Creating a Process-based Cost Model

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Session Outline

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

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

**Product Description**
- Part Geometry
- Material Properties
- Economic Characteristics
- Operating Conditions

**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
    - 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:
Comparison of Body Weights (incl. CIV inserts)

- Steel
- SMC
- RTM Glass
- Carbon Fiber

<table>
<thead>
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<th>Component</th>
<th>Bodyside</th>
<th>Floorpan</th>
<th>Cross Member</th>
<th>Front End</th>
<th>Roof</th>
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Uses of Cost Models in Technical Decision-making

- Comparing options
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  - Designs
    - Exogenous conditions
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Comparing Manufactured Costs:
Process-based models provide insight into novel options

- Steel
- RTM Glass
- SMC

Total Parts Production & Assembly Cost

Unit Cost per Body

Annual Production Volume (000s)

$1,000

$1,500

$2,000

$2,500

Uses of Cost Models in Technical Decision-making

- Comparing options
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  - Exogenous conditions

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BIW Cost Breakdown at 35,000 parts/year

Uses of Cost Models in Technical Decision-making

- Comparing options
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Comparing Cost Performance in Individual Subsystems

- **Steel:** 57 parts
- **RTM:** 2 parts + 20 inserts
- **SMC:** 9 parts + 20 inserts

### Floorpan / Cross member

- **Steel:** 9 parts
- **RTM:** 2 Parts
- **SMC:** 1 Part

### Roof

- **Steel:** 57 parts
- **RTM:** 2 parts + 20 inserts
- **SMC:** 9 parts + 20 inserts

Hybrid Body Scenarios

- **Steel**
- **Hybrid 5%**
- **Hybrid 30%**
- **RTM**
- **SMC**

Annual Production Volume (x 1000)
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.

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
**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 cost drivers
4. Quantifies necessary process performance hurdles
Identifying Key Cost Drivers
Models Provide Unequaled Resolution

(Monolithically Integrated Laser-Modulator)

- Other Fixed
- Equipment
- Other Var
- Materials

Unit Cost (USD)

Align
Assembly Test
Front-End
Chip Burn
Back-End
Burn-In
Spin-On-Assemble
Visual Test
Bench Test
Waldron

(APV 10,000)

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
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 cost drivers
4. Quantifies necessary process performance hurdles

Cost Sensitivity to Final Test Yield

(Monolithically Integrated Laser-Modulator)
**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)**
  - Monolithically Integrated Laser-Modulator
  - Discrete Devices, Single Package
  - Discrete Packages

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

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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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**PBCM**

**Production Cost**

**Process-based Cost Modeling (PBCM)**

- PBCM forecasts manufacturing requirements $\rightarrow$ 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

[Diagram showing the recycling process of an old car, including stages like dismantling, shredding, and processing, with labels for parts such as large castings, battery, and catalytic converter, and outputs like steel scrap, ASR, and aluminum.]