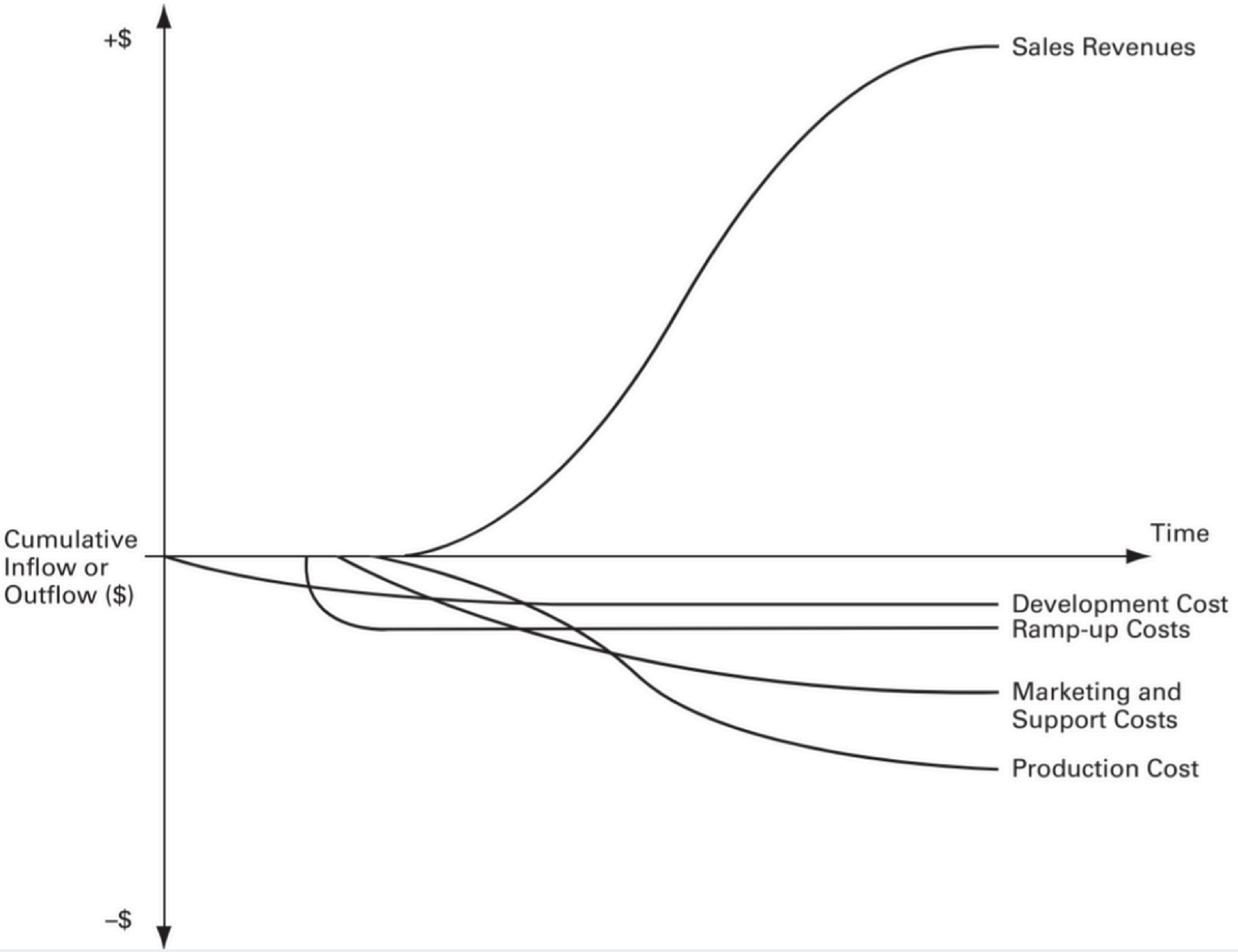
$$NPV = -C_0 + \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}$$

Elements of Economic Analysis

Quantitative Analysis

Why It Matters:

- Helps evaluate the financial viability of a new product.
- NPV provides a snapshot of future returns in today's dollars.
- Adds structure and discipline to decision-making.
- Widely used in business due to its simplicity and effectiveness.

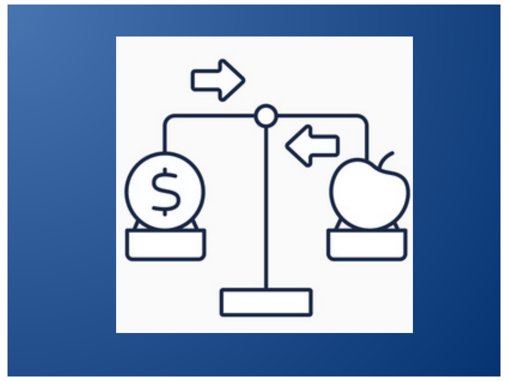


Economic Analysis Process

A structured four-step approach to guide economic analysis in product development:

Build a Base-Case Financial Model
Estimate future cash flows and calculate Net Present Value (NPV).

Perform Sensitivity Analysis
Identify how changes in assumptions and variables impact financial outcomes.



Evaluate Project Trade-Offs
Use insights from sensitivity analysis to weigh different strategic options.

Incorporate Qualitative Factors
Consider the impact of market dynamics, company strategy, and external conditions on success.

* These four steps provide a comprehensive framework for informed decision-making throughout the project lifecycle.

1- Build a Base-Case Financial Model

Overview Goal:

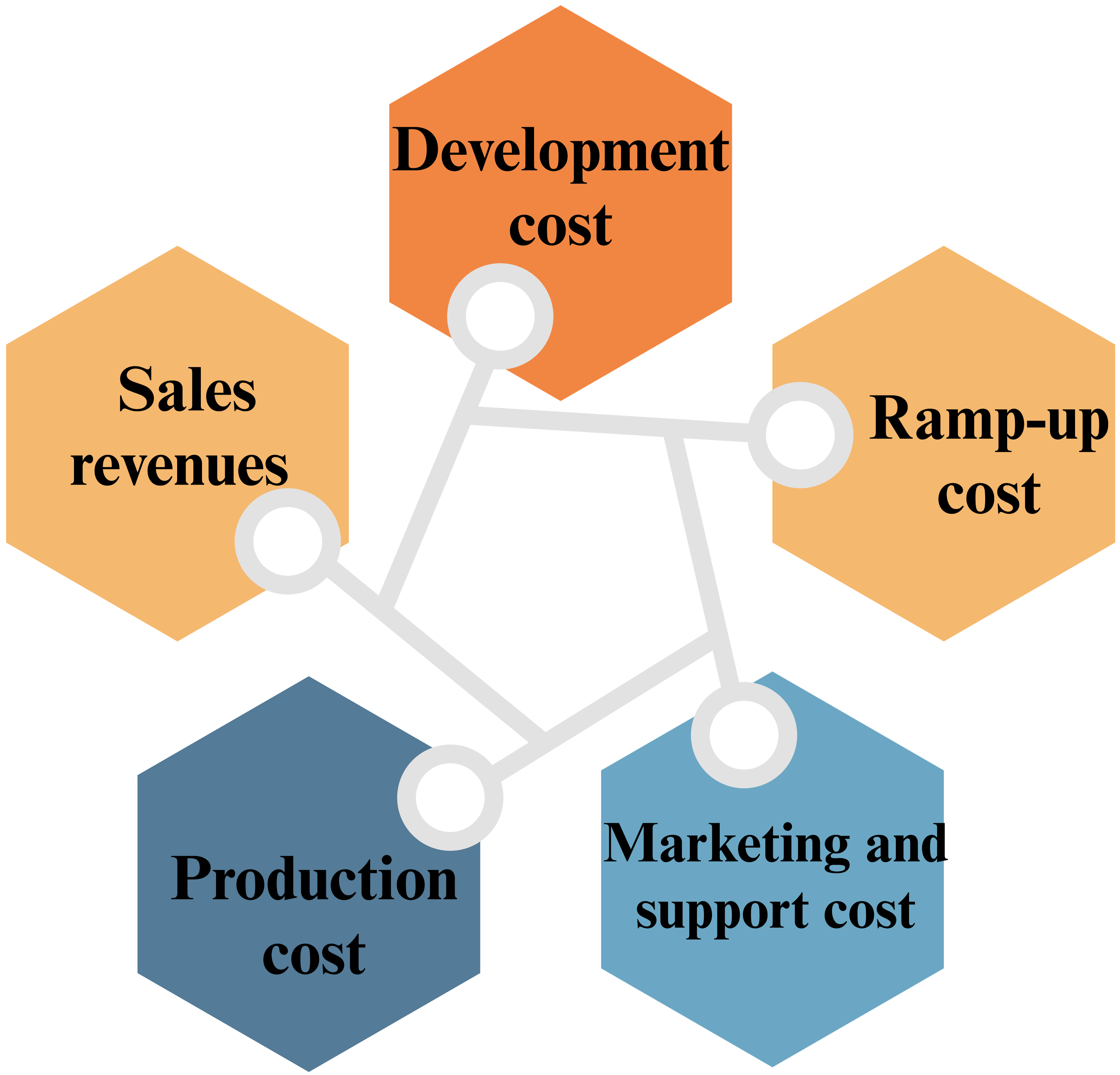
Estimate future cash inflows/outflows and calculate Net Present Value (NPV).

Key Steps:

Merge the project schedule, budget, sales forecasts, and production costs.

Focus on clarity (not excessive detail) while keeping decision-making effective.

Core Cash Flow Categories:



1- Build a Base-Case Financial Model

Advanced Considerations:

When More Detail is Needed:

Break down:

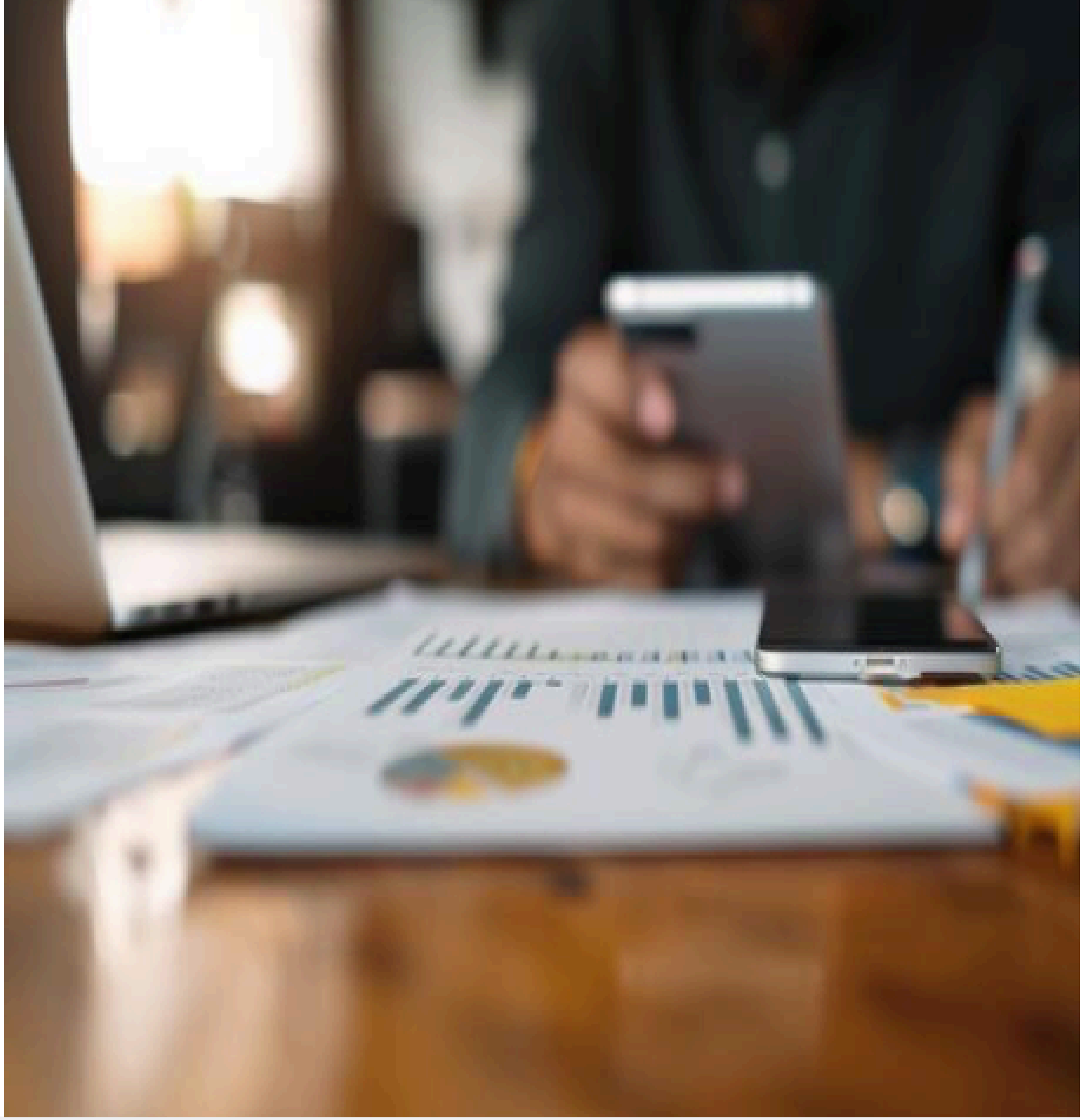
Production: direct vs. indirect costs

Marketing: launch, promo, service, etc.

Optional Inclusions:

Tax effects (depreciation, tax credits)

Working capital, cannibalization, salvage value, opportunity cost



Case Study – CI-700

1. Development cost $5 million
2. Ramp-up cost $2 million
3. Marketing and support cost $1 million/year
4. Unit production cost $400/unit
5. Sales and production volume 20,000 units/year
6. Unit price $800/unit

	Year 1				Year 2				Year 3				Year 4			
($ values in thousands)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Development cost	–1,250	–1,250	–1,250	–1,250												
Ramp-up cost				–1,000	–1,000											
Marketing & support cost					–250	–250	–250	–250	–250	–250	–250	–250	–250	–250	–250	–250
Production cost						–2,000	–2,000	–2,000	–2,000	–2,000	–2,000	–2,000	–2,000	–2,000	–2,000	–2,000
Production volume						5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Unit production cost						–0.4	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4
Sales revenue						4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Sales volume						5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Unit price						0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Case Study – CI-700

Marketing cost	$ –250,000
Product revenues	4,000,000
Production cost	–2,000,000
Period cash flow	$1,750,000

	Year 1				Year 2				Year 3				Year 4			
($ values in thousands)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Development cost	–1,250	–1,250	–1,250	–1,250												
Ramp-up cost				–1,000	–1,000											
Marketing & support cost					–250	–250	–250	–250	–250	–250	–250	–250	–250	–250	–250	–250
Production cost						–2,000	–2,000	–2,000	–2,000	–2,000	–2,000	–2,000	–2,000	–2,000	–2,000	–2,000
Production volume						5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Unit production cost						–0.4	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4	–0.4
Sales revenue						4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Sales volume						5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Unit price						0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Period Cash Flow	–1,250	–1,250	–1,250	–2,250	–1,250	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
PV Year 1, r = 10%	–1,250	–1,220	–1,190	–2,089	–1,132	1,547	1,509	1,472	1,436	1,401	1,367	1,334	1,301	1,269	1,239	1,208
Project NPV	**8,203**															

Using the Base-Case Financial Model for Smart Decisions

The base-case financial model helps answer:

- Should we proceed with this project? (Go/No-Go)
- Which option creates more value? (Investment Choice)

* *A positive NPV means the project adds value and supports moving forward with development.*

Example: Polaroid's Decision:

Polaroid compared two production facility options:

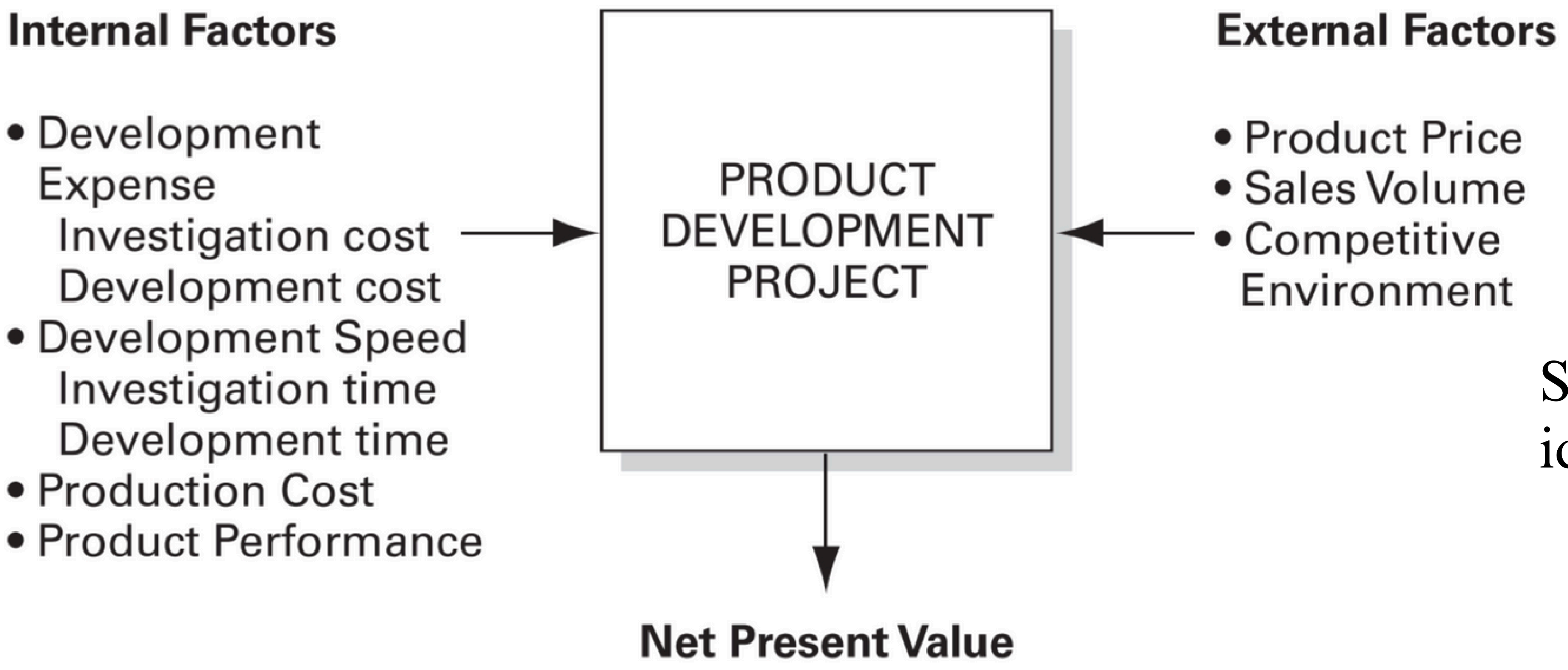
- Each had different ramp-up, production, and support costs
- The team calculated the NPV for each scenario

The option with the higher NPV was chosen to support the investment
This approach helps compare multiple strategies and choose the one that maximizes financial value

2 – Perform Sensitivity Analysis Purpose

To evaluate how changes in internal and external factors affect Net Present Value (NPV).

Internal (Team Control)	External (Market-Driven)
Development cost Development time Production cost Product performance	Sales volume Product pricing Competitor actions Market response



Sensitivity analysis answers the "What if?" and identifies the most influential project variables.

2- Cost & Time Sensitivities – CI-700 Case

Development Cost Sensitivity

20% cost reduction (from \$5M → \$4M). Quarterly spend drops: \$1.25M → \$1M
NPV increases to \$9.167M (+\$964K or +11.8%)

Development Time Sensitivity

25% increase in duration (4 → 5 quarters) NPV drops to \$6.764M (–\$1.439M or –17.5%)
* Development cost and time have strong, measurable effects on profitability.
Control them strategically for value optimization.

Change in Development Cost, %	Development Cost, $ Thousands	Change in Development Cost, $ Thousands	Change in NVP, %	NPV, $ Thousands	Change in NPV, $ Thousands
50	7,500	2,500	–29.4	5,791	–2,412
20	6,000	1,000	–11.8	7,238	–964
10	5,500	500	–5.9	7,721	–482
base	5,000	base	0.0	8,203	0
–10	4,500	–500	5.9	8,685	482
–20	4,000	–1,000	11.8	9,167	964
–50	2,500	–2,500	29.4	10,615	2,412

2 – Perform Sensitivity Analysis Purpose

Sensitivity analysis reveals

The financial impact of project decisions
Which factors deserve the most attention
Helps align decisions with maximum value creation

- CI-700 Lessons:
- Reducing cost boosts NPV
- Delays lower NPV significantly

Change in Development Time, %	Development Time, Quarters	Change in Development Time, Quarters	Change in NVP, %	NPV, $ Thousands	Change in NPV, $ Thousands
50	6	2	–34.6	5,363	–2,840
25	5	1	–17.5	6,764	–1,439
base	4	base	–0.0	8,203	0
–25	3	–1	18.0	9,678	1,475
–10	2	–2	36.4	11,190	2,987

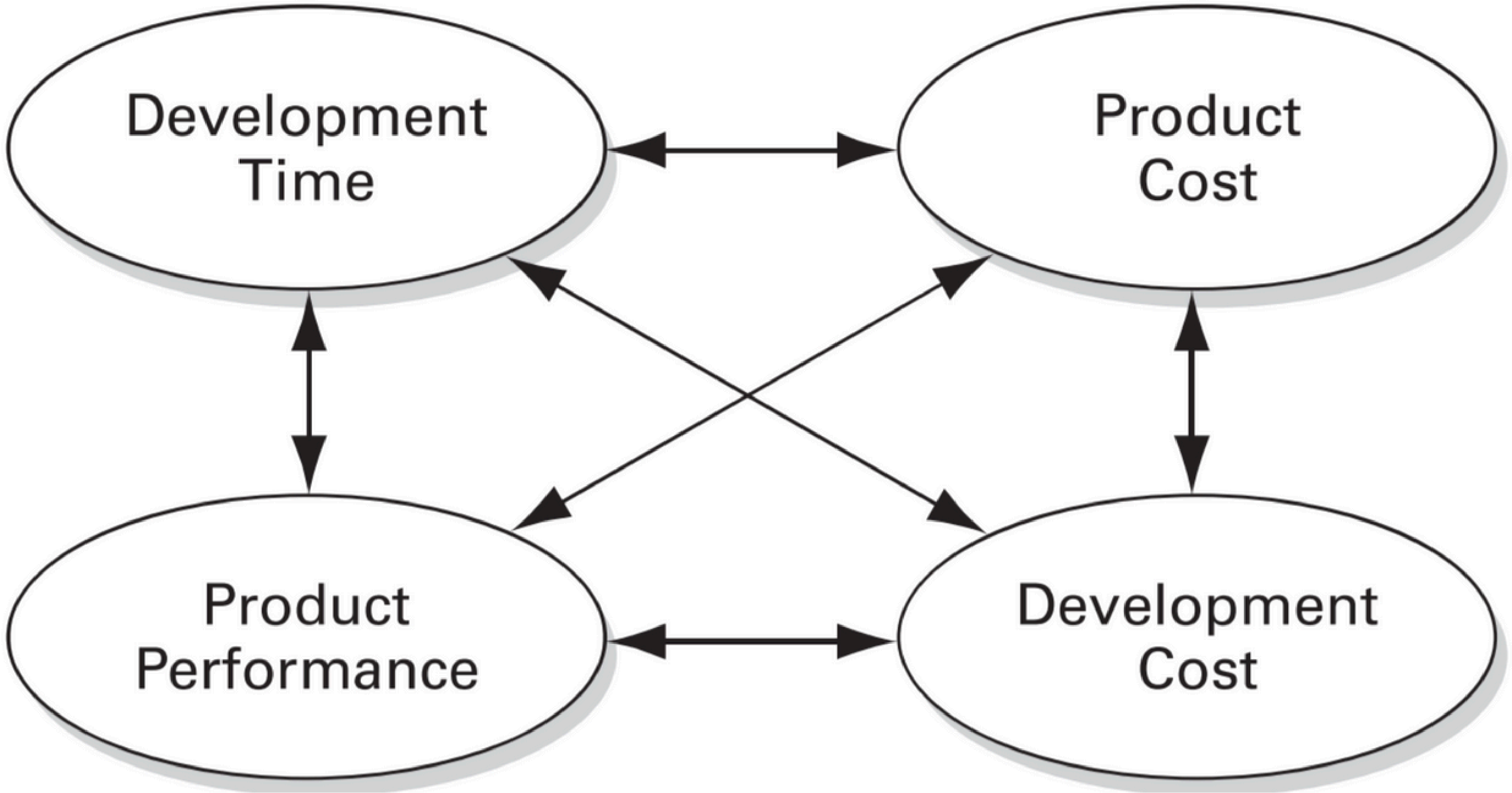
* Use sensitivity analysis to drive smarter, faster, and more profitable decisions.

3 – Understanding Project Trade-Offs Goal:

Use sensitivity analysis to explore how changes in key internal factors affect outcomes, helping guide strategic decisions.

Focus on Internally Driven Factors:

- Development Time
- Development Cost
- Product Cost
- Production Performance



These interactions help the team analyze the trade-offs between time, cost, and performance.

3 – Trade-Off Rules & Decision Making:

Trade-Off Rules simplify complex decisions by assigning a cost to each change in key variables.
Example Rule:

- What is the cost of a one-month delay in development time?

Key Benefit:

Helps the team balance speed, cost, and quality.
Supports daily decision-making with quantifiable logic.

- Think of trade-off rules as "if-then" financial tools to support real-time adjustments.

Factor	Trade-Off Rule	Comments
Development time	$480,000 per month change	Assumes a fixed window of opportunity for sales.
Sales volume	$1,724,000 per 10% change	Increasing sales is a powerful way to increase profits; 10% is 500 units/quarter.
Product cost or sales price	$43,000 per $1 change in cost or price	A $1 increase in price or a $1 decrease in cost; each result in a $1 increase in unit profit margins.
Development cost	$482,000 per 10% change	A dollar spent or saved on development is worth the present value of that dollar; 10% is $500,000.

3 – Limitations of Quantitative Analysis

Despite its strengths, quantitative analysis has important limitations:

1- Focuses Only on What's Measurable
- Ignores intangible assets (e.g., brand value, innovation potential)
- May discourage strategic investments

2- Heavily Depends on Assumptions
- Wrong assumptions = misleading NPV
- Precision does not equal accuracy

3- Can Increase Bureaucracy
- Excessive control/planning slows down real productivity
- Too much formal management may reduce creative problem-solving

4 – Qualitative Analysis for Project Success Purpose:

Evaluate the non-measurable but strategically critical factors that influence a project's success.
Explore Interactions Across Three Key Dimensions:

1. Project & the Firm

Does the project align with strategic goals?
Can it generate externalities (positive spillovers)?

2. Project & the Market

How will customers, competitors, and suppliers respond?
Will the project shift market dynamics?

3. Project & the Macro Environment

How could economic changes, government policy, or societal trends impact success?
Use qualitative analysis alongside financial models for well-rounded decision-making.

How Project Interacts

Project Interaction with the Firm: A Strategic Perspective
Why It Matters:
Projects don’t exist in a vacuum—they shape and are shaped by the firm’s goals, market forces, and the macro environment. Understanding these interactions is key to long-term success.

* Combine qualitative insights with financial models to fully evaluate project success in a dynamic environment.

1. Project & the Firm

- Strategic Fit: Does the project align with the company’s goals, resources, and unique strengths?
- Externalities: Can it create positive spillovers (e.g., shared knowledge, capabilities)?

2. Project & the Market

- Competitors: New entrants or product launches may alter timing or pricing strategies.
- Customers: Changing preferences and incomes influence product appeal.
- Suppliers: Their own market challenges affect your cost and input availability.

3. Project & the Macro Environment

- Economic Shifts: Exchange rates, labor, and material cost fluctuations.
- Regulations: Can enable or restrict whole product lines.
- Social Trends: Rising importance of sustainability, ethics, and values.

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4- Case study

TenAlpina Tools

Introduction – Company & Opportunity

- Founded by Giulia Ferrato, known for titanium pitons.
- Focus: Lightweight, durable, ergonomic mountaineering gear.
- Recognized by pros for quality and innovation.
- New expansion: Ergonomic wall hammer using titanium + padded handle.

Introduction – The New Product

- Giulia's climbing hammer features a unified structure, combining the titanium head shaft and handle into a single unit.

- The thinness of the handle posed a challenge, prompting Giulia to develop a padded handle solution.The padded handle enhances ergonomics and protects climbers' hands from shock during metal spike impact.

- Giulia's product has a comparative advantage over competitors due to the superior strength and lightweight nature of the titanium handle.(Unlike traditional wooden or fiberglass handles)

Introduction – A New Machine

- Acquisition Need: Giulia's factory lacks an injection molding machine to produce the wall hammer, necessitating a $35,000 investment for procurement and installation and has a lifespan of seven years ($5,000/year).
- Operational Considerations: The factory has enough space to house the machine once some of the existing equipment has been rearranged.
- Cost Analysis: Giulia estimated that each hammer will consume $10.44 for titanium alloy and plastic resin, $0.46 for energy per unit, and supplies cost at $0.14 per unit.

Introduction – Manufacturing Parameters

- Giulia and her production team discuss adding 350 hammers to the monthly production schedule.(4200/year)
- Analysis shows increased work effort per unit at each existing workstation due to the hammer's design.
- Current staff levels are insufficient due to reduced productive time caused by the existing workflow. (two more laborers)
- The installation of the new machine allows for workflow rearrangement by relocating existing equipment.
- The new setup includes six workstations: Roll/Cutting, Heat/Forging, Hole (Drilling), De-burr and Polish, Injection Molding, Packaging.

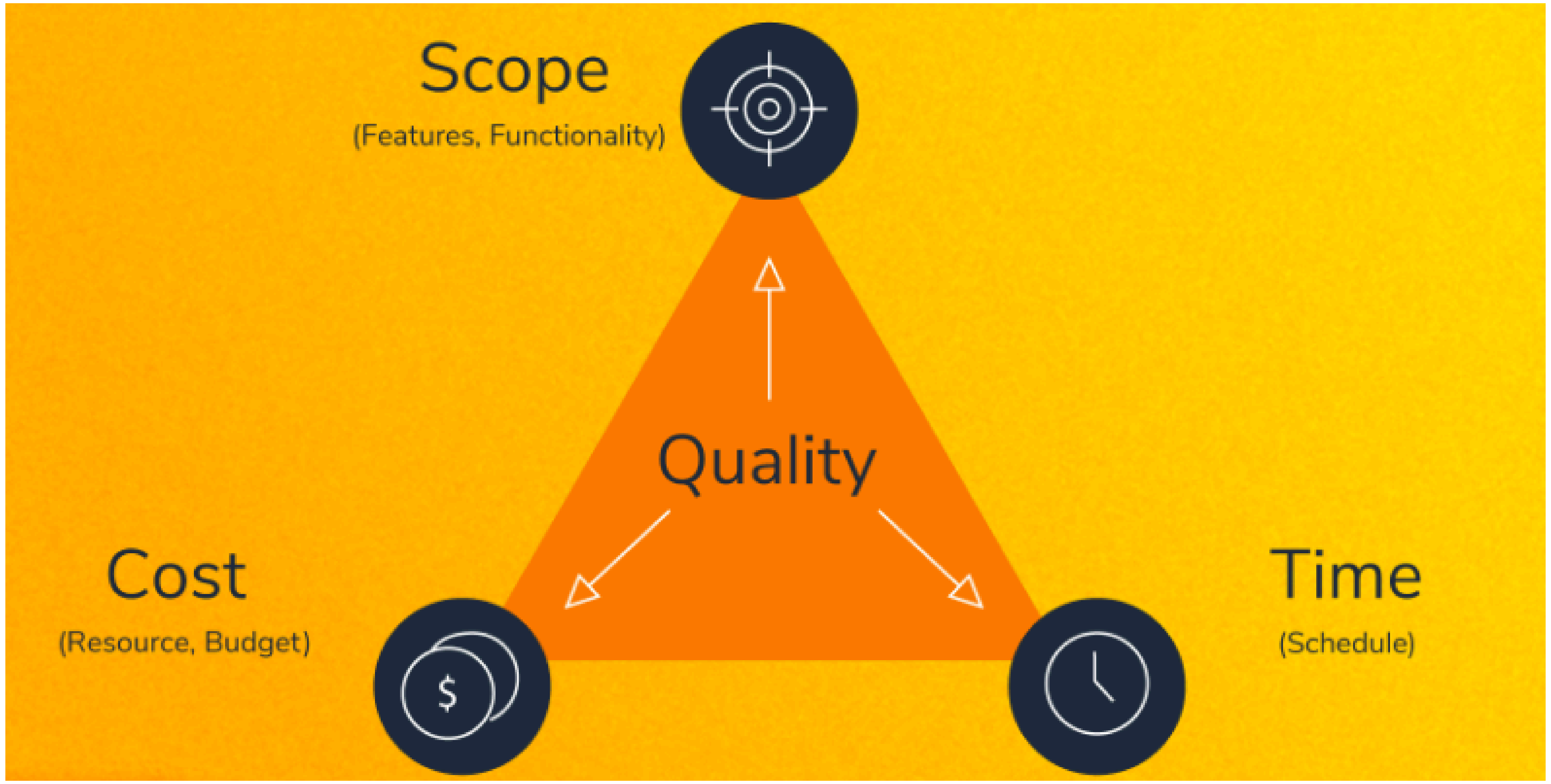
Introduction – Problem

1. How many hammers must we sell to maintain our current annual profit level?
2. What can we expect regarding the overall profit effect of adding the hammer to our product line??
3. Is the investment in the new injection molding machine justified?
4. What will be the gross margin on the new hammer?

Estimating P&D and S&A costs

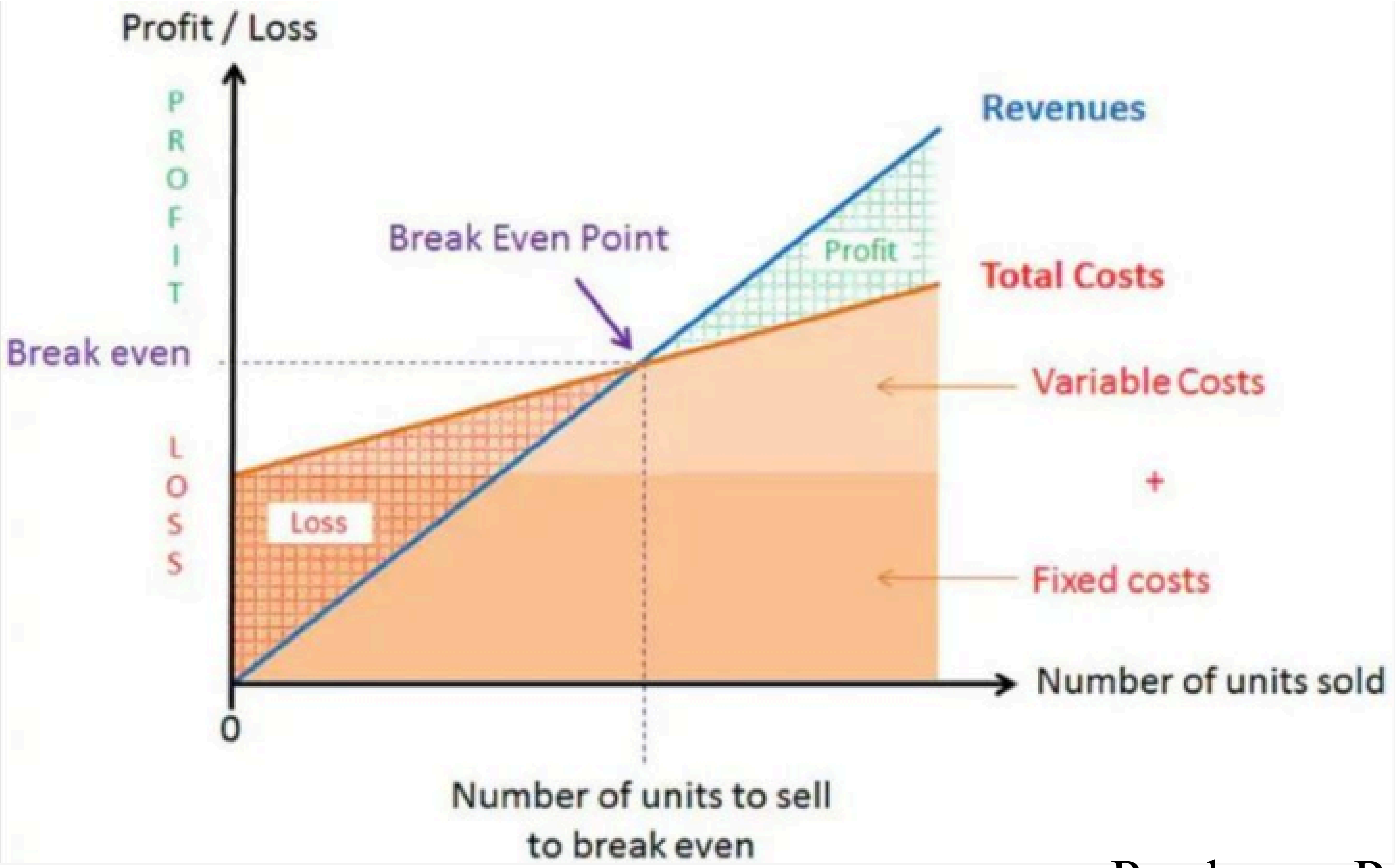
- the new product line: hammers.
- Giulia sets the retail target price at $94.00 and calculates the price for resellers and distributors at $61.00 by reversing her piton client's markup.
- After consulting rock climbing equipment dealers, she predicts a demand for the hammers.(350 units per month)
- Her current pitons customer refuses to cover shipping costs for the hammers ($1.00 per unit).
- Giulia decides to take a modest salary slightly higher (10%) than that of the factory workers, considering its impact on the company's earnings.

The Challenge – Production & Cost Constraints



- €35,000 injection molding machine required (7-year life).
- Workflow redesign needed for 6 workstations.
- Material, energy, and supplies: €12.04 per hammer.
- 2 additional workers required due to labor intensity.

Financial Analysis – Break-Even & Payback



- Distributor Price: €61 | Variable Cost: €12.04
- Contribution Margin: €48.96 per unit
- Break-even: ?
- Payback Period: ?

$$\text{Break even Point} = \frac{\text{Fixed Costs}}{\text{Selling Price - Variable Cost}}$$

Quantity of wall hammers TenAlpina Tools must sell to match the annual gross margin of selling

Category	Details / Values
Annual labor cost (per worker)	$57,500
Annual machine and tool depreciation	$14,355
Depreciation on injection molding machine	$5,000
Annual occupancy cost (building lease)	$33,000
Fixed lighting/heating cost	$20,736 (= $29,808 – 50,400×$0.18)
Annual demand for pitons	50,400 units
Monthly demand for hammers	4,200 units
Selling price per piton	$10.50
Direct material cost per piton	$1.45
Variable energy cost per piton	$0.18
Variable supplies cost per piton	$0.11
Direct material cost per hammer	$10.44
Variable energy cost per hammer	$0.46
Variable supplies cost per hammer	$0.14
Delivery cost per hammer	$1.00
Administrative costs	$7,200 ($600/month)
Administrative salary (incl. benefits)	$63,250 (10% higher than production staff)
Estimated fixed utility cost (new machine)	$864

quantity of wall hammers TenAlpina Tools must sell to match the annual gross margin of selling

Step 1: Gross Margin

- **Annual piton demand**: 50,400 units
- **Selling price per piton**: $10.50
- **Total variable cost per piton** = Direct Material ($1.45) + Energy ($0.18) + Supplies ($0.11) = **$1.74**
- **Contribution Margin per piton** = $10.50 – $1.74 = **$8.76**

$$\text{Total Gross Margin from pitons} = 50,400 \times 8.76 = \boxed{441,504}$$

Step 2: Contribution Margin per Hammer

- **Selling price per hammer**: $61.00 (from earlier slides)
- **Variable costs** = Material ($10.44) + Energy ($0.46) + Supplies ($0.14) + Delivery ($1.00) = **$12.04**
- **Contribution Margin per hammer**: $61 – $12.04 = **$48.96**

Step 3: Required Hammer Sales to Match Margin

$$\text{Required Units} = \frac{441,504}{48.96} \approx \boxed{9,018 \text{ hammers}}$$

Total Annual Aggregate Effect on Total Gross Margin

Total revenue generated from both pitons and hammers
Total gross margin= Revenue (Pitons + Hammers) - Total Costs
The Net income = The final profit after deducting all expenses from the gross margin

Revenue (Pitons + Hammers) = $785,400
Total Costs = $668,019
Gross Margin = $117,381
Gross Margin % = (117,381 / 785,400) × 100 ≈ 14.9%

Total Annual Aggregate Effect on Total Gross Margin

Category	Amount ($)
Revenue	785,400
Direct materials	116,928
Direct labor	460,000
Variable power	11,004
Supplies	6,132
Fixed power	21,600
Depreciation	19,355
Occupancy	33,000
Total Gross Margin	117,381 (14.9%)
Delivery costs	4,200
Admin costs	7,200
Admin salaries	63,250
Net income	42,731 (4.7%)

Strategic Benefits – Product Line Synergy

$$\text{MOS} = 1 - \left(\frac{\text{Break-even Sales}}{\text{Actual or Expected Sales}}\right)$$

Total Fixed Costs = €604,405

Contribution Margin Ratio = 82.4%

→ So,

$$\text{Break-even Revenue} = \frac{604,405}{0.824} \approx €733,539$$

Expected Sales Revenue = €785,400

- Combined gross margin improves factory utilization.
- Gross Margin: Pitons €0.15 → Combined €2.16
- Total Revenue (Pitons + Hammers): €785,400
- Margin of Safety: 6.6% – moderate buffer

Strategic Benefits – Cash Flow-Based Payback Period

Incremental Cash per Hammer Sold=$48.96
Depreciation on New Machine = $5,000
New Fixed Power Costs = $864
Total Fixed Costs (Including Depreciation)= 115,000+864+5,000=120,864
Units Required to Recover These Costs = 2,469
Monthly Demand and Payback Time=
(Monthly sales forecast = 350 hammers)

$$\frac{2,469}{350} \approx \boxed{7.04 \text{ months}}$$

Learning Objectives

Concept	Formula	Example (Hammer)	Definition
Contribution Margin	CM = Selling Price - Variable Cost	61 - 12.04 = $48.96	Revenue left after variable costs; used to cover fixed costs and generate profit.
Break-even Point (Units)	BE Units = Fixed Costs / CM	122,864 / 48.96 ≈ 2,469 units	Number of units to sell to cover all fixed costs (zero profit/loss point).
Break-even Revenue (Dollars)	BE Revenue = Fixed Costs / Contribution Margin Ratio	604,405 / 0.824 ≈ $733,539	Revenue level where total contribution margin equals fixed costs.
Margin of Safety	MOS = 1 - (Break-even Revenue / Total Revenue)	1 - (733,539 / 785,400) ≈ 6.6%	Percent buffer between actual sales and break-even sales.
Payback Units (Cash Flow-Based)	(Machine Cost + Fixed Costs) / CM	(35,000 + 115,864) / 48.96 ≈ 3,082 units	Units needed to recover actual cash outflows.
Payback Period (Cash Flow-Based)	Payback Units / Monthly Demand	3,082 / 350 ≈ 8.81 months	Time required to recover investment based on cash outflows.
Payback Units (Income-Based)	(Fixed Costs + Depreciation + Power Costs) / CM	(115,000 + 5,000 + 864) / 48.96 ≈ 2,469 units	Units needed to break even accounting for non-cash costs.
Payback Period (Income-Based)	Payback Units / Monthly Demand	2,469 / 350 ≈ 7.05 months	Time to break even from an accounting (net income) perspective.
Net Income Calculation	Net Income = Total Revenue - Total Costs	785,400 - 668,019 = 117,381	Final profit after subtracting all fixed and variable costs.

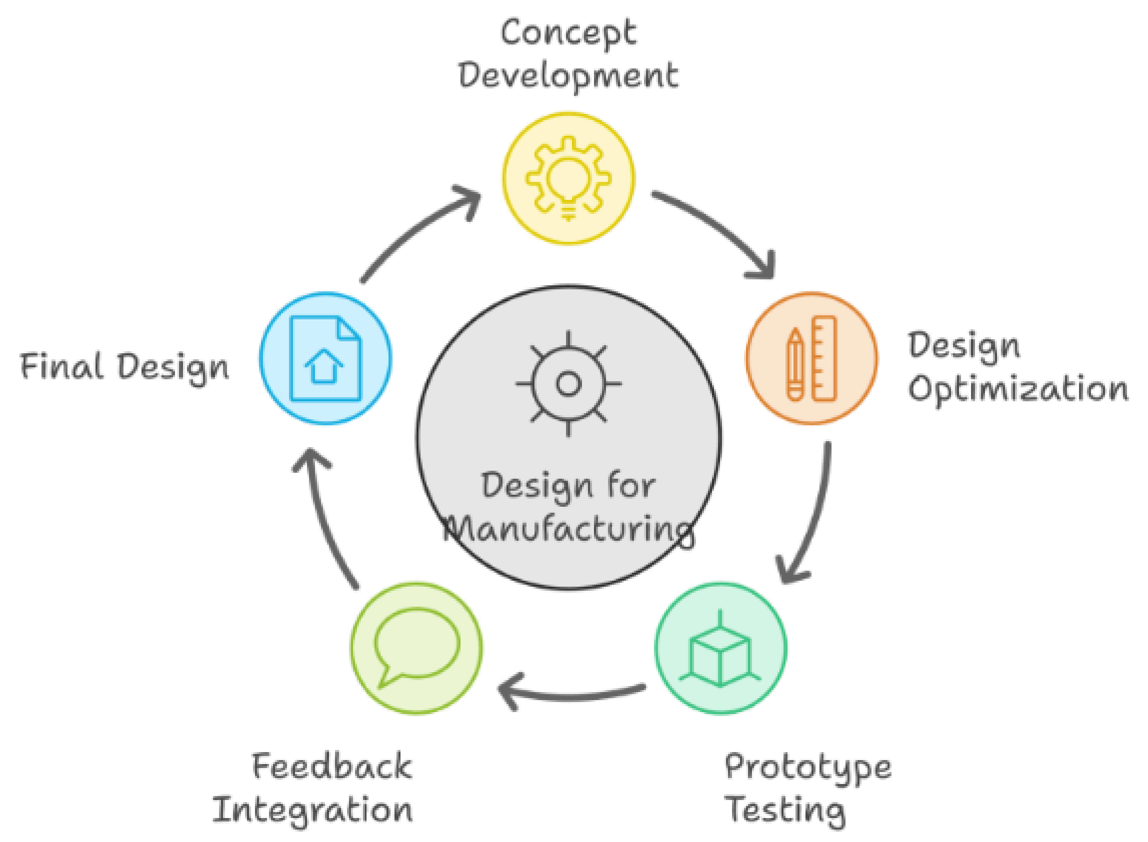
Learning Objectives

- Multi Product Breakeven Concept (Sales mix)
- Incremental Costing for Decision Making (Variable & fixed costs)
- Accounting Payback Period Analysis
- Cost Allocation Methods and Considerations (Directly traceable & Common cost)
- Resource Optimization and Cost Structure Analysis

Workflow Optimization via DFM

Design for Manufacturing (DFM)

- Reduced production support & assembly complexity
- Integrated titanium parts reduce steps & boost quality
- 6 Stations: Roll, Forge, Drill, Polish, Mold, Package
- DFM ensures ergonomic & cost-efficient production



Conclusion & Recommendations

- Wall hammer is financially and technically viable.
- Strong unit margin and brand alignment support launch.
- Risk is moderate with quick return on investment.
- Recommendation: Proceed with product launch.

5- Quize

QUIZ

References

1. Ulrich, K. T., & Eppinger, S. D. (2017). Product design and development (4th ed.). McGraw-Hill Higher Education.
2. Ulrich, K. T., & Pearson, S. (1998). Assessing the importance of design through product archaeology. Management Science, 44(3), 352–369. https://doi.org/10.1287/mnsc.44.3.352
3. Ulrich, K. T., & Eppinger, S. D. (2016). Product Design and Development (6th ed.). McGraw-Hill EducationAlmquist, E., & Wyner, G. (2001). Boost your marketing ROI with experimental design. Harvard Business Review, 79(9), 135–141.
4. Hertenstein, J. H., Platt, M. B., & Veryzer, R. W. (2005). The impact of industrial design effectiveness on corporate financial performance. Journal of Product Innovation Management, 22(1), 3–21.
5. Nanni, A. J., Jr., & Juras, P. E. (2015a). TenAlpina Tools: Product Line Expansion Case Study (BAB279 / MAY 2015). Babson College.
6. Nanni, A. J., Jr., & Juras, P. E. (2015b). TenAlpina Tools: Product Line Expansion Teaching Note (BAB275j-HAX 24, 5). Babson College.
7. Hahn, D. (2025). 37208-ENG - Laboratory Digital Innovation and Management (DIM.)-DIM Lab: Introduction to new product development and product strategy. University of Bergamo.

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THANK YOU.

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