Build4 Scale
U.S. Department of Energy

Design for Manufacturing, Assembly, and Reliability

Module 3A Market Feasibility

Motivation

Why is this module important?

- A basic understanding of how products are engineered, manufactured, and assembled can help entrepreneurs avoid critical mistakes early in the development process
- Many hardware startups excel at creating technically viable prototypes, but struggle with engineering challenges related to safety, cost-effectiveness, durability, and (most importantly) market viability

A Yale University management professor in response to student Fred Smith's paper proposing reliable overnight delivery service: "The concept is interesting and well-formed, but in order to earn better than a 'C', the idea must be feasible."
- Frederick W. Smith

Motivation

Common mistakes and misconceptions

- Designing a product that is too complex to manufacture or assemble at scale
- Introducing a product at too high of a price point due to high cost of production
- Poor understanding of product costs that leads to unsustainable margins
- Failing to obtain an intimate understanding of manufacturing cost and takt time in order to optimize scaling strategy
- Insufficient understanding of the market and customer expectations (e.g., needs, price points, and competition)

Module Outline

- Leaning objectives
- Market feasibility analysis
- Determining fixed versus variable costs for your company
- Calculating your cost of goods sold (COGS)
- Impact of design on costs
- Making decisions on cost models
- Achieving economies of scale

Learning Objectives

- LO1. What is COGS, how to calculate it, and what does it influence
- LO2. Basics of fixed and variable costs and how they change with volume
- LO3. How to achieve economies of scale

What This Module Addresses

- Market feasibility analysis
- Determining fixed versus variable costs for your company
- Calculating your COGS
- Impact of design on costs
- Making decisions on cost models
- Achieving economies of scale

Market Feasibility

Best practices

- Reduce complexity of product design before making critical investments in manufacturing
- Reduce product costs before launch, allowing for introduction of product at appropriate price point
- Accurately assess your product costs that lead to sustainable margins
- Obtain an intimate understanding of manufacturing cost and take time to optimize scaling strategy
- Obtain a deep understanding of the market and customer expectations (e.g., needs, price points and competition)

Market Feasibility Study

Basics

The topics that should be covered in a market feasibility study include the following:

- Industry and customer needs assessment
- Current market analysis
- Competitive landscape analysis
- Anticipated future market potential
- Potential buyers and sources of revenues
- Sales projections
- Opportunity versus risk assessment (portions covered in this module)
- Cost and margin analysis (the focus of this module)

Manufacturing Risk

Mitigate Financial Risk

Mitigate Timing Risk

Mitigate Quality Risk

Mitigate Technology Risk

Mitigate Labor Risk

Mitigate Price–Cost Risk

Mitigate Manufacturability Risk

Fixed And Variable Costs

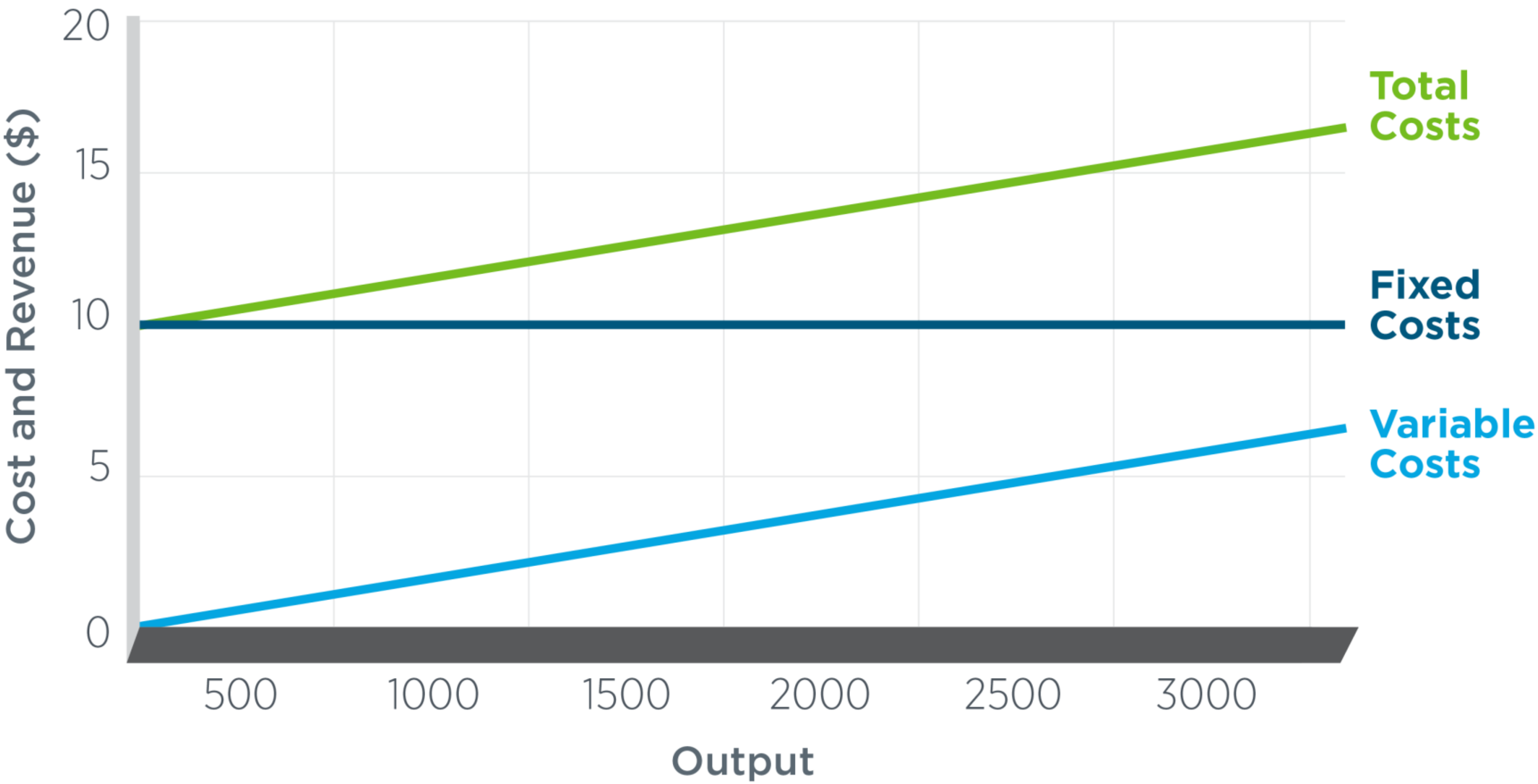
Basics

Businesses need to know their total costs:

- A **fixed cost (FC)** is a cost that does not change the level of output and needs to be paid independent of any business activity
- A **variable cost (VC)** varies with the level of output
- The **total cost** is the amount of money spent by a firm on producing a given level of output

Fixed And Variable Costs

Basics (cont.)

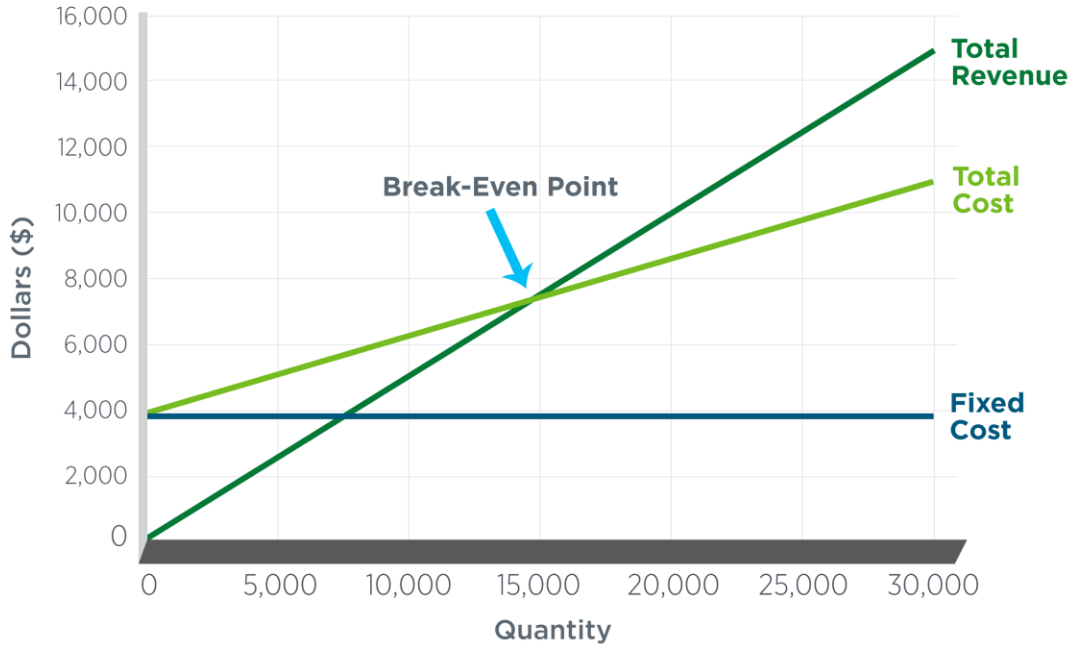


Fixed And Variable Costs

Break-even

- The **break-even point** (BEP) or **break-even level** represents the sales amount—in either unit (quantity) or revenue (sales) terms—that is required to cover total costs
- Total profit at the **break-even point** is zero

Note: by keeping your overhead (fixed cost) low you can achieve your breakeven point with much lower sales and begin to be profitable



Fixed And Variable Costs

Examples – Variable costs

Merchandising companies:

- COGS

Manufacturing companies:

- Direct materials, direct labor, and variable overhead

Merchandising and manufacturing companies:

- Shipping costs, commissions, and clerical costs (i.e., invoicing)

Service companies:

- Supplies, travel expenses, and clerical costs

Fixed And Variable Costs

Cost metrics

Important costs metrics:

- **Burn Rate** = R-C = Negative Monthly Cost Flow
- **Runway** = Cash Balance / Burn Rate
- **Cash-Out Date** = Today + Runway

	Examples	Insight
Fixed Costs (Don't change with volume)	Salaries, leases, insurance, utilities, housing, etc.	Fixed > variable costs for virtual goods and services
Variable Costs (Tied to volume)	Product materials and delivery costs, shipping, hosting usage, etc.	Calculate unit costs by dividing total variable costs by volume

Fixed And Variable Costs

Examples

Variable Costs	Semi-Variable Costs	Fixed Costs
Supplies Fuel Power Small tools Spoiled inventory Communication costs Overtime premium Royalties	Contractors and Consultants Production Equipment maintenance and repair Office cleaning and maintenance Power and Energy Health and accident insurance	Staff salaries Production facility Machinery and hard tooling Depreciation Rent Property tax Property insurance Patent amortization

Direct Versus Indirect Costs

Basics

- **Direct costs** are directly attributable to the product (The costs of materials, labor, equipment, etc., and all directly involved efforts or expenses for the product are direct costs)
- In manufacturing or other non-construction industries, the portion of operating costs that is directly assignable to a specific product or process is a direct cost
- Direct costs are for activities or services that benefit specific products

Examples: salaries for product staff, materials required for a particular product

Direct Versus Indirect Costs

Basics (cont.)

- **Indirect costs** are not directly attributable to the product (they are typically allocated to the product)
- In manufacturing, costs not directly assignable to the end product or process are indirect
- Indirect costs are for activities or services that benefit more than one product

  Examples: rent, management, insurance, taxes, or maintenance

Direct Versus Indirect Costs

Basics (cont.)

Costs usually charged directly:

- Product-development and manufacturing staff
- Consultants
- Product supplies
- Publications
- Travel associated with product development and manufacturing
- Labor
- Direct bill of materials (BOM)
- Electricity (only if it is the principal source)

Direct Versus Indirect Costs

Basics (cont.)

- An **allocated cost** is a type of expense that is clearly associated with, and therefore assigned to, a certain business process, project or department etc. It can be allocated in different ways such as percent of square feet, percent of hours usage etc.

Costs charged directly or allocated indirectly:

- Director's salary (usually an indirect cost)
- Electricity (if it needs allocation it is indirect)

Costs usually allocated indirectly:

- Electricity and other utilities
- Administration cost
- Selling and distribution cost
- Office expenses
- Travel associated with business development and company administration

Direct Versus Indirect Costs

How to calculate indirect costs and overhead

- Find your **overhead percentage**; an overhead percentage tells you how much of your business is spent on overhead and how much is spent making a product
- Overhead percentage: divide indirect costs by direct costs

Example: $16,800 / $48,000 = 0.35

- Multiply this number by 100 to get your overhead percentage

Example: 0.35 x 100 = 35 percent. This means that your business spends 35 percent of its money on legal fees, administrative staff, rent, etc. for every product it produces

- A low overhead rating is good! The lower your overhead rating, the larger your profit (Most manufacturing companies have relatively large overhead ratings)

Direct Versus Indirect Costs

Exercise – Identify existing operation costs

Module 2: Market Feasibility - Calculate Your Fixed vs. Variable Costs	Costs
Fixed Costs	
Product development and manufacturing staff	
Manufacturing/Assembly/Inventory facilities (rent or mortgage)	
Capital equipment and machinery	
Hard tooling	
Product testing, inspection, quality systems	
Asset depreciation	
Product supplies, packaging	
Operation maintenance and repair	
Operation management (e.g., lean mfg systems)	
Travel associated with product development and manufacturing	
Labor associated with product development and manufacturing	
Product bill of materials	
Electricity (only if electricity is the principal source for producing the product)	
Consultants/Contractors	
Property taxes	
Property and product insurance	
Patent amortization	
Total	

Direct Versus Indirect Costs

Exercise – Identify existing operation costs (cont.)

Module 2: Market Feasibility - Workshop Exercise: Calculate Your Fixed vs. Variable Costs	**Costs**
Variable Costs	
Electricity (only if electricity is NOT the principal source for producing the product)	
Soft or disposable tooling	
Product scrap and waste removal	
Overtime premium	
Administration staff labor cost	
Selling and distribution cost	
Office space cost	
Office supplies	
Travel associated with business development and company administration	
Directors Salary (if not directly contributing to product)	
R&D (if general or associated with multiple products)	
Marketing and Communications expenses	
Technology/Product royalties or licensing fees	
Total	

Cost Of Goods Sold

Key questions

- What is my current and expected (i.e., future) cost of goods sold (COGS)?
- How do I account for everything associated with my COGS?
- What is the best method to estimate my existing hardware cost?
- What is the design and engineering validation cost for each component?
- What are my non-recurring expenses (NRE) associated with the BOM now versus product at scale?
- How do my business model/operations decisions impact costs and margins?
- What is the impact of product design changes on costs and margins?

Cost Of Goods Sold

Calculating your COGS

Beginning finished goods inventory + **Cost of goods manufactured** = **Finished goods available for sale** − **Ending finished goods inventory** = **COGS**

The formula can be rearranged to read as follows:

Cost of goods manufactured +/- the change in finished goods inventory = COGS

- If the finished goods available for sale (i.e., inventory) decreased, then the amount of this decrease is added to the cost of goods manufactured (If the finished goods inventory increased, then the amount of this increase is deducted from the cost of goods manufactured)

Cost Of Goods Manufactured

Schedule

- Direct materials
  - Raw materials inventory, beginning
  - *Add: Raw materials purchased*
  - Raw materials available for use
  - *Deduct: Raw materials inventory, ending*
  - Total: Raw materials used
- Direct labor
- Manufacturing overhead
  - Indirect material
  - Add: Indirect labor
  - Add: Rental of factory building
  - Add: Depreciation of factory equipment
  - Add: Utilities
  - Add: Property taxes
  - *Add: Insurance*
  - Total Manufacturing overhead
  - *Deduct: Under-applied overhead*
  - Total: Overhead applied to work in process

- Direct materials
  - Add: Direct labor
  - *Add: Manufacturing overhead*
- Total: Manufacturing costs incurred
  - Add: Work in process, beginning of period
- Manufacturing costs to be accounted for
  - *Deduct: Work in process, end of period*
- Cost of goods manufactured

Transferred to Schedule of COGS

Cost Of Goods Manufactured/Sold

Example – Calculation

Toll Brothers Inc. Cost of Goods Manufactured and Sold Report	
Beginning raw materials inventory	0
(+) Raw materials purchased	+150,000
(-) Indirect materials used	-10,000
(-) Ending raw materials inventory	0
Direct materials used in production	**140,000**
Direct Labor	**50,000**
Manufacturing overhead applied	**60,000**
Total current manufacturing costs	**250,000**
(+) Beginning work-in-process inventory	+0
(-) Ending work-in-process (Job #3335)	-75,000
Cost of goods manufactured (Job #2719)	**175,000**
(+) Beginning finished-goods inventory	+0
(-) Ending finished-goods inventory	-0
Unadjusted cost of goods sold	**175,000**
Adjustment for under-applied manufacturing overhead	**+3,000**
Cost of Goods Sold	**178,000**

Cost Of Goods Sold

Exercise - Calculation

Product Manufacturer Cost of Good Sold Calculator	$
Beginning Raw Materials Inventory	$
(+) Raw Material Purchased	$
(-) Indirect Materials Used	$
(-) Ending Raw Materials Inventory	$
Direct Materials Used in Production	$
Direct Labor	$
Manufacturing Overhead (applied)	$
Total Current Manufacturing Cost	$
(+) Beginning Work in Process Inventory	$
(-) Ending Work in Process	$
Cost of Goods Manufactured	$
(+) Beginning Finished Goods Inventory	$
(-) Ending Finished Goods Inventory	$
Unadjusted Cost of Goods Sold	$
Adjustments for Underapplied Manufacturing Overhead	$
Cost of Goods Sold	$

Impact Of Design On Costs

Common mistakes

- A never-ending cycle of design changes
- Responding to a customer design change request without considering the cost of making that change
- Making design changes without considering impact to manufacturing process and costs

Impact Of Design On Costs

Best practices

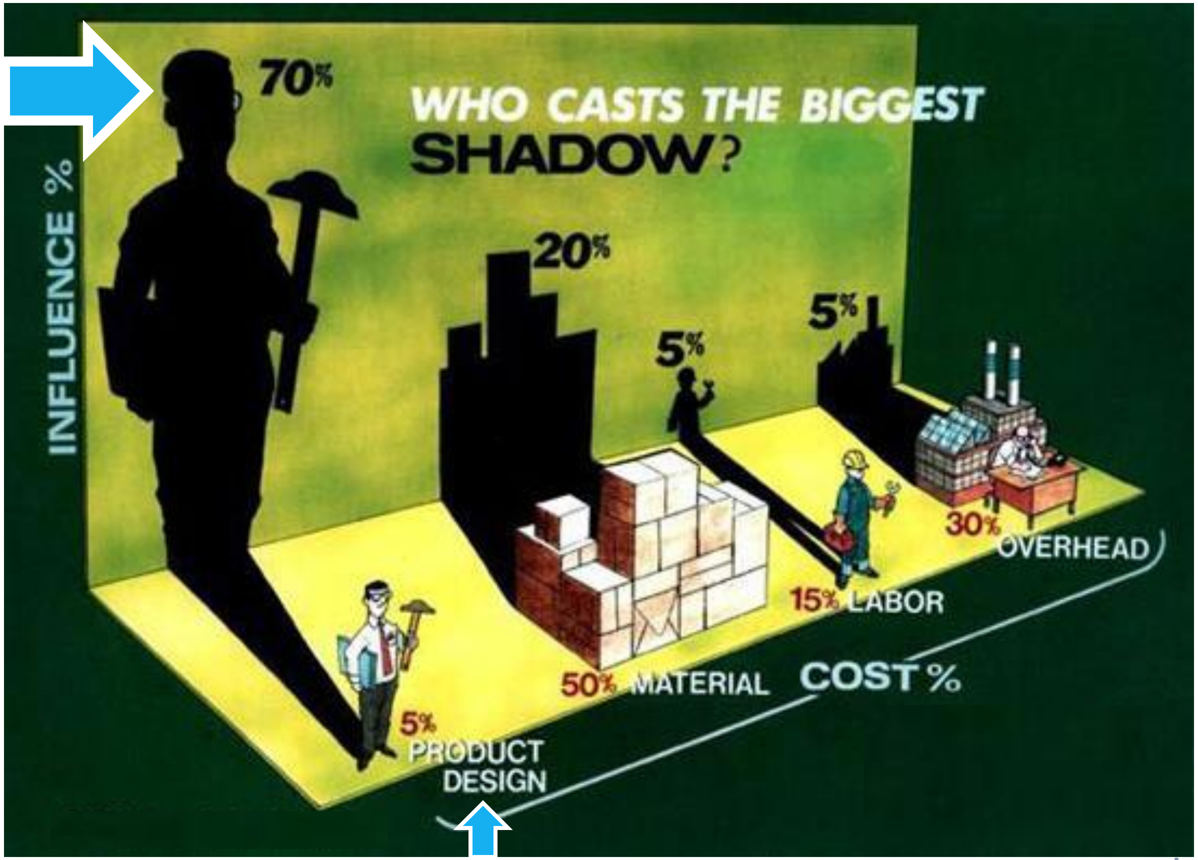
- Early on in the product-development timeline, establish design-freeze dates
- Establish cost targets for your product at system and component levels
- Track design changes to determine manufacturing process adjustments

Determine if design changes:

- Require use of different materials
- Require investment in new tooling
- Require different capital equipment
- Impact the assembly process

Impact Of Design On Cost

*Decisions made during the **design process** have significant effects on the success (or failure) of your product*



Source: Copyright 1989 Monroe & Associates, Inc.

Non-/Recurring Costs

Basics

- **Recurring costs** are known as "revenue expenses" that your company needs to incur on a regular basis; for example, raw material expenses, and labor expenses
- **Non-recurring expenses** are known as "capital expenses" that are not incurred on a regular basis—Once incurred, they provide long-term benefits

Example: purchase of land, building, and machinery

Non-Recurring Engineering

Budgeting and design expenses

- **Non-recurring engineering** (NRE) expenses refer to the one-time cost to research, design, develop and test a new product
- When budgeting for a new product, NRE must be considered to determine if a new product will be profitable
- Even though a company will pay for NRE on a project only once, NRE costs can be prohibitively high and the product will need to sell well enough to produce a return on the initial investment
- NRE is unlike recurring engineering production costs, which must be paid constantly to maintain production of a product. It is a form of fixed cost in economics terms. Once a system is designed, any number of units can be manufactured without increasing NRE cost.

Note: NRE can become costly if several generations of product development are needed before a product can be viable for market

Cost Models

Decision impacts

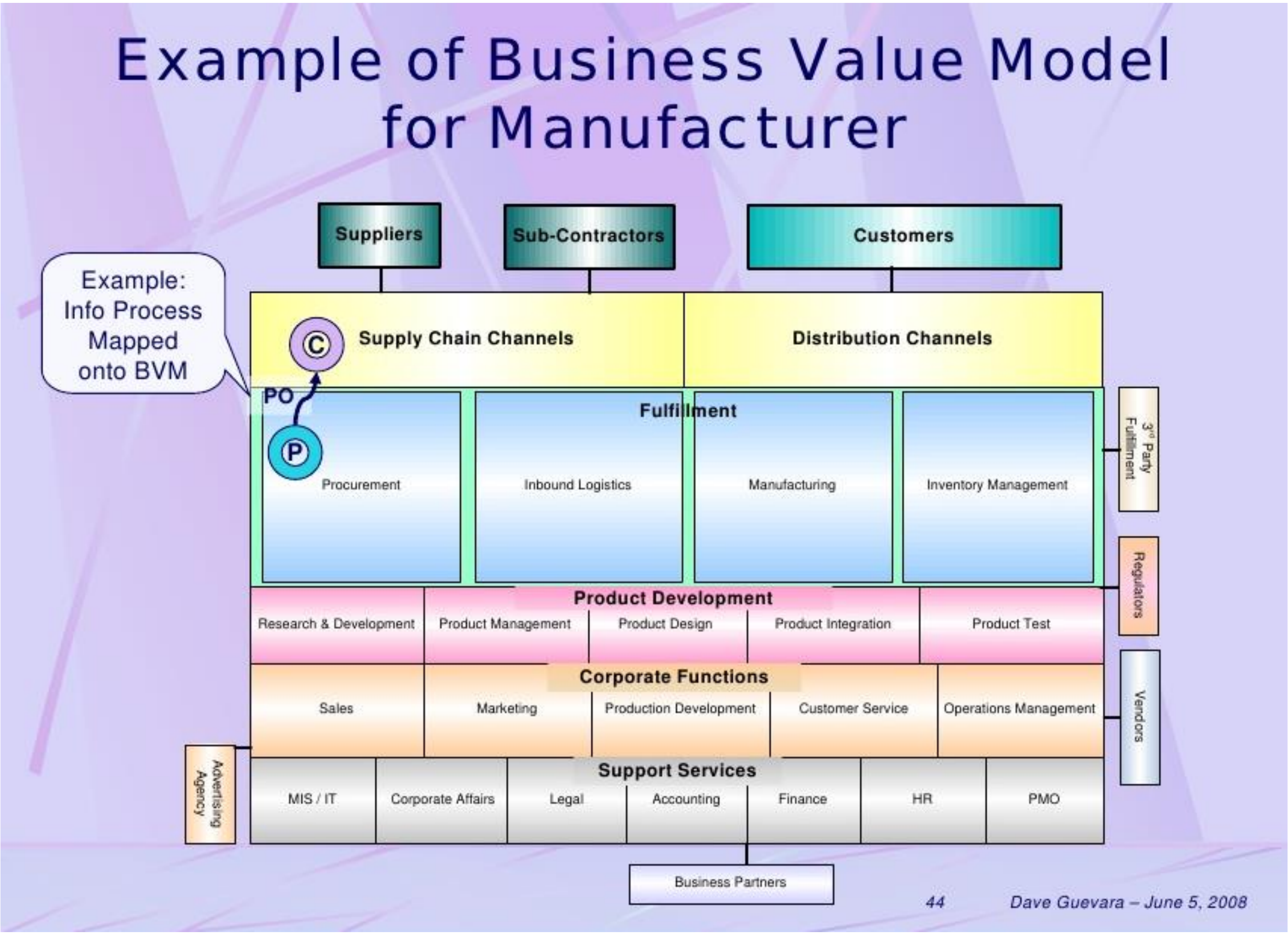
For "manufactured" products in mature industries, the cost of implementation and scaling can often be a deal breaker

Reality check:

- ☐ Can I deliver my product for a sustainable price?
- ☐ Will the costs and risks of implementation at scale eliminate my ability to achieve profit margins?
- ☐ Do I change my manufacturing strategy and business model to reduce operational risk?
- ☐ How do my "business operations model" decisions impact my cost model?

Manufacturer Value Model

Example – It's complex



Cost Model Options

Decision Impacts

Business Model Decisions Impact Cost Models			
Facilities/Equipment	Buy/Build/Install	vs.	Contract Manufacturing
Product	Manufacture	vs.	License
R&D	In-house	vs.	Outsourced Design/Engineering
Operations	Fixed (economies of scale)	vs.	Variable Operational Costs
Sales Channels	Direct Sales	vs.	Distributors/Reps
Customer Relationships	Direct Customer Relationship Management	vs.	Distributors/Reps
Headcount	Salaried Employees	vs.	Contract Employees
IP	US/Global Patent	vs.	Proprietary Trade Secrets

Manufacturing Decisions

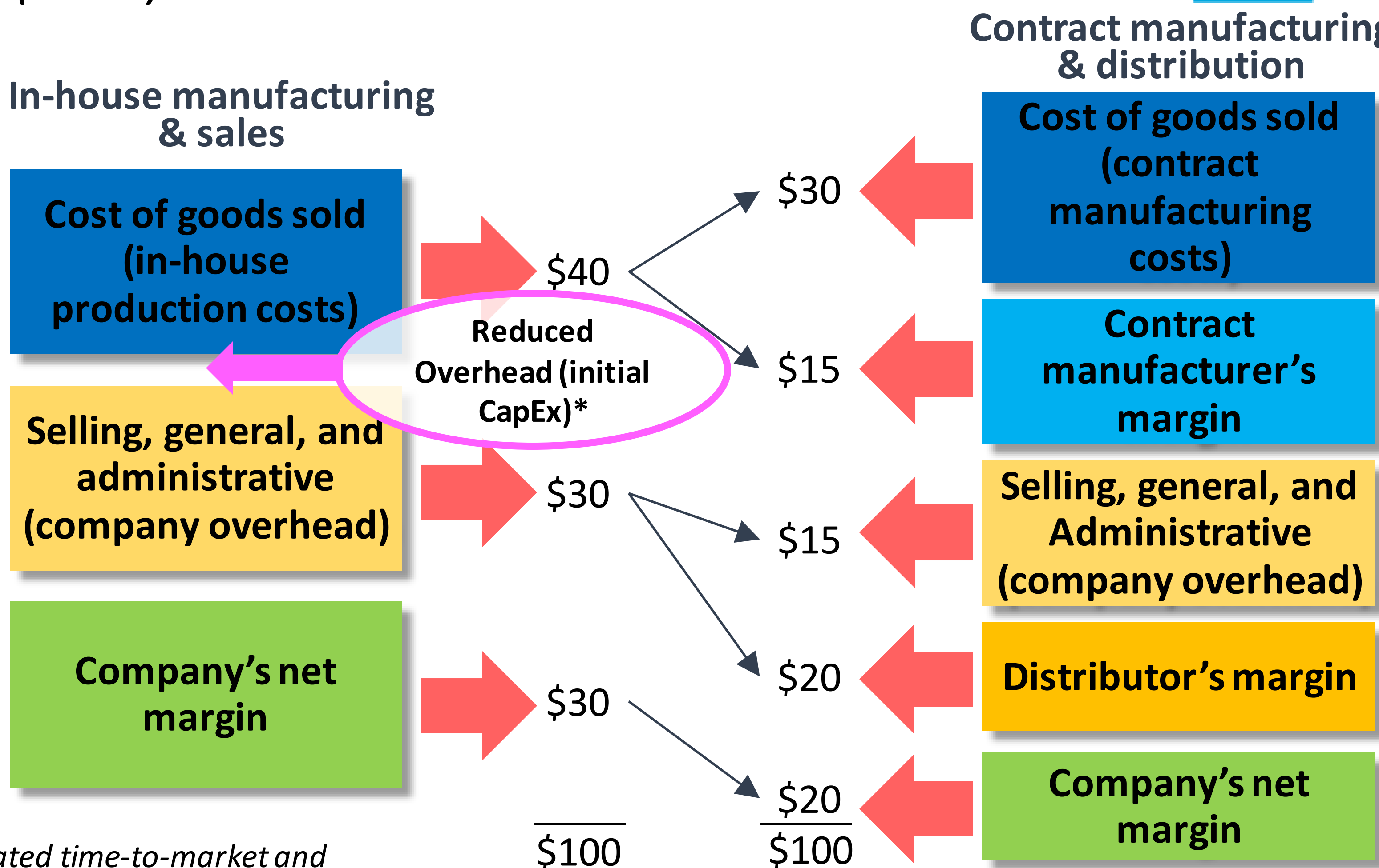
Captive versus outsource impacts on margins

In-house manufacturing & sales

Cost of goods sold (in-house production costs)	$40
Selling, general, and administrative (company overhead)	$30
Company's net margin	$30
	$100

Manufacturing Decisions

Captive versus outsource impacts on margins (cont.)

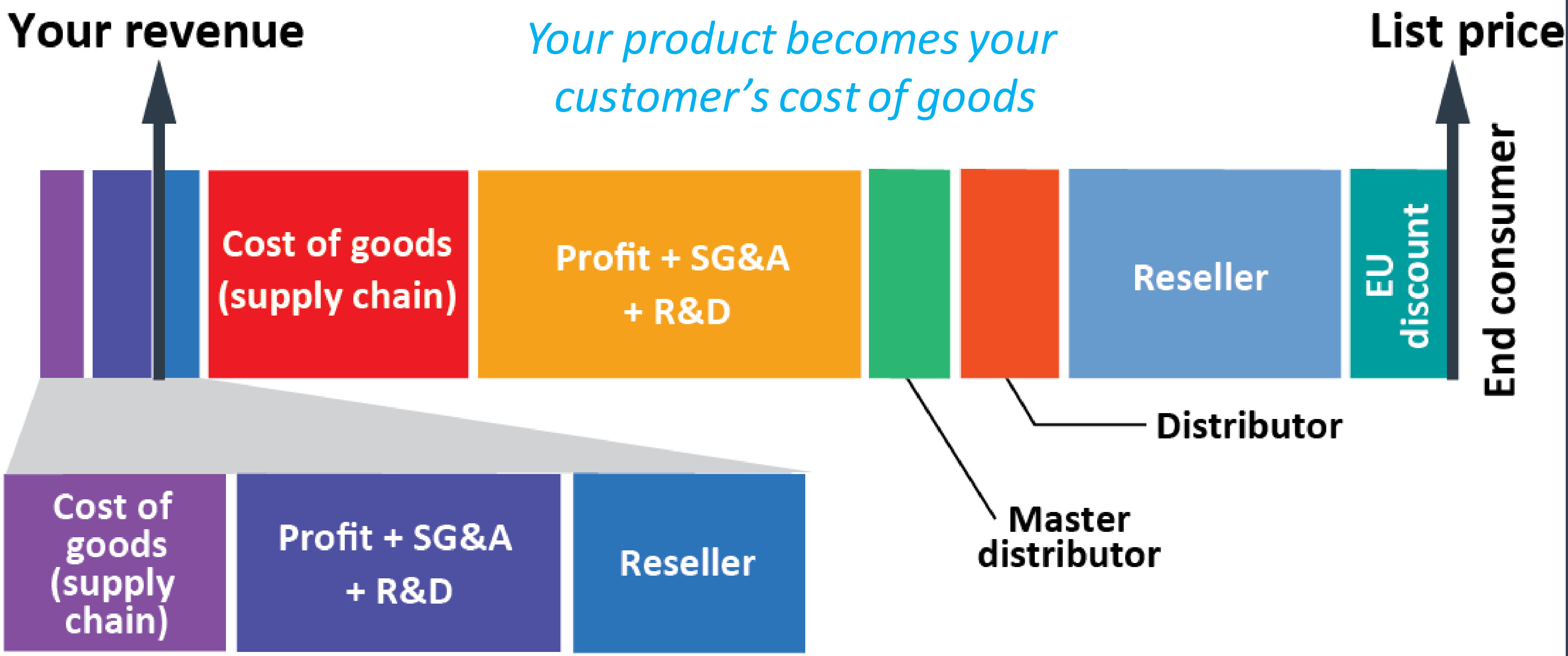


**Related time-to-market and cash-flow considerations*

Business Model Impacts

Cost and margins

- Physical product channel economics: original equipment manufacturer (OEM) or IP licensing?



* SG&A = Selling, General and Administrative Expenses

Business Model Impacts

Go to market options

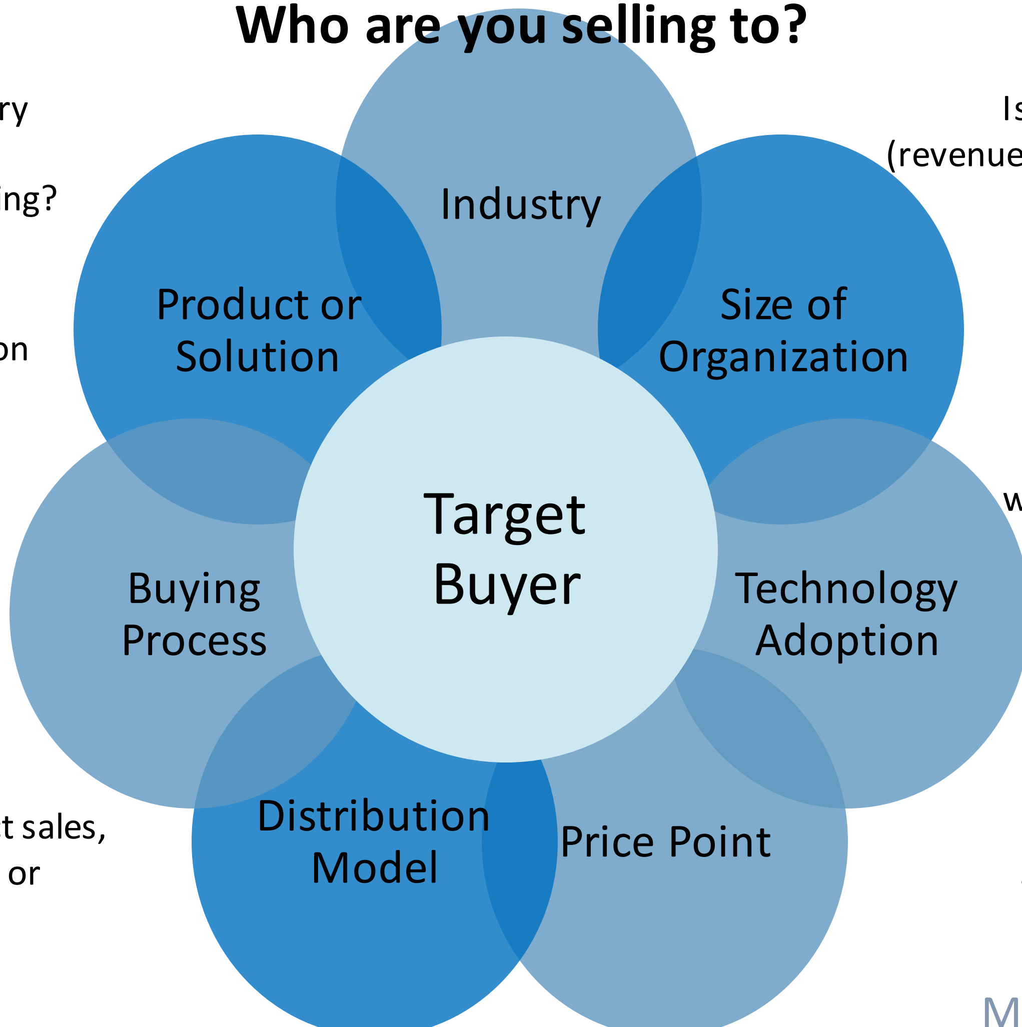
Who are you selling to?

Is there a specific industry or industries that are best suited for the offering?

Is this a complete solution or a point product?

Is this a complex sale that involved an approver, decision maker, recommender and influencer?

Will this be sold by direct sales, inside sales, online sales or indirect channels?



Is there a specific size (revenue, assets, employees) of organization that is being targeted?

Is this a new market where the focus is on early adopters or a mature market?

What is the average selling price and the average sales cycle?

Source: Adapted from www.fourquadrant.com

Business Model Impacts

Example – Market segmentation

TRANSPORTATION

Passenger vehicles
- Compact
- Sedan
- SUV/vans
- Trucks

Commercial vehicles
- Light duty
- Medium duty
- Heavy duty

Military ground vehicles
- Tactical
- Non-tactical
- UGV's

Off Road Vehicles
- Agriculture
- Construction
- Sport (golf carts)
- Racing

2–3 Wheel Vehicles
- Bicycles
- Motorcycles, ATV's
- E-Bikes
- Community/ neighborhood
- Trailers

Aerospace
- Commercial
- Cargo/Shipping
- Air Force
- UAV's
- Space travel

Marine
- Yachts
- Cargo/Shipping
- Naval

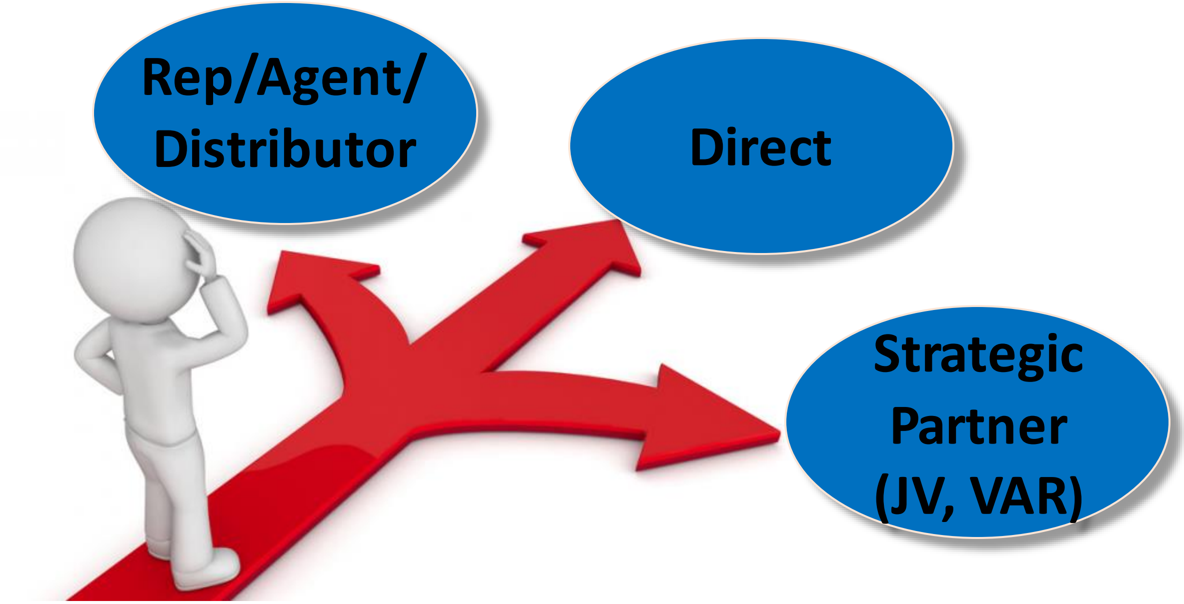
Rail
- Commuter Light
- Cargo /Shipping
- High Speed

Business Model Impacts

Pathway to customers?

Considerations in determining pathway to secure customers:

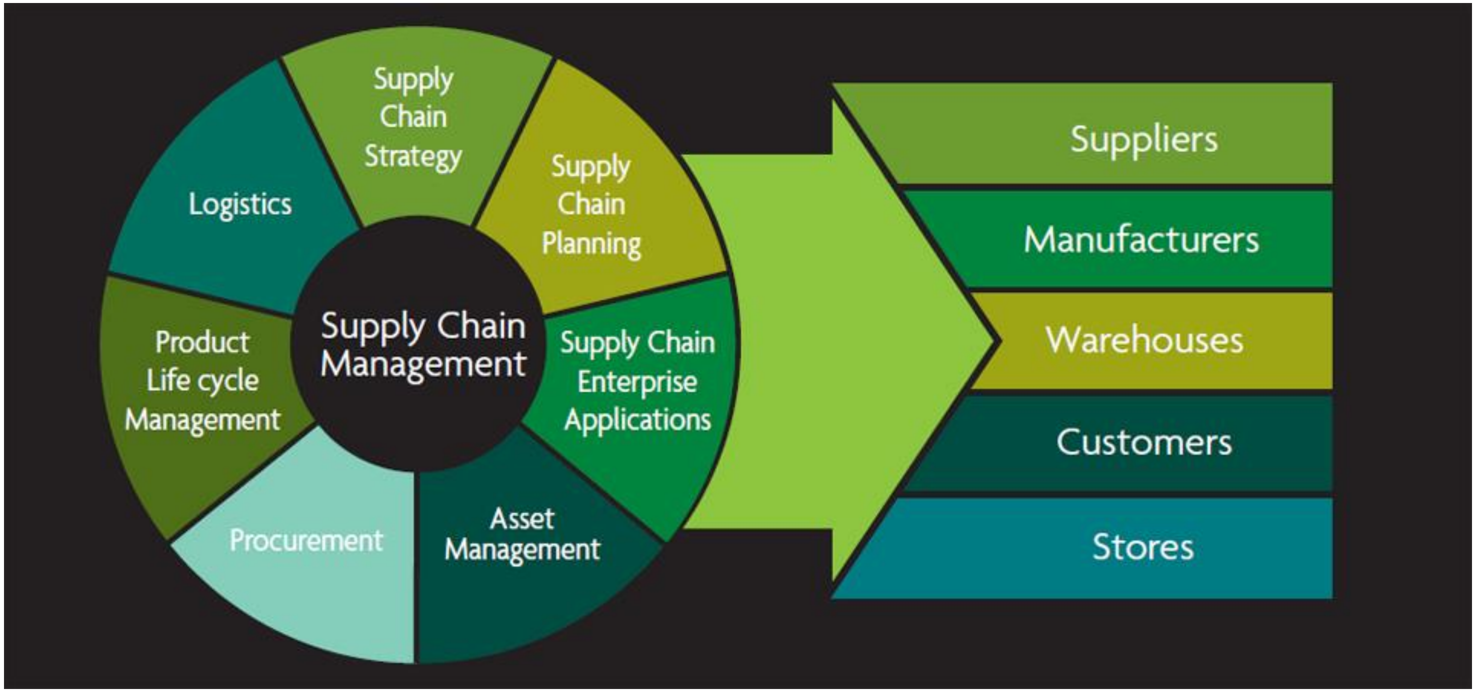
- Customer Acquisition Cost
- Time to Secure Customer
- Customer Maintenance Cost



Business Model Impacts

Product to customer pathway options?

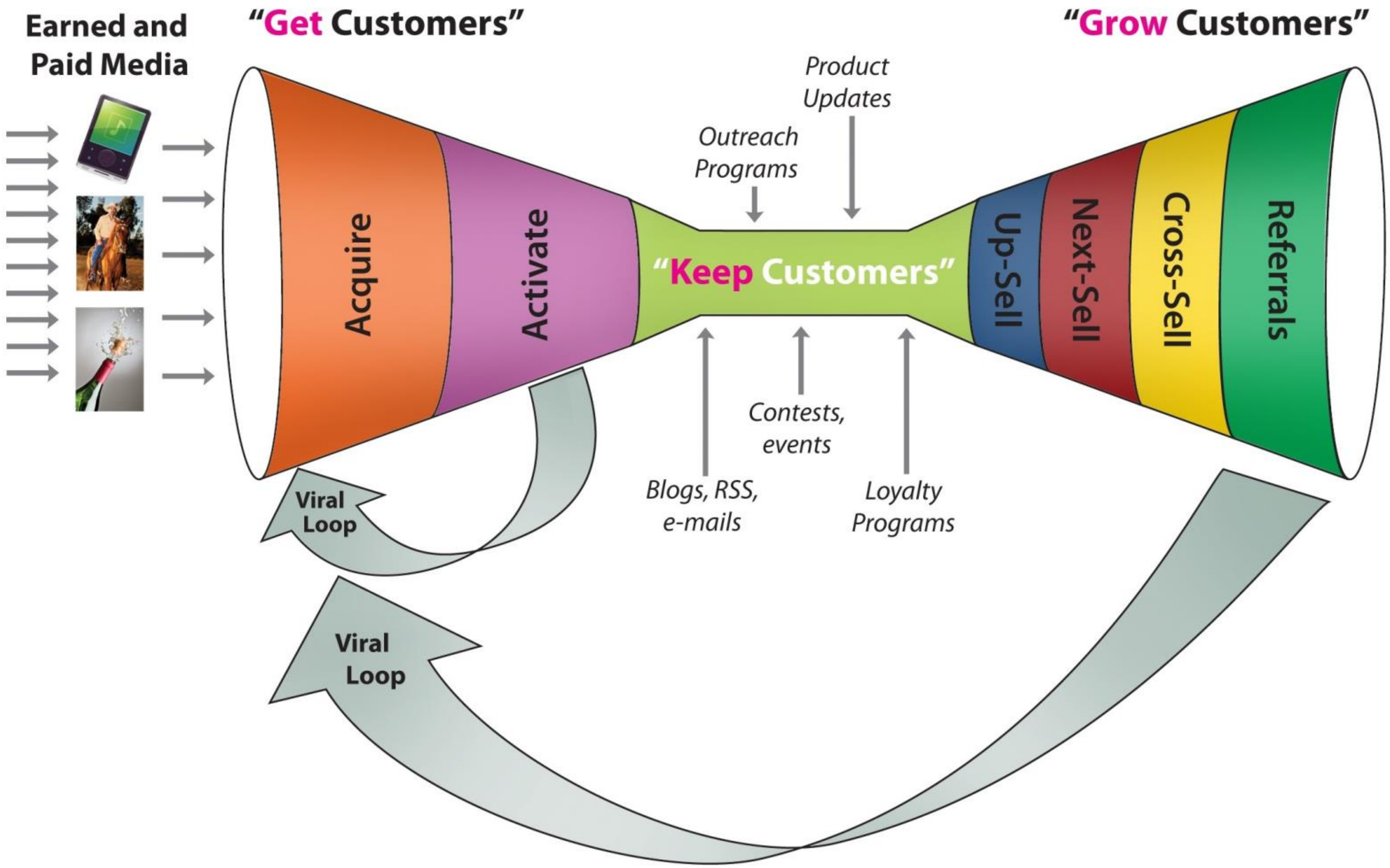
- What is the wait time for customer to access your product?
- Who inventories your product?
- What is the cost to inventory your product?



Source: www.thepackaginghub.eu

Business Model Impact

Customer growth plan



Source: The Startup Owners Manual

Cost Versus Price And Margins

Economies of scale

Economies of scale:

- ☐ How do I achieve economies of scale?
- ☐ How do fixed and variable costs change based on product volume?
- ☐ What is my “should cost”?
- ☐ How do I benchmark my competitors and their cost?
- ☐ How do I evaluate my value proposition in the value chain?
- ☐ What is my current product-manufacturing work flow?
- ☐ How is my work flow impacted as I begin to scale?
- ☐ How to develop a “Pro forma” based on production work flow

Economies Of Scale

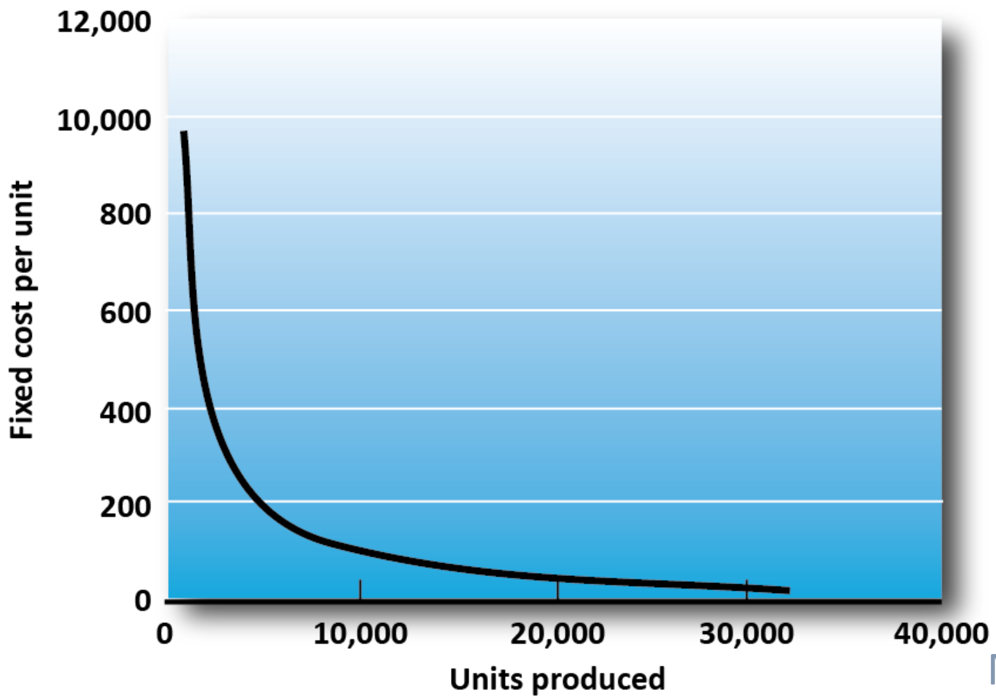
Basics

- Increase product volume
- Reduce fixed cost of product
- Reduce variability and options in product
- Map your manufacturing work flow process and develop ways to streamline operations
- Intimately understand your investment in terms of both manufacturing cost and takt time in order to optimize the scaling strategy

Economies Of Scale

Enabling margins

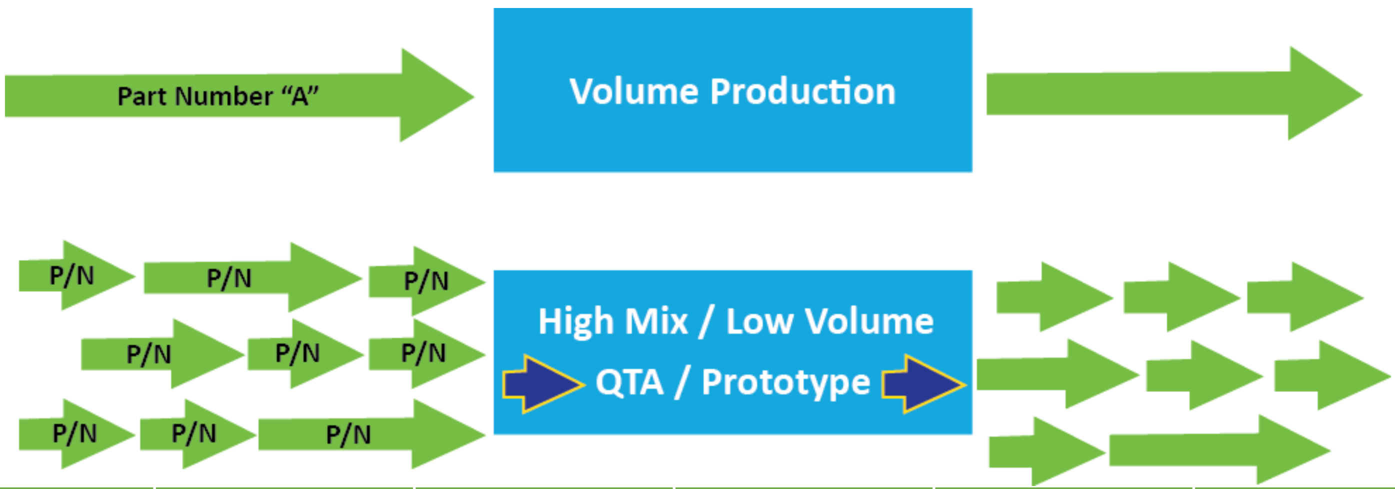
- **Common misconception**: *"It's all about volume"*
- Yes it is, in part, but greater margins are also realized by a concerted effort to reduce fixed costs over time by learning to improve product manufacturing!



Economies Of Scale

Reduce variability and options in the product

Manufacturing models



Model	Capital utilization	Setups and changeovers	Human capital required	Tooling capacity	Focus
Volume	High	Low	Low	Low	Materials Cost
High Mix	Medium	High	High	Medium	Fixed-Cost Absorption
QTA	Low	High	High	High	On-Time Delivery

Economies Of Scale

Where to start?

Common mistake: Most companies leap into volume production with expensive capital equipment and tooling before conducting a thorough analysis of reducing their fixed product cost

- ☐ Begin by determining your current product cost
- ☐ Benchmark your competition
- ☐ Set a cost target for your product and individual components
- ☐ Identify your "Should cost" by engaging your own team and external experts to rethink the design of your product

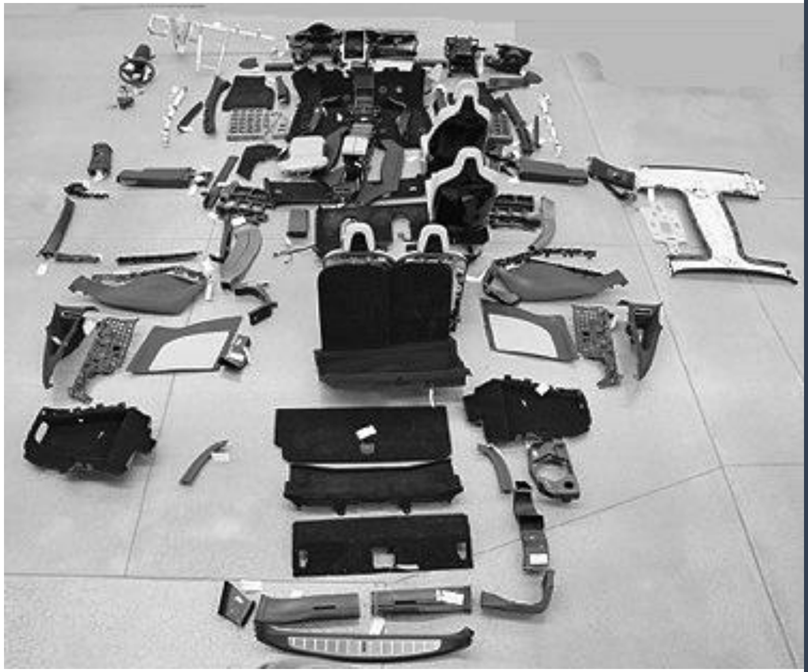
Benchmarking

Basics

- Buy a unit of your competitor’s product
- Disassemble the product
- Estimate its cost

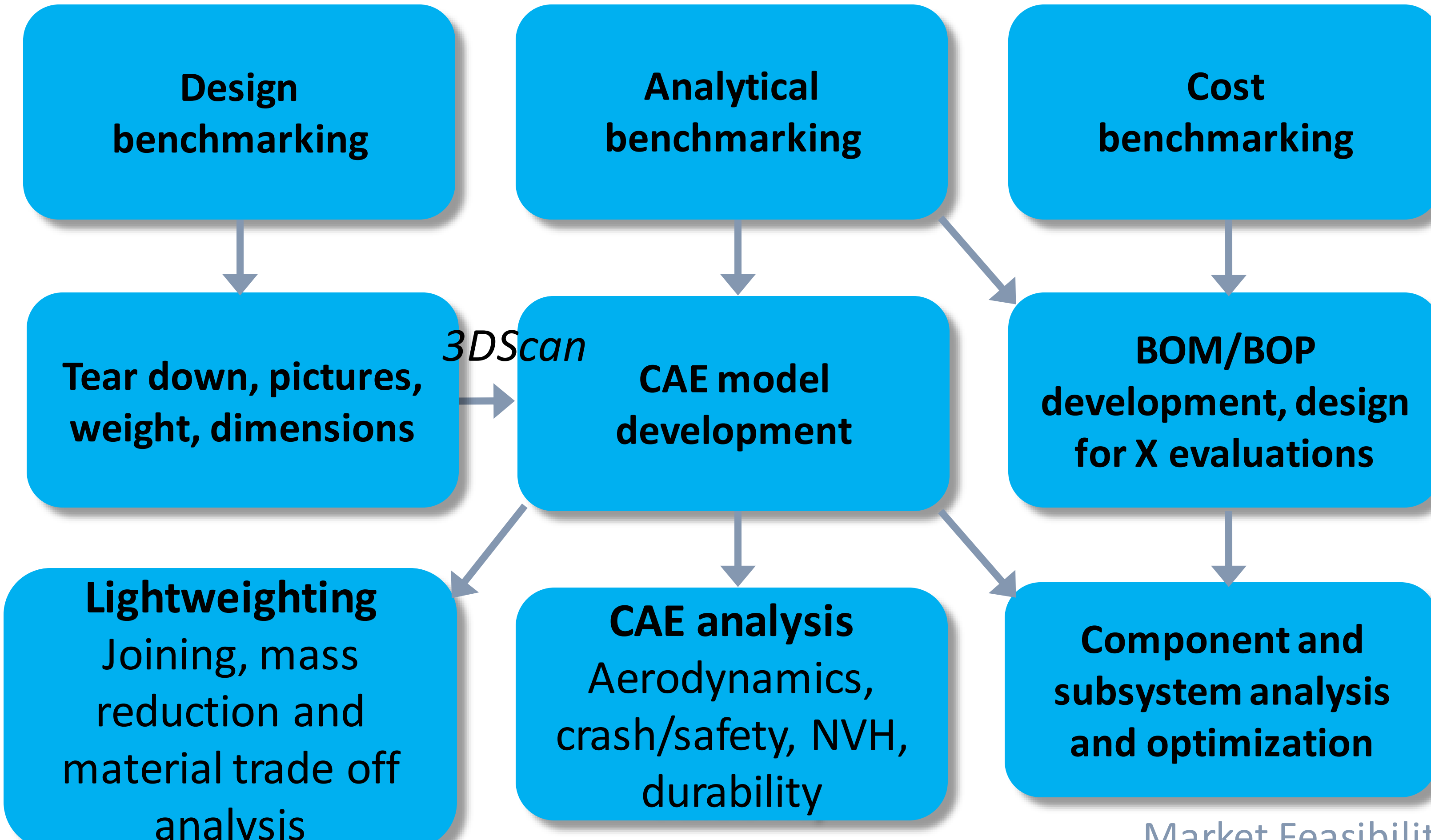
Evaluate how it was designed for:

- Manufacturability and assembly
- Cost
- Performance
- Durability and lifecycle
- Maintenance and serviceability
- Packaging



Design/Analytical Benchmarking

Example - automotive



Economies Of Scale

What should it cost?

Identify the "should cost" by engaging your own team and external experts to rethink the design of your product:

- ☐ Can you remove cost? Or replace expensive materials?
- ☐ Can you adopt cheaper manufacturing processes?
- ☐ Can you reduce expensive tooling?
- ☐ Can you reduce part count?
- ☐ Can you reduce assembly steps?
- ☐ Can you lean the manufacturing process to reduce time, waste, etc.?
- ☐ Can you reduce manufacturing stations by employing flexible work cells?
- ☐ Can you streamline testing (e.g., in-line)?

Should Cost

Case study 1 – Vehicle battery-pack tray

- The initial vehicle battery tray consisted of three separate metal parts with a number of individual fasteners (J-nuts, weld nuts and bolts)

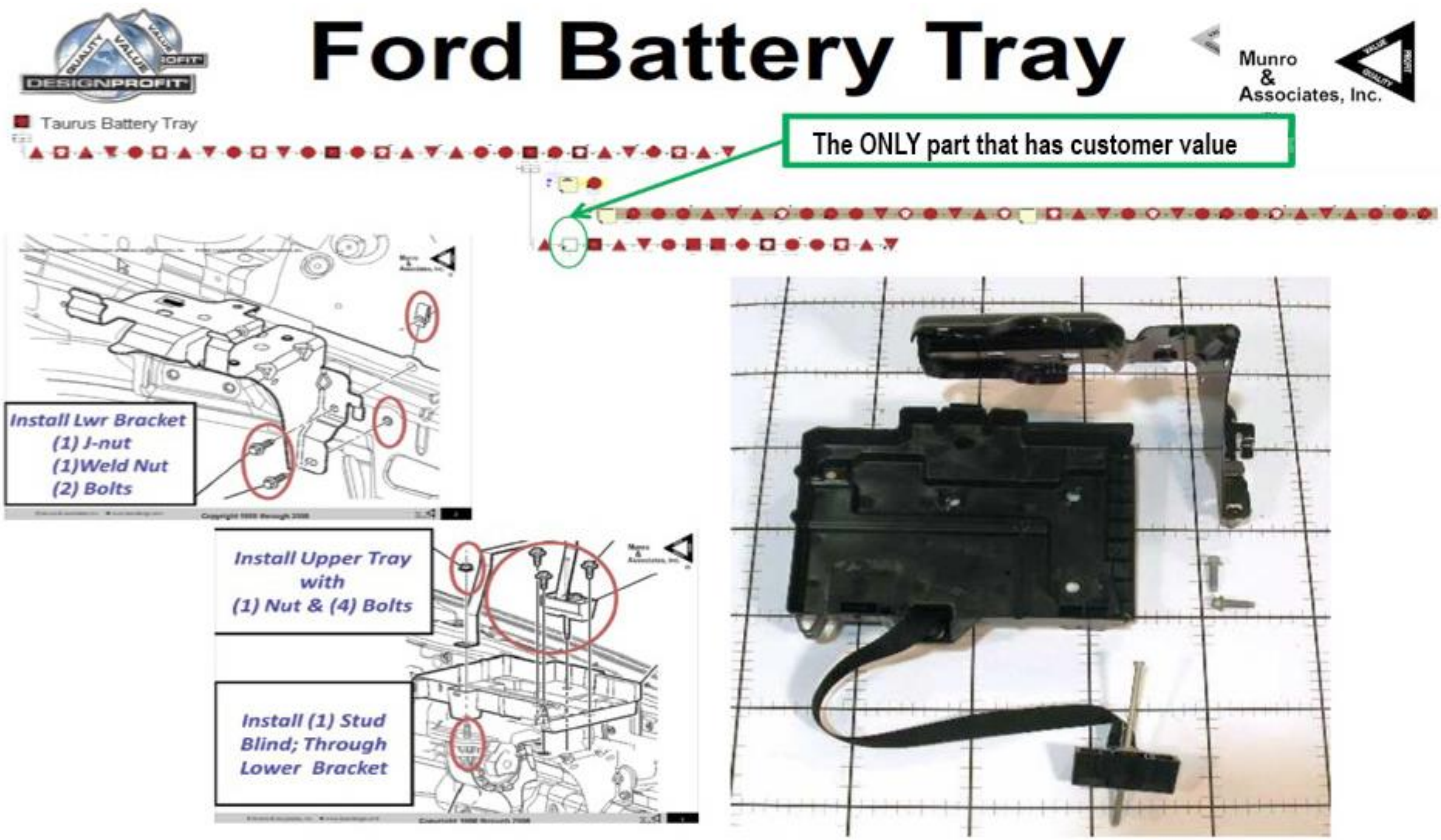
By converting the battery-pack tray to a single piece of molded plastic, the following benefits were recognized:

- The part count went from 16 to 1
- The number of fasteners decreased from 11 to 4
- Material costs decreased by more 70 percent
- Labor costs (i.e., installation) decreased by 40 percent
- Achieved a weight savings of 48 percent
- The manufacturer estimated a savings of over $2M annually due to this change

Source: Munro & Associates

Assembly-Process Map

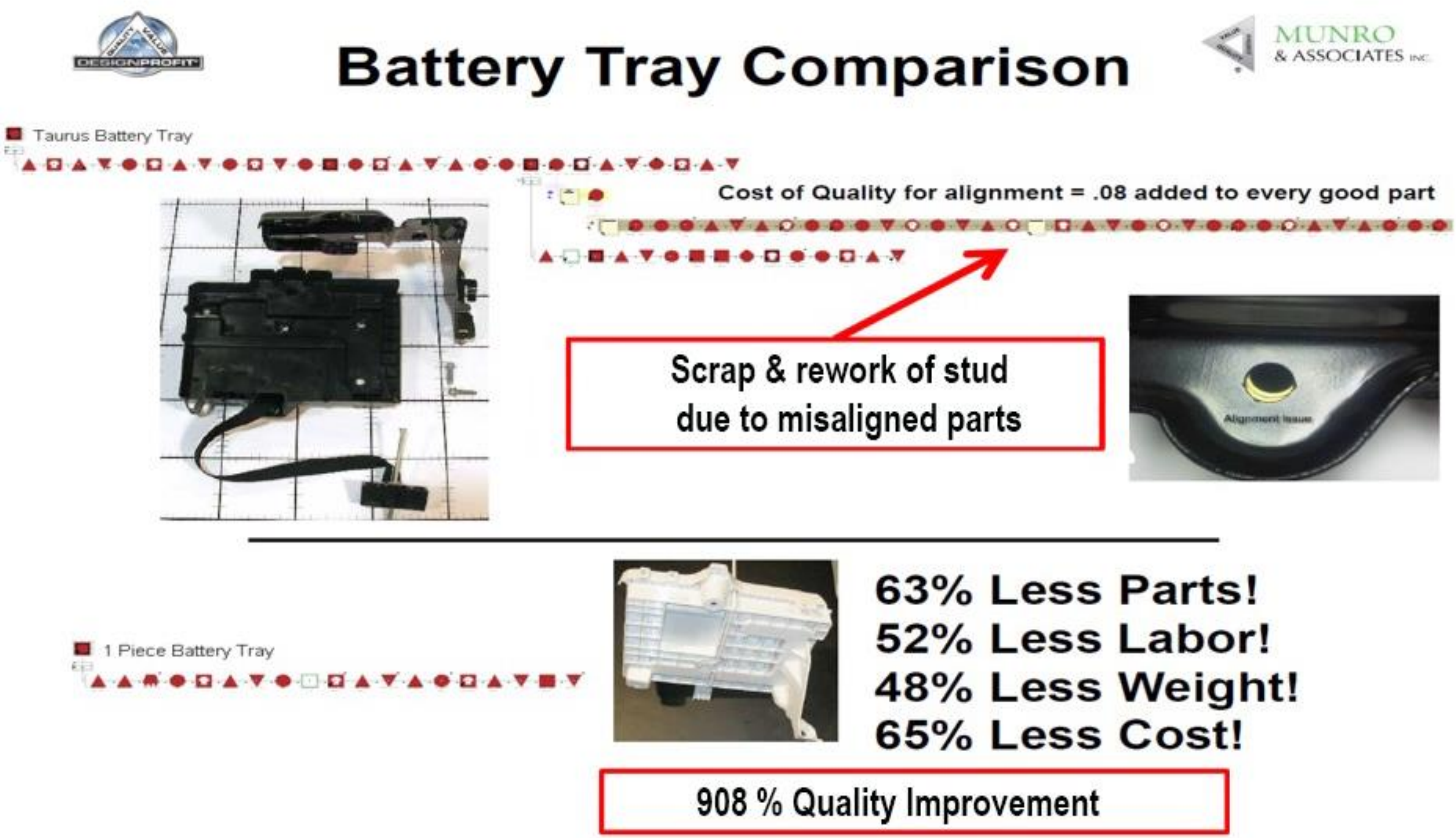
Case study 1 – Vehicle battery-pack tray (cont.)



Source: Munro & Associates

Assembly-Process Map

Case study 1 – Vehicle battery-pack tray (cont.)



Source: Munro & Associates

Executive Summary

Case study 1 – Vehicle battery-pack tray (cont.)

EXECUTIVE SUMMARY
Taurus Battery Tray

MUNRO & ASSOCIATES INC.
DESIGNPROFIT®

	Taurus Battery Tray	1 Piece Battery Tray	% ↓
Parts	16	6	63%
Good Parts	1	1	0%
Steps	53	24	55%
Actual Time	210.00 sec	101.00 sec	52%
Fasteners	11	4	64%
Ergo Dangers	0	0	0%
Poka Yoke Issues	1	0	100%
Total Weight	1,736.54 gm	899.87 gm	48%
Piece Cost	$11.08	$3.22	71%
Total Labor Cost	$2.36	$1.40	40%
Q Burden	$0.59	$0.00	100%
Total Cost	$14.03	$4.62	67%
Investment Cost	$476,316	$85,000	82%
Annual Savings	N/A	$2,351,730	0%
Right First Time	9.83%	99.96%	-917%
Sigma	3.61	5.65	-56%

A design for assembly (DFA) cycle led to substantial savings for a battery-pack tray manufacturer!

Source: Munro & Associates

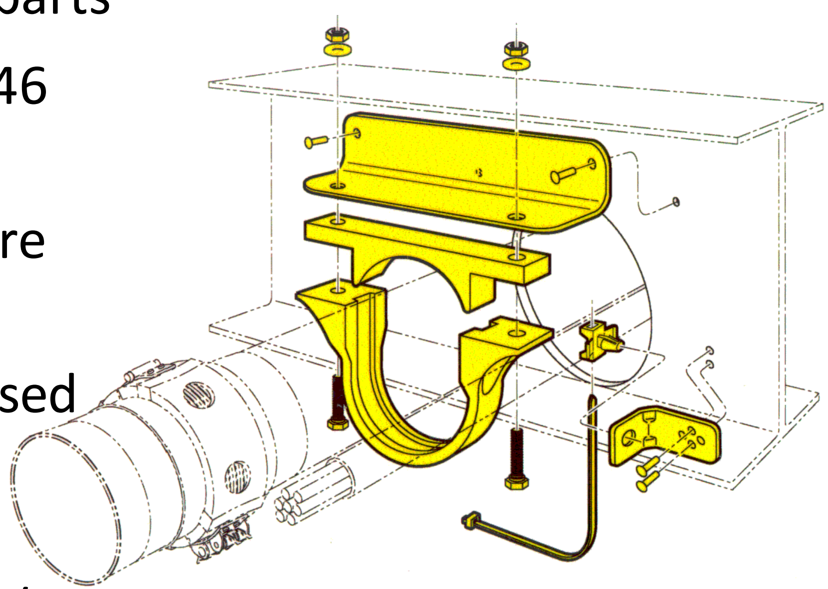
Should Cost

Case study 2 - Aircraft waste-pipe bracket

- The initial pipe bracket consisted of 16 parts with many fasteners and a complex assembly process

Using a component integration redesigning approach to the pipe bracket, the following benefits were recognized:

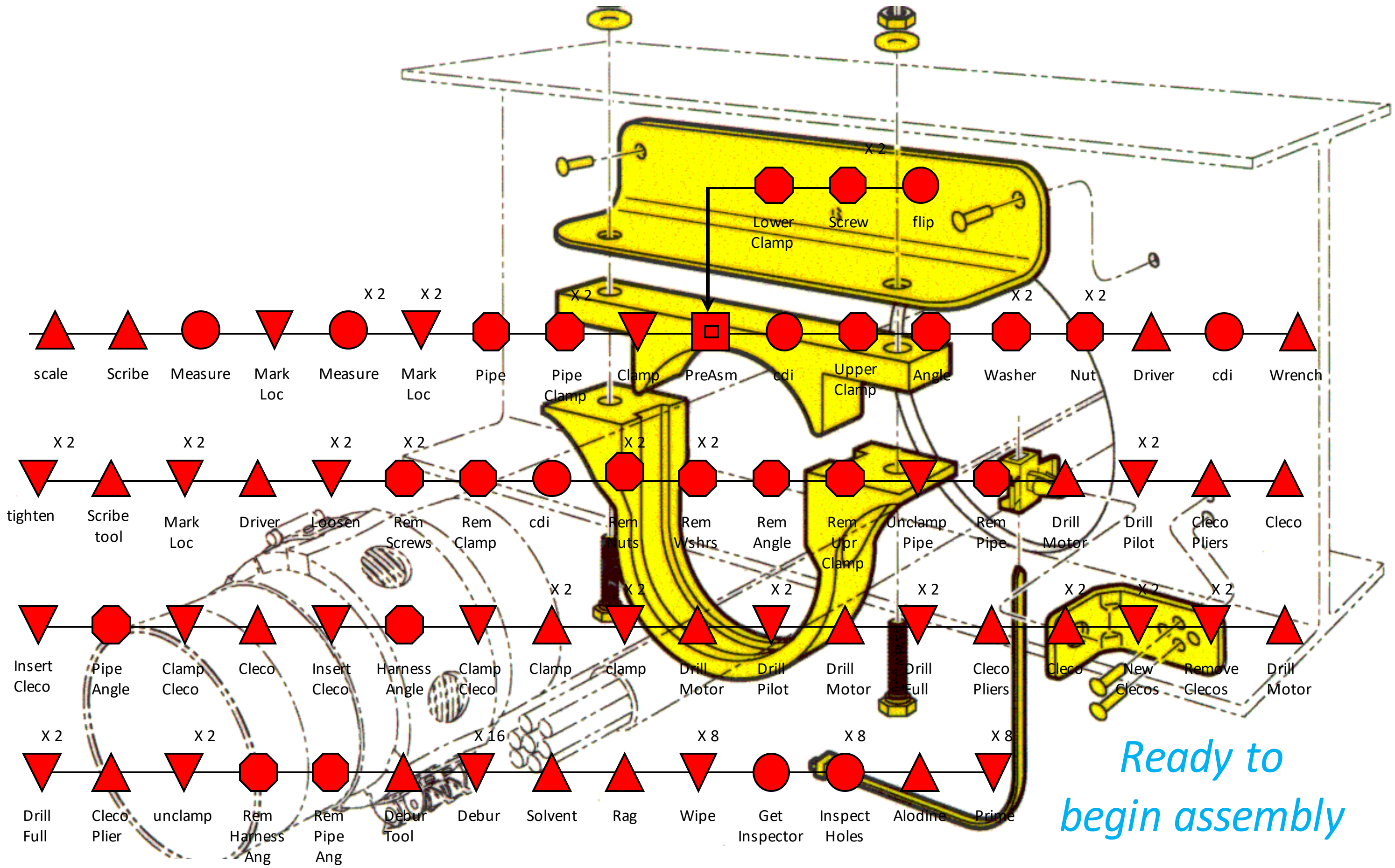
- Part count went from 16 to 3 parts
- Assembly time reduced from 46 to 3 minutes
- Material costs dropped by more than 92 percent
- Labor costs (assembly) decreased by 93 percent
- Major tooling and part cost reduced from $64 to under $5/part



Source: Munro & Associates

Initial Assembly-Process Map

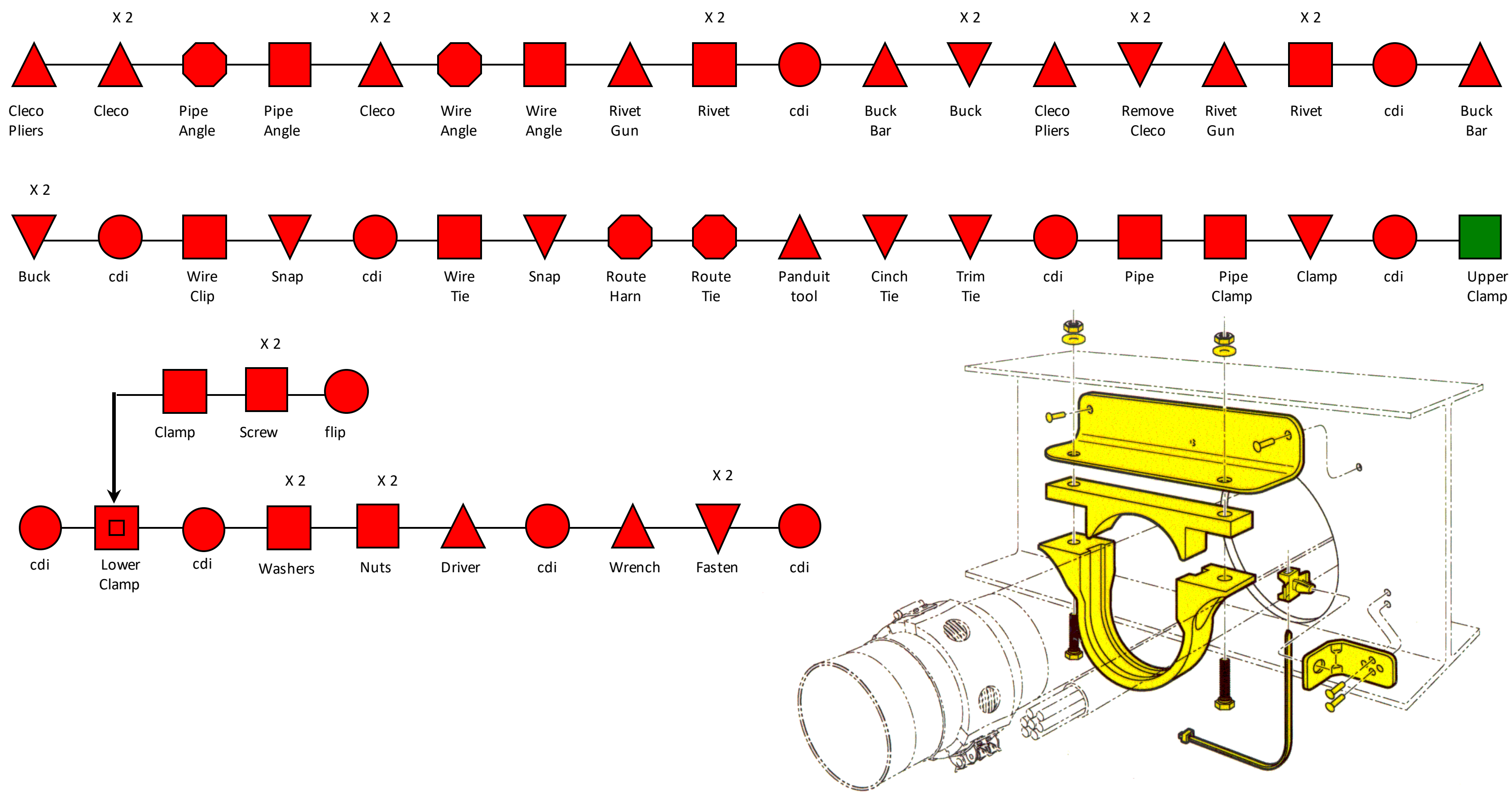
Case study 2 - Aircraft waste-pipe bracket (cont.)



Ready to begin assembly

Initial Assembly-Process Map

Case study 2 - Aircraft waste-pipe bracket (cont.)

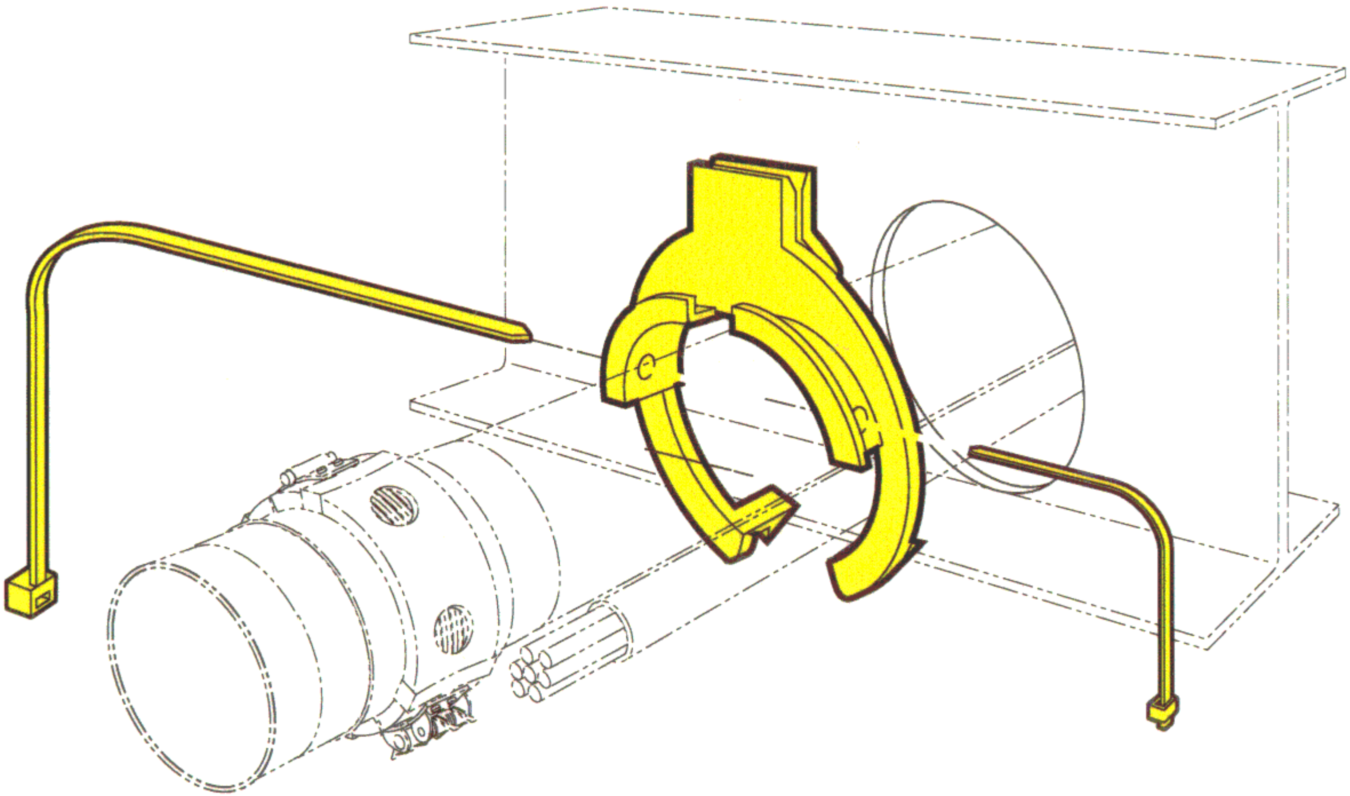


Source: Munro & Associates

www.build4scale.org

Revamped Lean Design

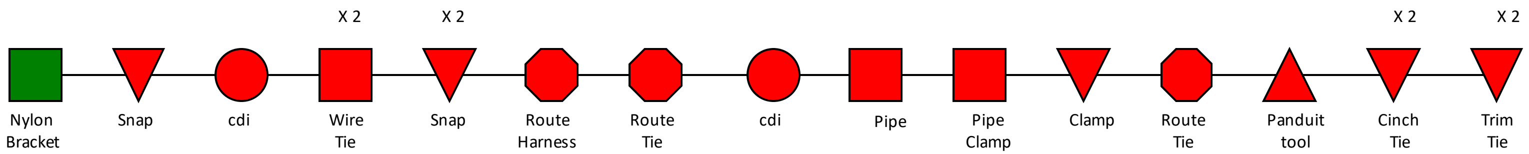
Case study 2 - Aircraft waste-pipe bracket (cont.)

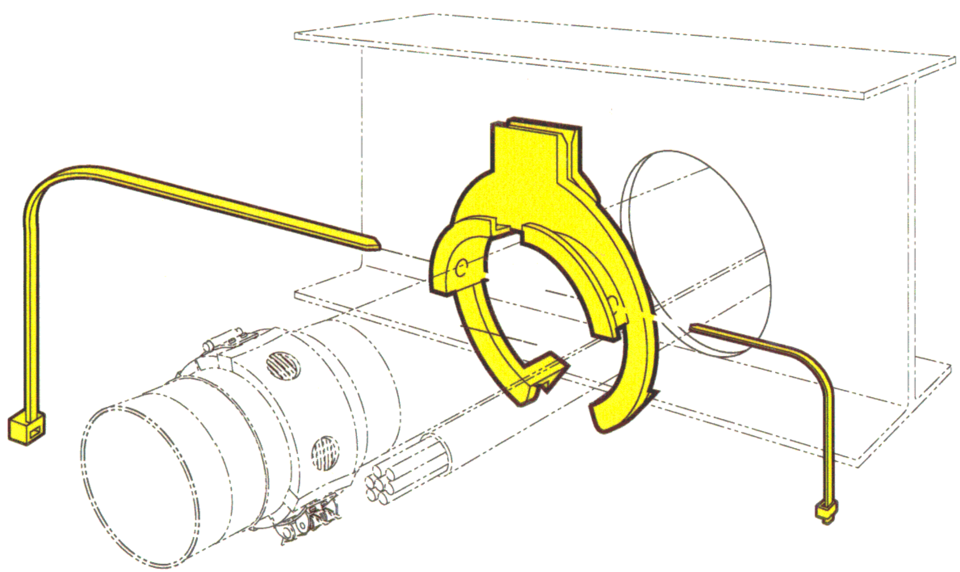


Source: Munro & Associates

Lean Assembly-Process Map

Case study 2 - Aircraft waste-pipe bracket (cont.)





Source: Munro & Associates

Executive Summary

Case study 2 - Aircraft waste-pipe bracket (cont.)

Waste Pipe and Harness Hangers	Baseline	Lean Design	Percent Decrease
Assembly Operations	210	8	96
Parts	16	3	80
Assembly Time (minutes)	46	3	93
Labor Cost	$35.27	$2.44	93
Material Cost	$28.74	$2.44	92
Tooling Cost	N/A	$14,522	N/A
Total Cost	$64.01	$4.74	93
Mass (ounces)	2.1	0.8	62

A "design for cost" reduction effort led to substantial savings for a pipe bracket manufacturer!

Source: Munro & Associates

Value Chain

Basics

- A **value chain** is a set of activities that a firm operating in a specific industry performs in order to deliver a valuable product or service for the markin chaet

A value chain assessment is a study that identifies the dynamics of the product or service delivery system incorporating:

- Upstream activities: R&D (design, engineering, testing), services (financing, leasing, certification, SAS), product supply chain including product manufacturing (materials, equipment, tooling, assembly, packaging)
- Downstream functions: sales, distribution, transportation, logistics, construction, operations/maintenance and repair)

Value Chain

Example – Wind energy industry

Materials

- Steel
- Cast iron
- GFRP
- CFRP
- Fiber glass
- Aluminum
- Copper
- Carbon fiber
- Rubber
- Wood epoxy
- Ferrite
- Brass
- Ceramics
- Magnets
- Concrete

Components

- Rotor/blades
- Controls
- Generator and Power Electronics
- Gearbox
- Tower

Manufacture

- OEM
- Manufacturing equipment providers
- Turbine assembly tooling

Logistics and Operations

- Project development
- Siting services
- Transportation
- Construction

End-Use

- Operations
- Maintenance
- Repair

Value Chain Assessment

Basics

- Well-structured value chain assessments include identification of the key industry players (OEM's, suppliers, universities, national labs, non-profits), indication of the supply chain dynamics (how R&D and procurement interactions work within the value chain), and isolation of high-value systems and processes

Value Chain Assessment

Basics

Identify major players:

- OEM's, tier 1–2 suppliers, equipment/tooling provides, service firms
- What is the value proposition for every segment of the value chain?

How does procurement interaction work?

- Who supplies to who in the value chain?
- Is there vertical integration that will negatively impact my ability to take my product to market?
- Are there mergers and acquisitions that impact value-chain decisions/relationships?

Value Chain Assessment

Basics (cont.)

High-value systems:

- Am I offering something unique or a commodity?
- What systems, components, materials, software, controls, services, manufacturing processes have the most value?

Supply chain competitiveness:

- Are there currently domestic or global supply-chain gaps that I can fill?
- Can I expect there to be US competitiveness issues and why?
- Where are the opportunities for business-model innovation?

Value Chain Assessment

Translate your core competency into a unique proposition!

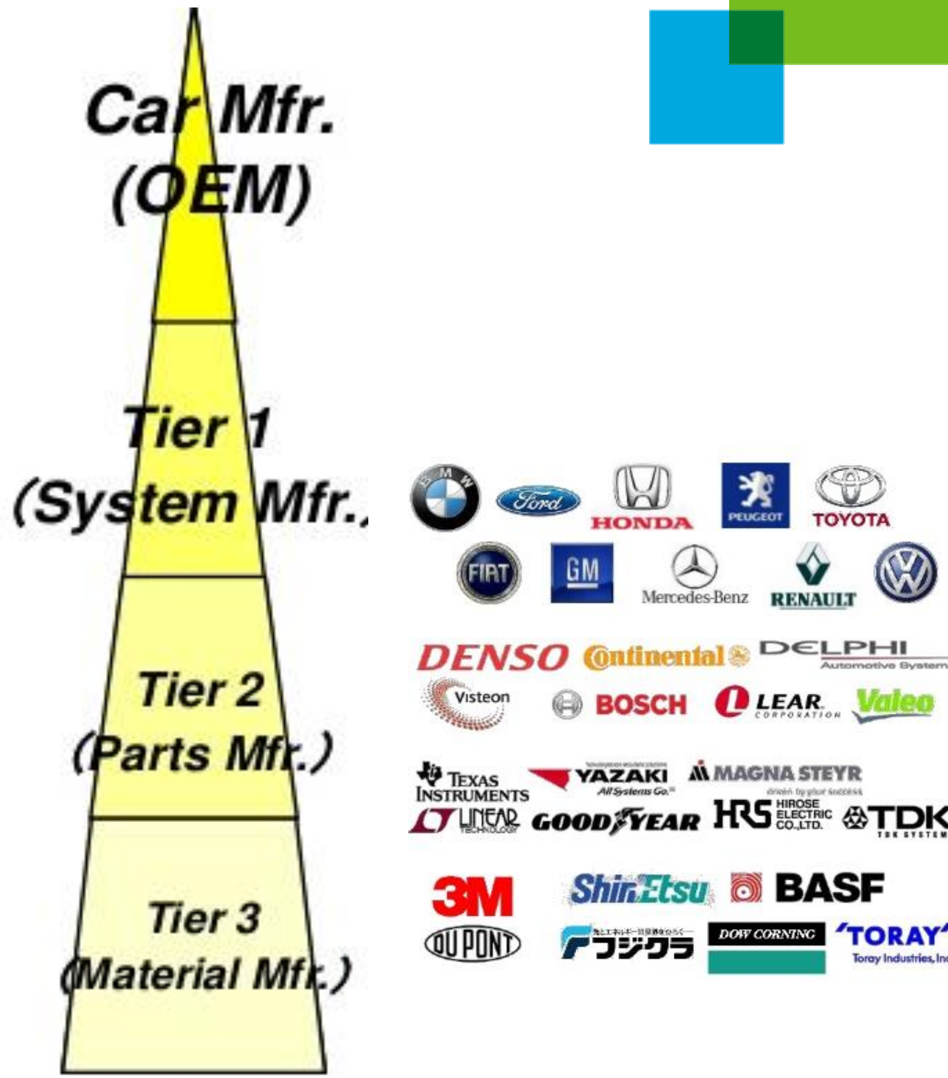
- Based on the unique value chain, what does my company offer?
- What is unique about my product?
- Do I have unique intellectual property?
- Who has the most to gain or loose by me entering the market?
- What is my value proposition? And to whom?
- Who in the value chain has "pain" that my product can alleviate?
- Who in the value chain has the most to "gain" from the introduction of my product?
- How do I evaluate the value proposition to be "specific" and "quantitative"?
- Who can I strategically partner with to accelerate my pathway to market?

Supply Chain

Example - Automotive

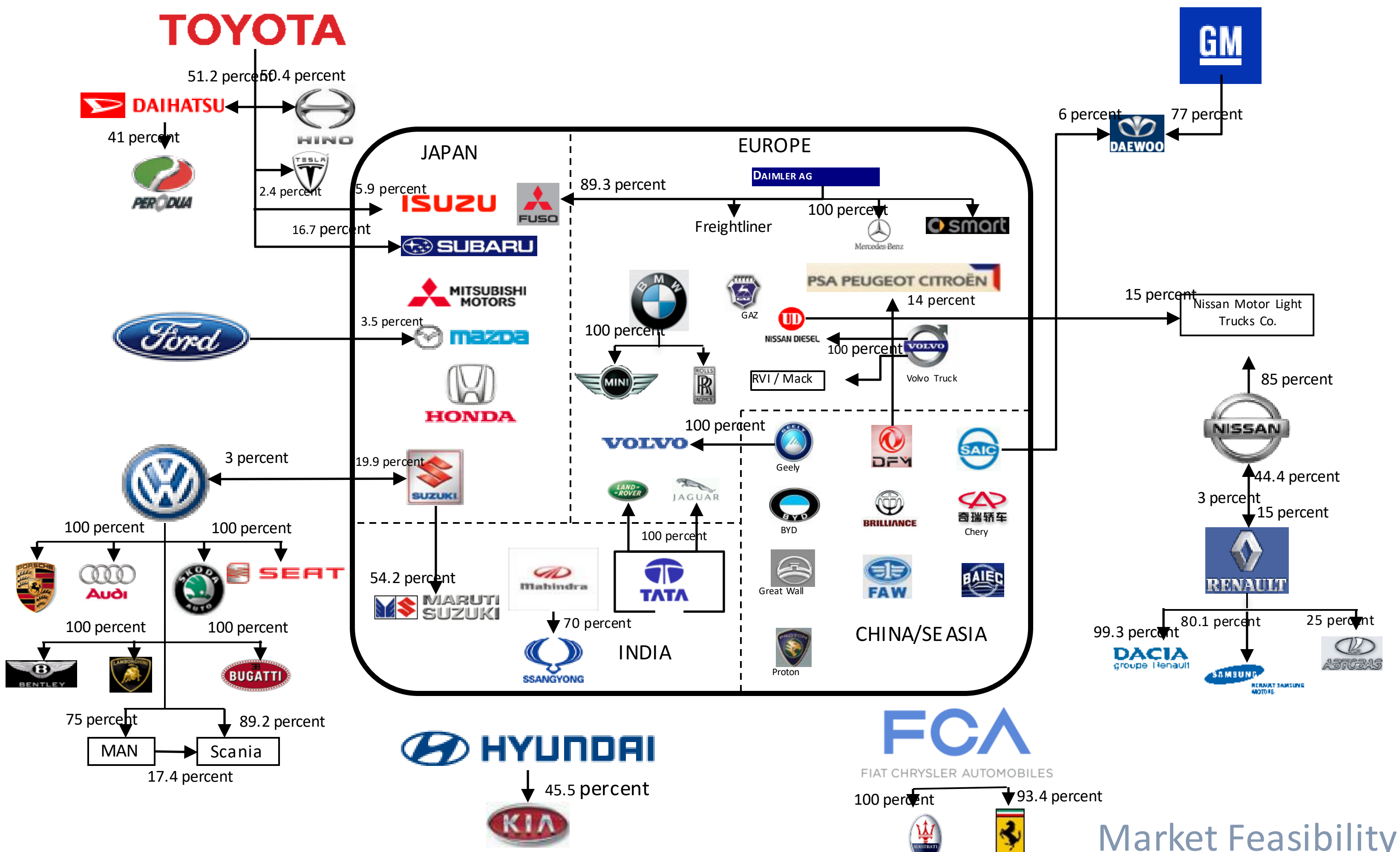
Industry Structure:

- Creating a **tiered supply chain** is part of supply chain management
- Each tier supplies to the one above it (tier 1 supply components directly (OEM))
- A company can be a tier 1 supplier in one supply chain and tier 2 in another



Supply Chain

Example - Auto manufacturing game board



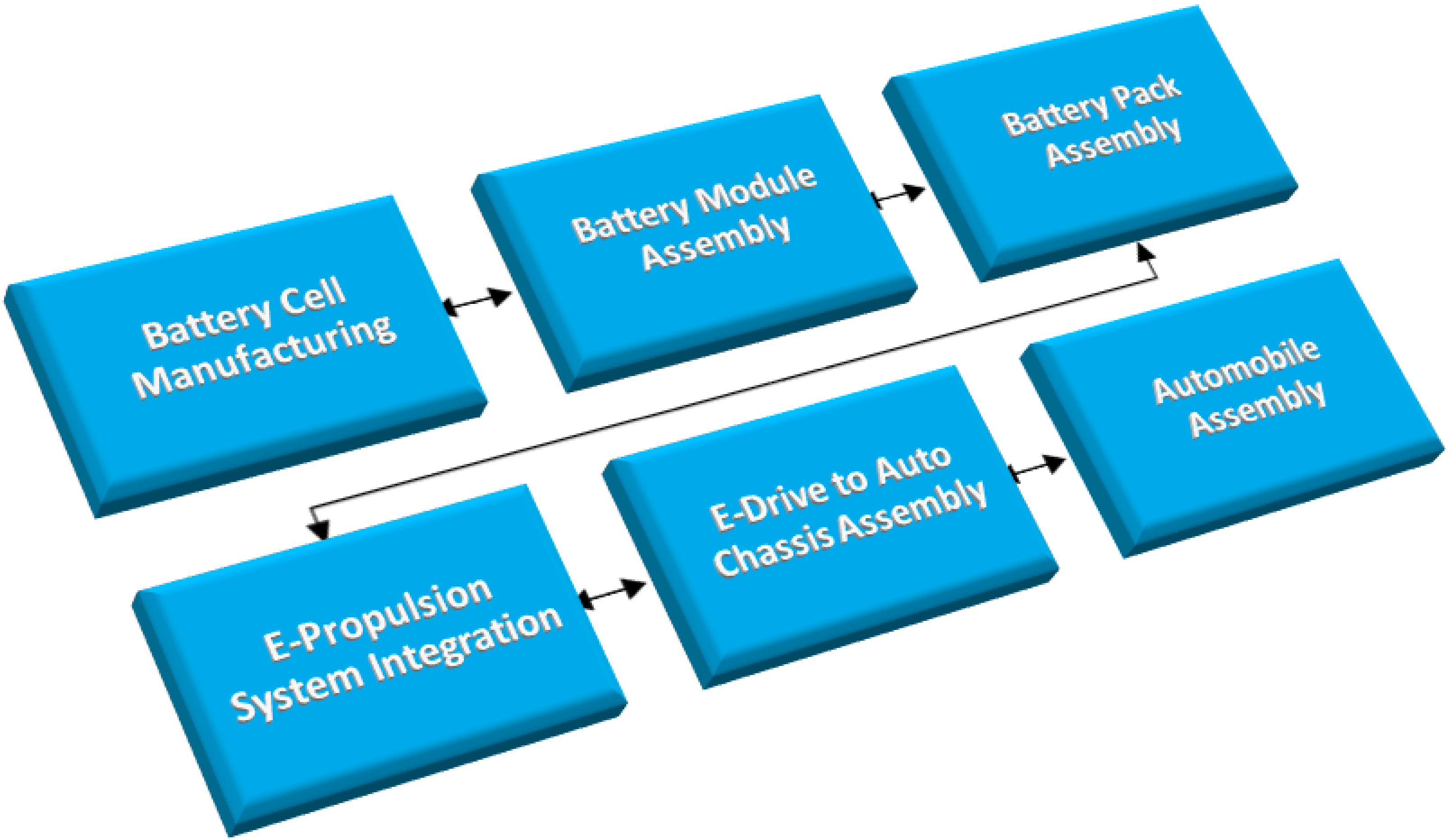
Workflow Process

Key questions

- What are the steps in the manufacturing process?
- What materials, equipment, energy, and people are needed and when?
- How does this work flow change when your product is scaled to a higher volume?

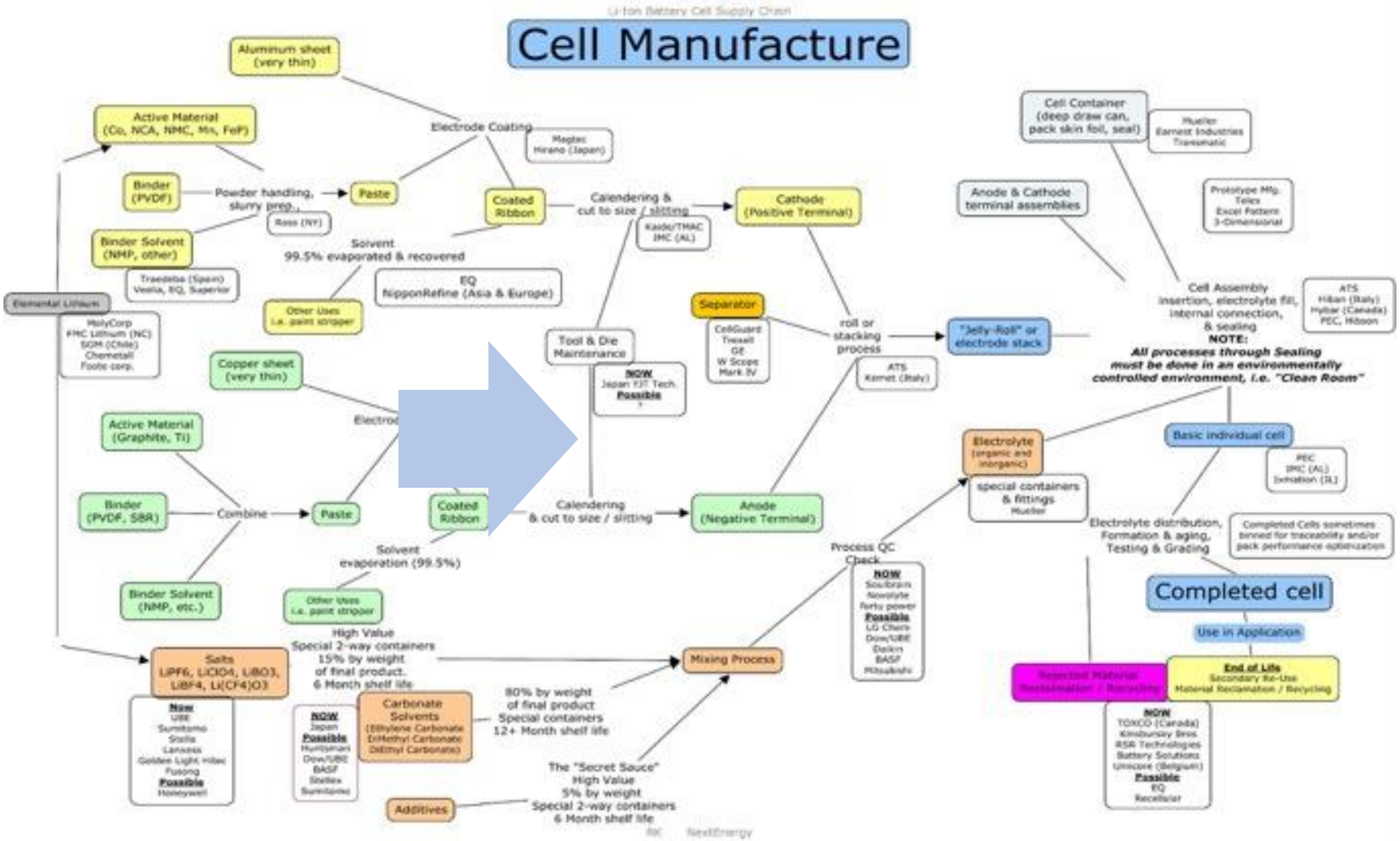
Workflow Process

Example - Lithium ion battery manufacturing



Workflow Process

Example - Lithium ion battery manufacturing (cont.)



Workflow Process To Pro Forma

Exercise – General production

For each station determine:
- Material cost
- Tooling cost
- Capital equipment cost

Inbound Inventory
- BOM Cost
- Space Cost

Station 1
Manufacturing?
Assembly?
Testing?

Station 2
Manufacturing?
Assembly?
Testing?

Station 3
Manufacturing?
Assembly?
Testing?

Outbound Inventory
- Space Cost

For each station determine:
- Labor cost
- Energy cost
- Space cost (sf)
- Takt time (processing time)

Workflow Process To Pro Forma

Exercise – Wind tower production

Inbound Inventory
- BOM Cost $100,000
- Space Cost 20,000sf @$70/sf

Station 1
Manufacturing
Roll Steel

- Material Cost = $100,000
- Tooling Cost = $50,000
- CapEx Cost = $250,000

1 Station = 2 per day
- Labor Cost = 1 staff @ $4,000
- Energy Cost = $3,000
- Takt Time = 4 hours/tower

Station 2
Assembly
Weld Tower Sections

- Material Cost = $0
- Tooling Cost = $20,000
- CapEx Cost = $100,000

1 Station = 4 per day
- Labor Cost = 1 staff @ $5,000
- Energy Cost = $5,000
- Takt Time = 2 hours/tower

Station 3
Testing
Weld Quality Check

- Material Cost = $0
- Tooling Cost = $50,000
- CapEx Cost = $50,000

1 Station = 8 per day
- Labor Cost = 1 staff @ $4,000
- Energy Cost = $2,000
- Takt Time = 1 hours/tower

Outbound Inventory
- Space Cost 50,000sf @$70/sf

Workflow Process To Pro Forma

Exercise – Wind tower production (cont.)

New Scaled-Up Product Volume = 100 towers a month or 10X increase (capacity approx. 150 towers a month)

- Material Cost = $400,000
- Tooling Cost = $200,000
- CapEx Cost = $1,000,000

- Material Cost = $0
- Tooling Cost = $40,000
- CapEx Cost = $200,000

- Material Cost = $0
- Tooling Cost = $50,000
- CapEx Cost = $50,000

Inbound Inventory
- BOM Cost $100,000
- Space Cost 20,000sf @$70/sf

Station 1a: Manufacturing - Roll Steel

Station 1b: Manufacturing - Roll Steel

Station 1c: Manufacturing - Roll Steel

Station 1d: Manufacturing - Roll Steel

Station 2a: Assembly – Weld Sections

Station 2b: Assembly – Weld Sections

Station 3: Testing – Quality Check

Outbound Inventory
- Space Cost 50,000sf @$70/sf

4 Stations = 8 per day
- Labor Cost = 4 staff, $16,000
- Energy Cost = $12,000
- Takt Time = 4 hours/tower

1 Station = 8 per day
- Labor Cost = 2 staff, $10,000
- Energy Cost = $10,000
- Takt Time = 2 hours/tower

1 Station = 8 per day
- Labor Cost = $4,000
- Energy Cost = $2,000
- Takt Time = 1 hours/tower

Manufacturing Pro Forma

Exercise

Current product volume = X per month

- Inventory Cost = SX
- Material Cost = $X
- Tooling Cost = $X
- CapEx Cost = $X

- Inventory Cost = SX
- Material Cost = $X
- Tooling Cost = $X
- CapEx Cost = $X

- Inventory Cost = SX
- Material Cost = $X
- Tooling Cost = $X
- CapEx Cost = $X

Inbound Inventory
- BOM Cost
- Space Cost

Station 1

?

Station 2

?

Station 3

?

Outbound Inventory
- Space Cost

1 Station = X per day
- Labor Cost = X staff @ $X
- Energy Cost = $X
- Takt Time = X hours/tower

1 Station = X per day
- Labor Cost = X staff @ $X
- Energy Cost = $X
- Takt Time = X hours/tower

1 Station = X per day
- Labor Cost = X staff @ $X
- Energy Cost = $X
- Takt Time = X hours/tower

Manufacturing Pro Forma

Exercise - (cont.)

New higher scaling product volume = X per month

Station 1

- Inventory Cost = SX
- Material Cost = $X
- Tooling Cost = $X
- CapEx Cost = $X

Station 1: ?

Inbound Inventory
- BOM Cost
- Space Cost

1 Station = X per day
- Labor Cost = X staff @ $X
- Energy Cost = $X
- Takt Time = X hours/tower

Station 2

- Inventory Cost = SX
- Material Cost = $X
- Tooling Cost = $X
- CapEx Cost = $X

Station 2: ?

1 Station = X per day
- Labor Cost = X staff @ $X
- Energy Cost = $X
- Takt Time = X hours/tower

Station 3

- Inventory Cost = SX
- Material Cost = $X
- Tooling Cost = $X
- CapEx Cost = $X

Station 3: ?

Outbound Inventory
- Space Cost

1 Station = X per day
- Labor Cost = X staff @ $X
- Energy Cost = $X
- Takt Time = X hours/tower