

Creating a Process-based Cost Model

Randolph Kirchain & Frank R. Field III
Materials Systems Laboratory
Massachusetts Institute of Technology

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Session Outline

- ❑ What is a process-based cost model?
- ❑ Examples of Technical Decisions
- ❑ Key steps to realizing a model

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What is an engineering model?

What is the purpose of creating such models?

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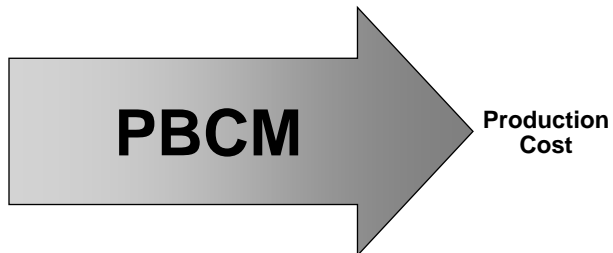
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Process-based Cost Modeling (PBCM)

- **Objective**
 - Map From Process Description To Operation Cost
- **Purpose**
 - Inform Decisions Concerning Technology Alternatives **BEFORE** Operations Are In Place

Product Description

Part Geometry
Material Properties
Economic Characteristics
Operating Conditions



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What is a PBCM?

- **Implementation:**
 - **Process Model**
 - **Operations Model**
 - **Financial Model**
- **General:**
 - **Incorporates Technical Information About Process**
 - *Builds Cost Up From Technical Detail*
 - **Must Be Able To Address Implications Of Change In**
 - *Product Design or*
 - *Process Operation – Incl. Production Volume*
- **Remember:**
 - **The Purpose Of A PBCM Is To Inform Technical Decisions**

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Uses of Cost Models in Technical Decision-making

- **Comparing options**
 - **Materials**
 - **Processes**
 - **Designs**
 - **Exogenous conditions**
- **Identifying cost drivers**
- **Considering hypothetical developments**
- **Characterizing strategic strengths**
- **Quantifying necessary performance improvements**

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Case One:

Considering Alternative Structural Materials

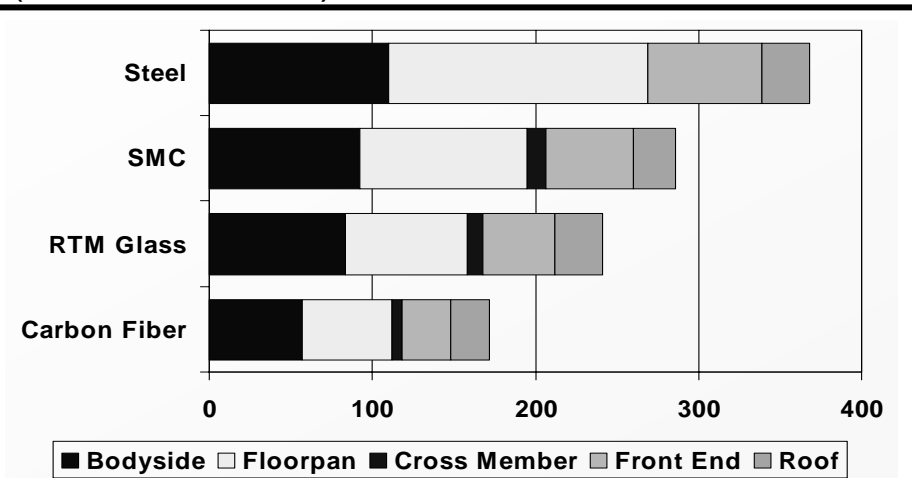
- **Steel Baseline**
 - Honda Odyssey minivan
 - Complete Body in White : 148 pieces
 - BIW Weight : approx. 370 kg
- **RTM Glass Composite Intensive Vehicle (CIV)**
 - Complete Body in White : 8 pieces, plus steel inserts
 - BIW Weight : approx. 240 kg
 - Baseline design uses glass reinforced composites produced by RTM
- **Hypothetical Designs**
 - Carbon fiber or SMC

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Comparison of Body Weights

(incl. CIV inserts)



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Uses of Cost Models in Technical Decision-making

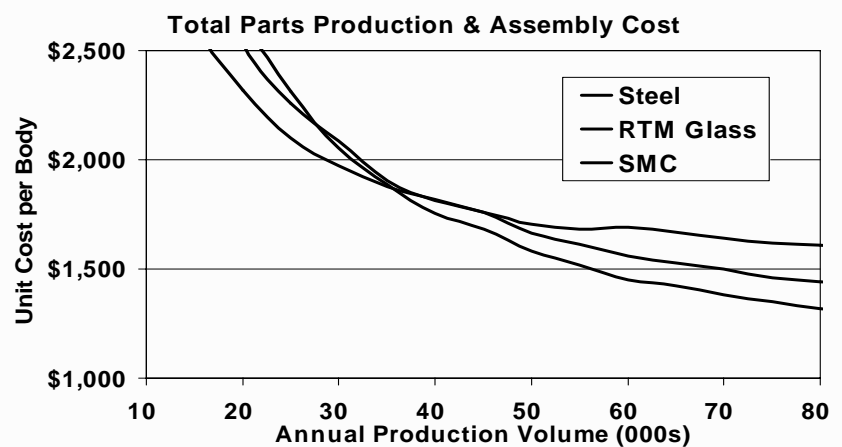
- Comparing options
 - Materials
 - Processes
 - Designs
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Comparing Manufactured Costs:

Process-based models provide insight into novel options



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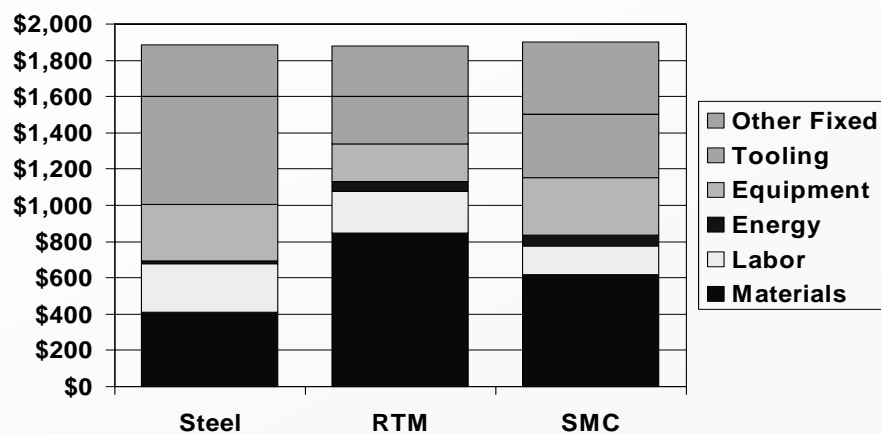
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BIW Cost Breakdown at 35,000 parts/year



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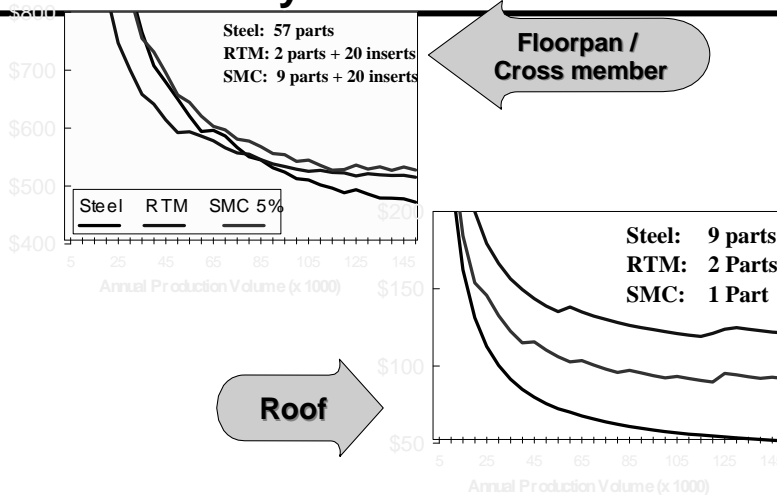
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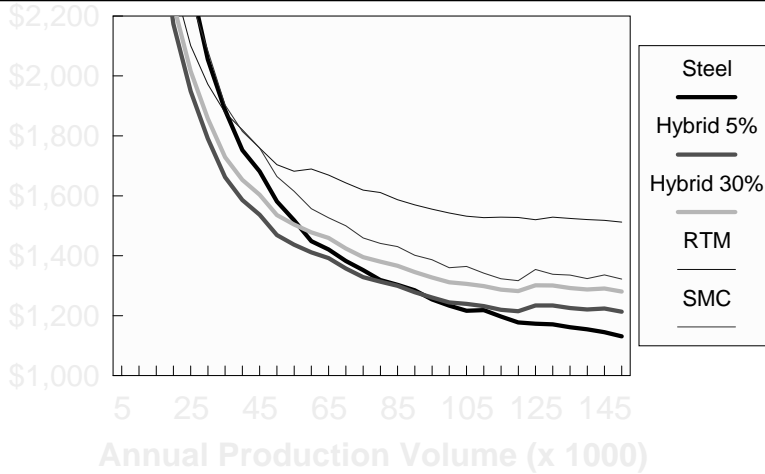
Comparing Cost Performance in Individual Subsystems



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Hybrid Body Scenarios



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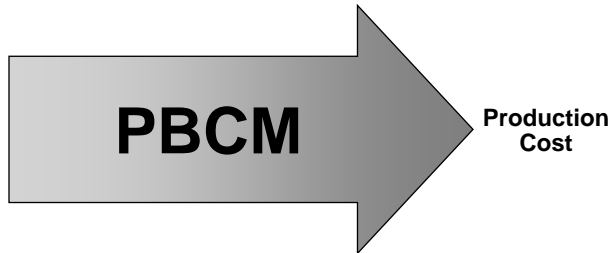
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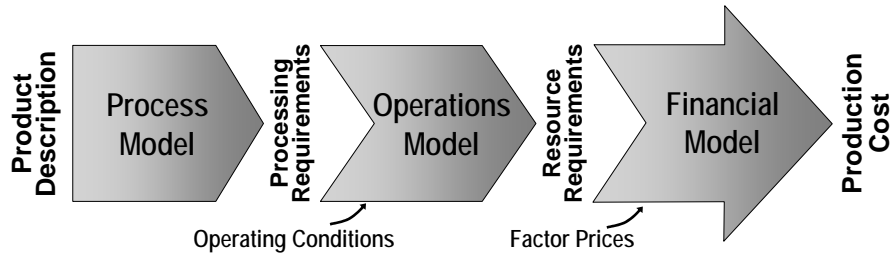


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Process-based Cost Modeling (PBCM)

- PBCM forecasts manufacturing requirements → costs
 - Processing requirements
 - *Cycle times, equipment specifications*
 - Resource requirements
 - *Number of tools, equipment, and laborers*
- How do technology changes impact manufacturing cost?

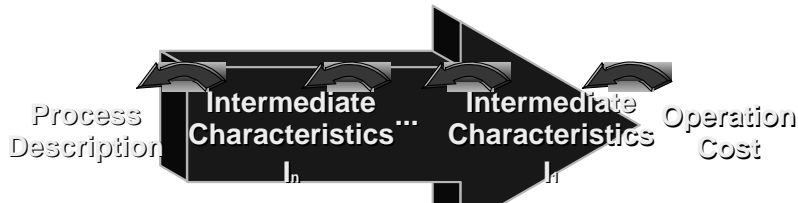


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Creating a PBCM: Overview

- Models are created by decomposing problem from cost backwards
 - Determine what characteristics, I1, effect cost
 - Determine what characteristics, I2, effect I1
... and so on until...
 - Determine how process description effects I_n



Model works from inputs to costs
<> Modeler works from costs to inputs

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Creating a PBCM: Critical Steps

- ❑ Define Question To Be Answered
- ❑ Identify Relevant Cost Elements
- ❑ Diagram Process Operations & Material Flows
- ❑ Relate Cost To What Is Known
- ❑ Understand Uncertain Characteristics

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Creating a PBCM: Step One

- ❑ Define Question To Be Answered
 - Cost of What?
 - *Carefully Understand Processing Boundaries*
 - Cost to Whom?
 - *Perspective Determines Pertinent Costs*
 - Cost Varying How?
 - *What Technical Changes Are Being Considered?*
 - Cost Compared to What?
 - *Relative to Other Options*
 - *Absolute Measure of Operation*
- ❑ More Than Any Physical Measure Cost Is Context Dependent
 - Cost estimation requires exhaustive definition of context

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Step Two: Identify Relevant Costs

What costs should be considered?

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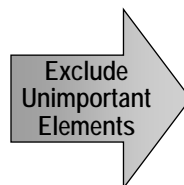
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Creating a PBCM: Step Two

- Identify Relevant Costs
 - Pertinent to Decision
 - Necessary for Completeness / Credibility

Elements of
Manufacturing Cost

Relevant Elements
of Cost



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Common Relevant Cost Elements

- **Begin With These, But Always Ask Whether Others Are Important**
 - **Tradeoff Amongst Time, Resources, and Available Knowledge**

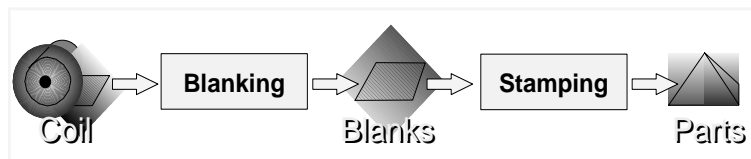
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Creating A PBCM: Step Three

- **Diagram Process Flows**
 - **Draw In Materials Flowing Into AND Out Of**
 - **Catalog For Each Process Step**
 - *Equipment*
 - *Labor*
 - *Energy*

*e.g., Sheet Metal Stamping
Forming Between Two Matched Dies*



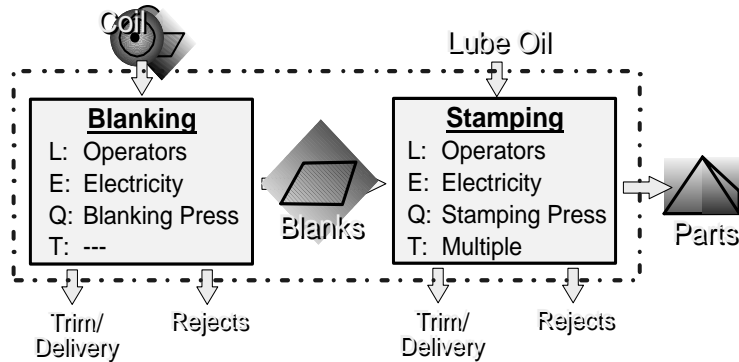
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Diagramming Flows Example: Stamping

- Catalog For Each Process Step

-- Labor -- Energy -- Equipment -- Tools



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Cost Modeling Challenge

- ❑ How much equipment to buy?
- ❑ What is the cost of producing your various products?
- ❑ Should you invest in the latest technology?

?

... for your business...

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Your Business

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Cost Modeling Challenge

?

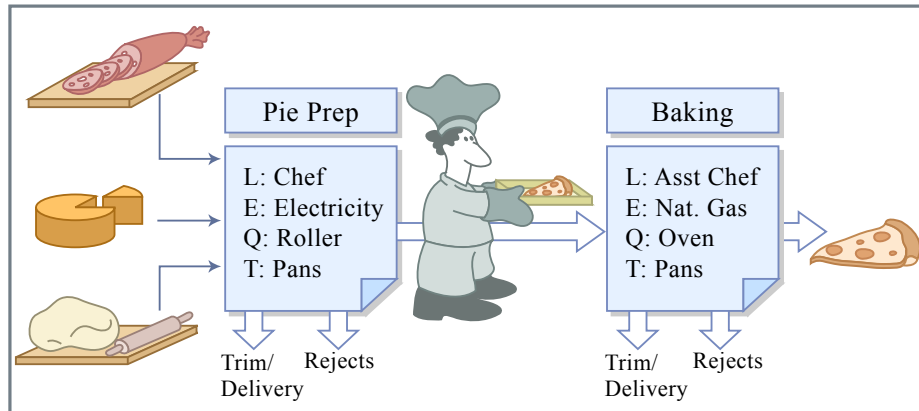
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Diagramming Flows Example: W & P

Catalog For Each Process Step

-- Labor -- Energy -- Equipment -- Tools



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Figure by MIT OCW.

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Data Collection & Model Development

- For each resource in your diagram
 - How much does a unit cost?
 - How many units are required?
- Begin data collection early!!!
 - Start with low risk sources
 - *Probably smaller firms*
 - End with high value sources

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Step Four: Relate Costs to What is Known

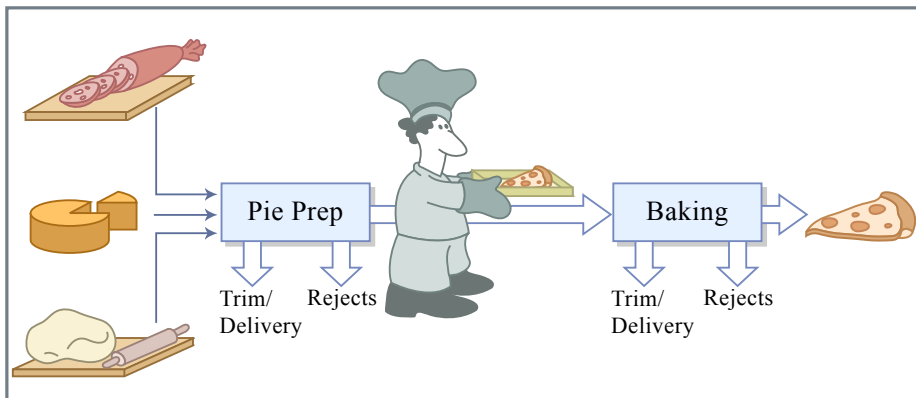
- **Process Involves Four Steps**
 - 1) **Begin At The Current Endpoint (initially, the costs)**
 - 2) **Ask: How Can That Quantity Be Broken Down?**
 - *Initially, How Many Do I Need x How Much Does Each Cost*
 - 3) **Analyze Required Information (i.e. parameters)**
 - *Are Those Parameters Acceptable Endpoints?*
 - *Can I (the model) Derive Them From A Simpler Or More Relevant Set Of Information?*
 - 4) **If No, Repeat 1 With New Endpoints**
- **Watch Out For Interdependent Parameters**
 - **e.g. Part Mass & Part Dimensions**

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Step Four Example: Pepperoni Costs

- **Start at the end**
- **Think in terms of annual quantities**



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Figure by MIT OCW.

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Two Important Quantities

- ❑ **Production Capacity =**
Qty. of "Good" Parts Capable of Being Produced
 - How much CAN a plant produce?

- ❑ **Production Volume =**
Quantity of "Good" Parts Produced
 - How much DOES a plant produce?

**Generally, Both Are Measured In Units Per Year
(e.g., parts / year, kgs / year)**

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Slices per Pizza

- ❑ **General area covering is difficult to solve**
 - Solutions for small number of circumscribed circles has been solved
- ❑ **Approximate:**

78%

90%

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Calculating Effective Production Volume: Work Backwards from Final Step

Prepped Pizzas Produced / Year = Good Preps + Rejects
effective $PV_{\text{Prepping}} = PV_{\text{Prepping}} + \text{Rejects}$

Can model Rejects as % of total production

$$\begin{aligned}\text{eff}PV_{\text{Prep}} &= PV_{\text{Prep}} + R \times \text{eff}PV_{\text{Prep}} \\ \text{eff}PV_{\text{Prep}} &= \frac{PV_{\text{Prep}}}{(1 - R)}\end{aligned}$$

But what is PV_{Prep} ?

Assume that $PV_{\text{Prep}} = \text{Total Pizzas Baked / Year}$ (i.e., $\text{eff}PV_{\text{Baking}}$)

$$\text{eff}PV_i = \frac{\text{eff}PV_{i+1}}{(1 - R)}$$

For last step, substitute PV for $\text{eff}PV_{i+1}$

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