Creating a Process-based Cost Model

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

Session Outline

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

Please read the supplemental document

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Kirchain, R., and F. Field. "Process-Based Cost Modeling:Understanding the Economics of Technical Decisions." In *Encyclopedia of Materials Science and Engineering*. Vol. 2. San Diego, CA: Elsevier, 2001, pp. 1718-27. ISBN: 0080431526.

What is an engineering model?

What is the purpose of creating such models?

Process-based Cost Modeling (PBCM)

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

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**

Uses of Cost Models in Technical Decision-making

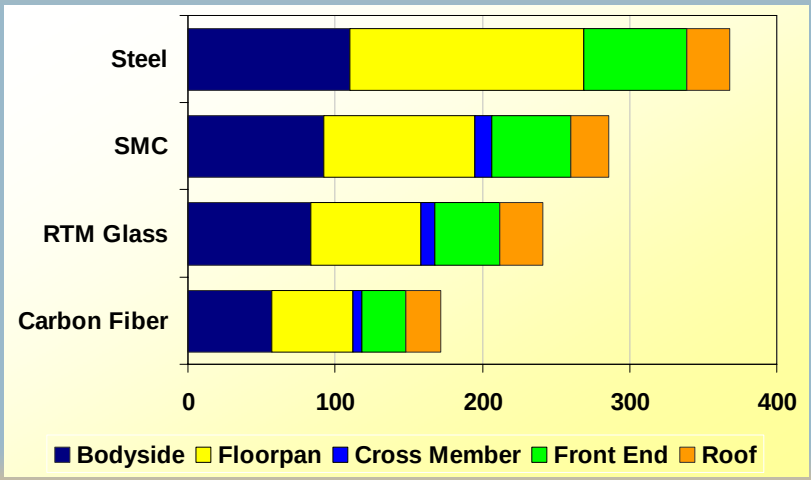
- Comparing options
  - Materials
  - Processes
  - Designs
  - Exogenous conditions
- Identifying cost drivers
- Considering hypothetical developments
- Characterizing strategic strengths
- Quantifying necessary performance improvements

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

From:
Kang, P. J. (1996). *A Technical and Economic Analysis of Structural Composite Use in Automotive Body-In-White Applications*. MS Thesis. Cambridge, Massachusetts Institute of Technology: 170.

Comparison of Body Weights
(incl. CIV inserts)

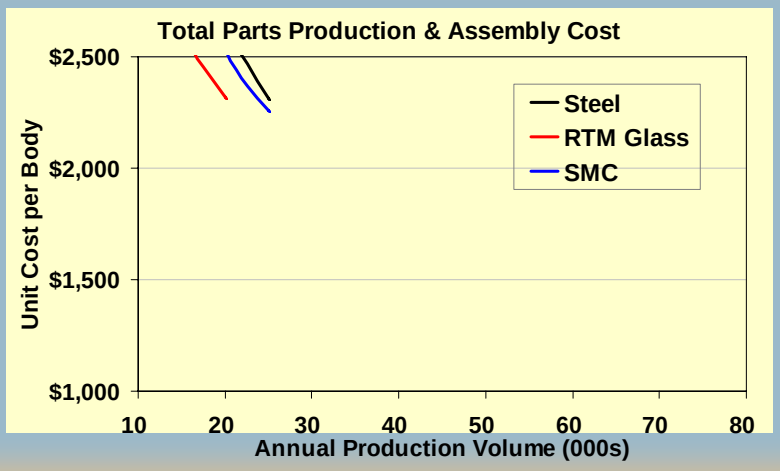


Uses of Cost Models in Technical Decision-making

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

Comparing Manufactured Costs:

Process-based models provide insight into novel options



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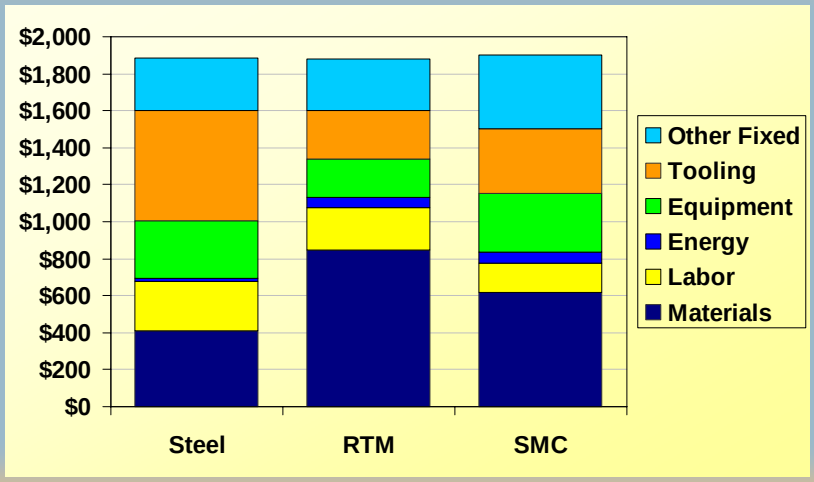
BIW Cost Breakdown at 35,000 parts/year



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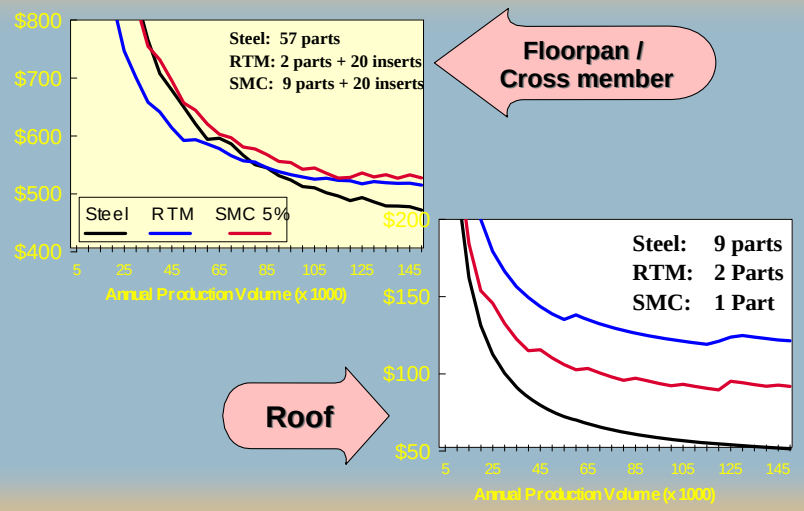
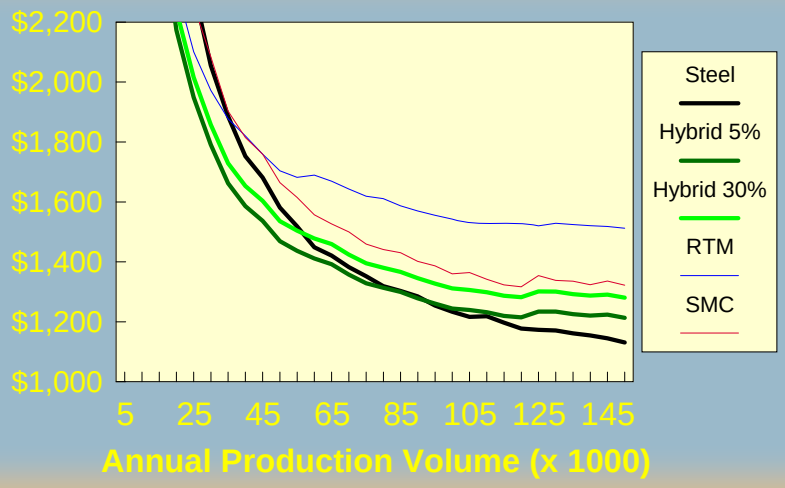
Comparing Cost Performance in Individual Subsystems



Hybrid Body Scenarios



Case Two: Investigating Early Stage Developments in Optoelectronic Components

- **Initial model development**
  - Integrated DFB laser and electro-absorptive modulator on an InP platform (1550nm)
- **Assessment of Integration (Two Additional Cases)**
  - Monolithically Integrated Laser-Modulator
  - Discrete Devices, Single Package
  - Discrete Packages

Figure removed for copyright reasons.

Schematic of DFB laser with electro-absorptive modulator on InP platform.

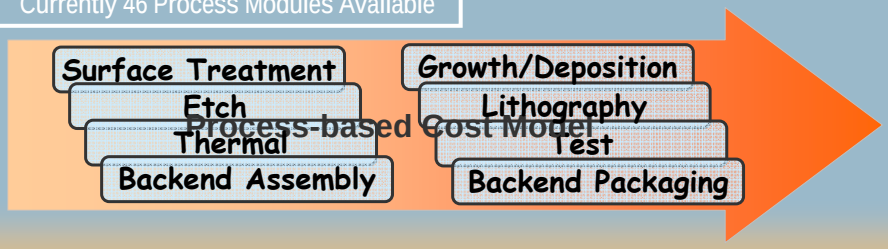
Source: Alcatel Optronics.

From:
E Fuchs, E Bruce, R Ram, & R Kirchain "Process Based Cost Modeling of Photonics Manufacture: The Cost-Competitiveness of Monolithic Integration of a 1550nm DFB Laser and An Electro-Absorptive Modulator on an InP Platform" in press *Journal of Lightwave Technology*

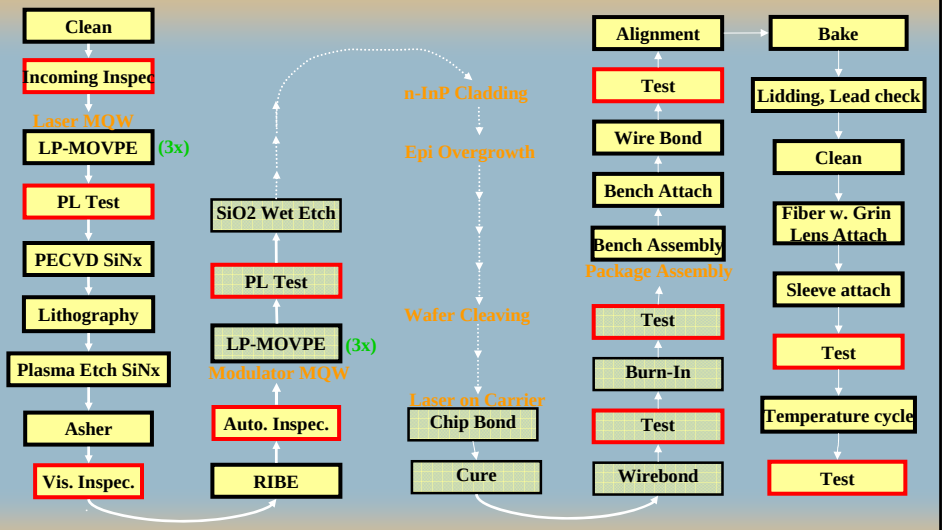
The MIT/CTR Optoelectronics Fabrication Model

- **Mimics production from bare substrate through assembly, packaging, and final test**
- **Provides full flexibility in building a process flow**
- **Captures effect of process derived yields at testing**

Currently 46 Process Modules Available



Process Modules Building Blocks in Product Flow

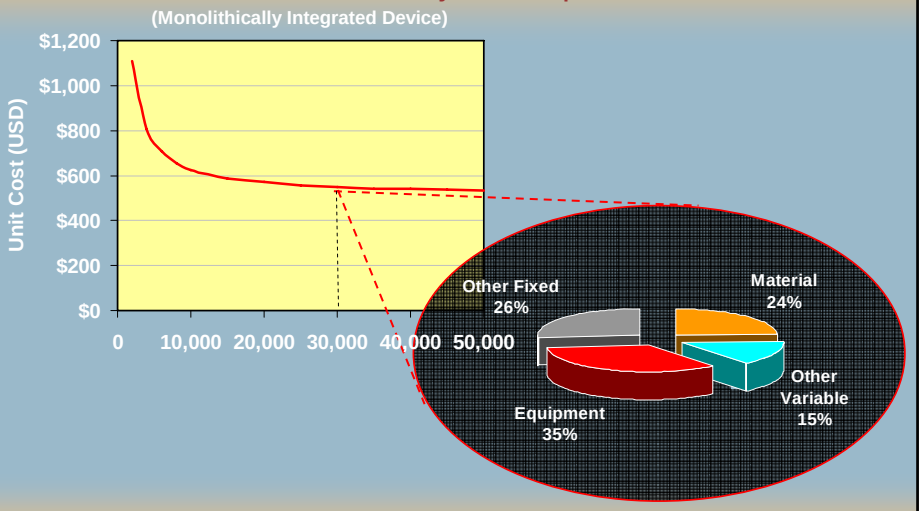


Cost Modeling Benefits to Roadmapping

1. Provides a generic platform to discuss the cost of process and product developments
2. **Quantifies impact of future scale growth**
3. Identifies key cost drivers
4. Quantifies necessary process performance hurdles

Quantifying Cost-Sensitivity to Scale

Models Derive Cost from Projected Optimal Fab Line



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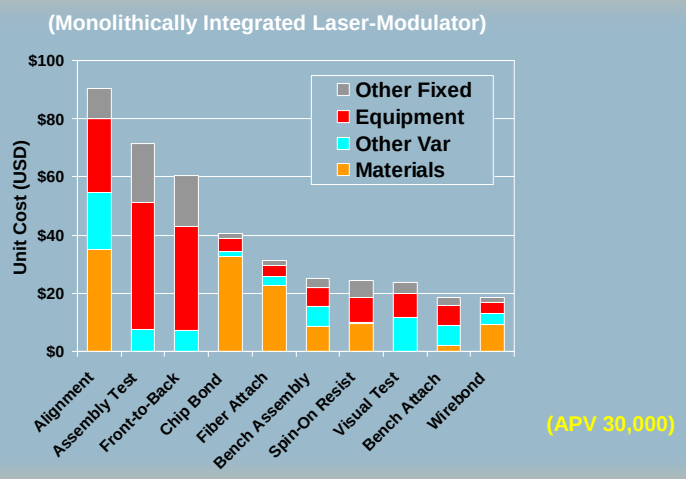
Identifying Key Cost Drivers
Models Provide Unequaled Resolution

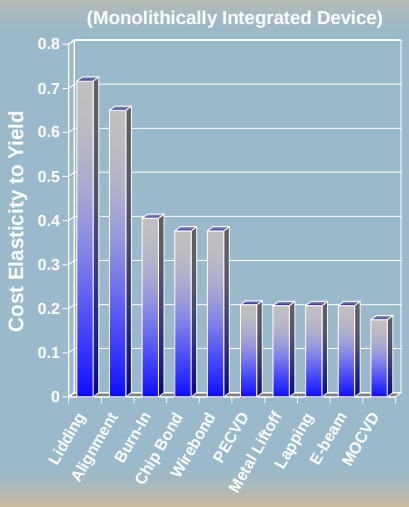


Identifying Opportunities for Improvement:
Unit Cost Elasticity to Yield

- **Yield is key issue for optoelectronics manufacturing cost**
- **What processes provide the most leverage?**
  - **Position in flow**
  - **Embedded yield**
- **Cost elasticity to yield**

$$\frac{\%\Delta Cost}{\%\Delta Yield}$$

  - **Identifies process yield impact on aggregate cost**



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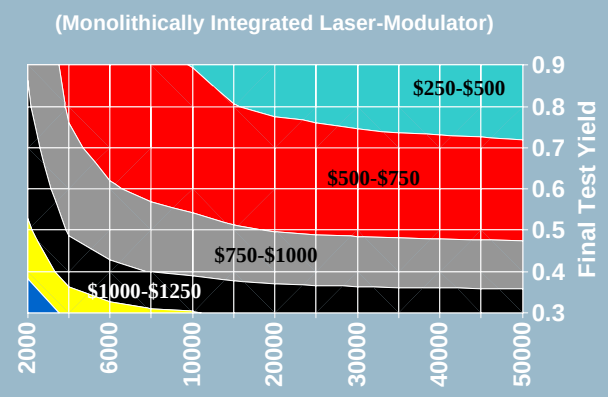
Cost Sensitivity to Final Test Yield



Case Two: Investigating Early Stage Developments in Optoelectronic Components

- **Initial model development is around a well-known case**
  - Integrated DFB laser and electro-absorptive modulator on an InP platform (1550nm)
- **Assessment of Integration (Two Additional Cases)**
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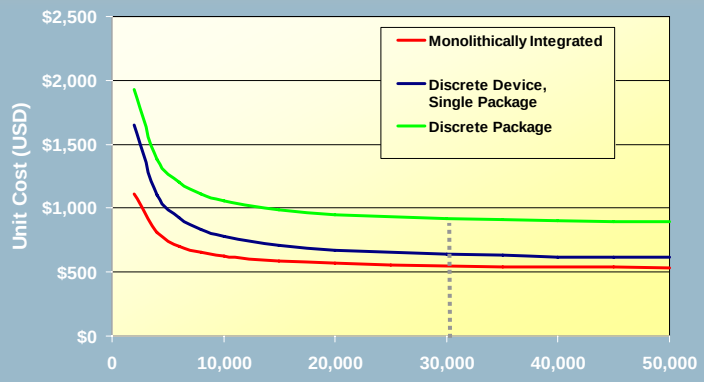
Exploring the Cost-Impact of Integration: Models Allow Testing of Novel Technologies



The most competitive alternative is the monolithically integrated laser-modulator.

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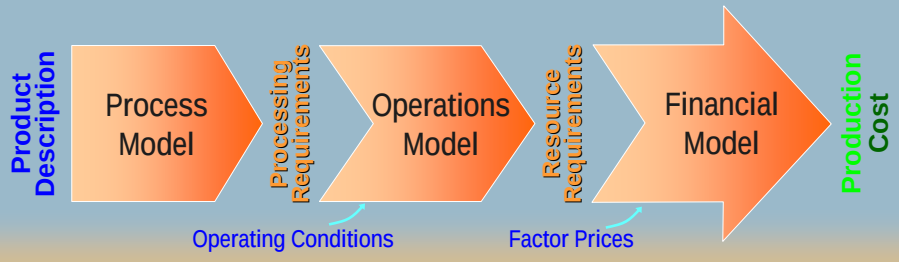
Process-based Cost Modeling (PBCM)

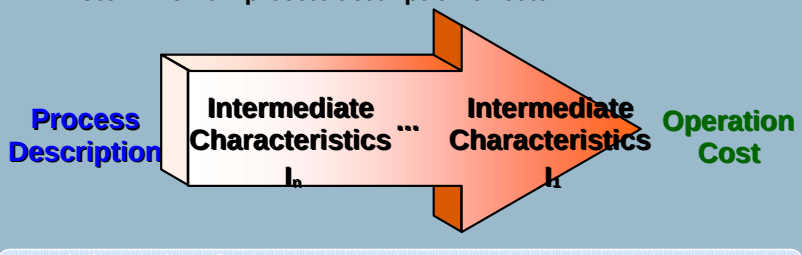
- **PBCM forecasts manufacturing requirements → costs**
  - **Processing requirements**
    - Cycle times, equipment specifications
  - **Resource requirements**
    - Number of tools, equipment, and laborers
- **How do technology changes impact manufacturing cost?**



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 In



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

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

Step One: Define Question

What is cost?

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**

Examining Automobile Recycling:
Applying Process-based Cost Modeling

- **Models account for:**
  - **Vehicle composition and configuration**
  - **Factor costs and transfer prices**
  - **Recycling practice**
- **Examined questions of:**
  - **Changing vehicle composition**
  - **Alternative recovery technologies**
  - **Imposed recovery targets**