## ECDM People

**Faculty & Associates**
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- Scott Duncan, PhD ME
- Al Harjati, MS ISYE
- Jin Lai, PHD ISYE
- Felipe Roman PhD ME
- Michael Muir, MS ME
- John Reap PhD ME
- Emilie Tullis BS ME

**Government & Industry Partners**

Past and Current:
- Eastman Kodak Co.
- Ford Motor Company
- Georgia Duck
- Interface
- NSF
- Timbec
- Toccoa Metals
Development of Total Cost Models for Transmission Gear Design

- Develop Predictive Cost Models
- Reduce Total Costs through Design

Env. Impacts

Student: Bert Bradley
Advisor: Dr. Bert Bras
Development of Total Cost Models for Transmission Gear Design

- Information Gathering of Major Process Steps
  - Hobbing
  - Chamfering
  - Heat Treat
  - Grinding
  - Honing
  - Washing

- Summer Internship

Inputs and Outputs to a Grinding Operation

Industry Partner: Ford Motor Company
Environmentally Conscious Part Family Process Design

- Goal: Minimize facility environmental burdens

- Targets for yearly reduction
- Energy
- Water
- Raw Materials
- FACILITIES
- CO2 Targets for yearly reduction
- Air Emissions
- Waste Water
- Reduce all types of wastes

Student: Felipe Roman
Advisor: Dr. Bert Bras
Environmentally Conscious Part Family
Process Design

Minimize / Meet Targets

Tradeoffs
Environmentally Conscious Part Family Process Design

Gear Manufacturing Process

Compilation of Process Models

Environmental Process Model

INPUTS

- Cutting Tools
- Gear Blank
- Electricity / Pneumatic
- Process Parameters
- Machining Assumptions

OUTPUTS

- Rough-Cut Gear
- Chips
- Worn Tools
- Lost Coolant
- Noise

INPUTS

- New Coolant
- Recycled Coolant

OUTPUTS

- Jig & Fixture

Production Platform Constructal Theory Method

One Machine (Capacity x1) Two Machines (Capacity x2)

Machine A (Capacity A) Machine B (Capacity B) Machine C (Capacity C)

Cutting Rate w (w ft/s) Cutting Rate x (x ft/s) Cutting Rate y (y ft/s) Cutting Rate z (z ft/s)
Sustainable Packaging for International Logistics

From Shanghai, China

Longbeach, CA

Detroit, MI

Belleville, MI

Ford Assembly Plants

Students: Lei Deng, Al Harjati, Jin Lai & Emilie Tullis

Advisors: Dr. Bert Bras, Dr. Leon McGinnis & Dr. Chen Zhou
Sustainable Packaging for International Logistics

Case Study - Current State

- Poor environmental sustainability with cardboard
- Potential cardboard contamination of Powertrain parts
- Non-Value Added repack process at third party logistics

Damage on packaging

Part quality risk (rust)
Sustainable Packaging for International Logistics

Case Study - Alternative A

Alternative A
Recycle international packaging into Ford vehicle splash shields (example: Ford Maumee Stamping Plant).
Sustainable Packaging for International Logistics

- System Models
  - Decision Tree (Option set)
  - Integrated Inventory Analysis
    - Total Cost Accounting (TCA)
    - Environmental Impact Analysis (LCA)
    - Energy Consumption Analysis (ECA)
  - Environmental Indicators

- TCA Report
- LCA Report
- ECA Report

- Sensitivity Analysis
Life Cycle Assessment for the Design of Product Service Systems

Consumer Imaging Systems

Student: Michael Muir
Advisor: Dr. Bert Bras
Industry Case Study: Eastman Kodak Company
Life Cycle Assessment for the Design of Product Service Systems

Life Cycle Perspective:

Life Cycle Assessment Structure:

1) ISO 14040: Goal & Scope Definition

2) ISO 14041 Inventory Analysis

3) ISO 14042 Impact Assessment

4) ISO 14043 Improvement Assessment
Life Cycle Assessment for the Design of Product Service Systems

Description of Data Sources

- Externally performed LCA’s
- Product Teardowns
  - linked with existing data
- Kodak Internal Process Information
  - linked with internal & external data
Investigation of the Utility of Biomimicry in Environmentally Conscious Design

Bios-Mimikos

Past Inventions

Future Innovations

Student: John Reap
Advisor: Dr. Bert Bras
Industry Partner: Interface
Investigation of the Utility of Biomimicry in Environmentally Conscious Design

<table>
<thead>
<tr>
<th>Life’s Characteristics as ECDM Guidelines</th>
<th>Characteristic of Life</th>
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<tbody>
<tr>
<td><strong>Life’s Characteristics as ECDM Guidelines</strong></td>
<td><strong>Characteristic of Life</strong></td>
</tr>
<tr>
<td></td>
<td>Life builds macroscopic objects using sub-cellular scale additive manufacture</td>
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<tr>
<td></td>
<td>Life fits form to function</td>
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<tr>
<td></td>
<td>Life depends on water</td>
</tr>
<tr>
<td></td>
<td>Life is cyclic (processes) and recycles (material resources)</td>
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<tr>
<td></td>
<td>Life is locally attuned and resourceful</td>
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<tr>
<td></td>
<td>Life adapts and evolves</td>
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<tr>
<td></td>
<td>Life creates conditions conducive to life</td>
</tr>
<tr>
<td></td>
<td>Life coexists within a cooperative framework</td>
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</tbody>
</table>

Biomimicry Advisor: Dr. Dayna Baumeister

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Investigation of the Utility of Biomimicry in Environmentally Conscious Design

Life’s Characteristics:
1. Life builds…
2. Life fits…
3. …

Interface’s Entropy Carpet Tile


Industry Partner: Interface
Adapting Information-Gap Decision Theory for Use in Environmental Life Cycle Design

- **Goal**: support decisions in *product life cycle design* when lack of information creates *severe uncertainty*, e.g., in:
  - Material recovery value or demand
  - Customer behaviors
  - Force and thermal loads
  - Environmental impact of burdens
  - Etc.

- **How much robustness to severe uncertainty can/should designs achieve?**

- **Case studies**: Transmission End-of-life

Scott Duncan, PhD ME Student  Advisor: Dr. Bert Bras  Case Studies: Ford Motor Co.
Reference: A Traditional Approach to Design for Robustness to Input Uncertainty

Input Parameters
- Deterministic: \{X_1, X_2, X_3\}
- Probabilistic: \(X_4\)
- Interval: \(X_5\)

Analysis Models
- Cost (\$)
- LCA (m, E)
- Function (speed, strength)
- Etc. (weight)

Performance

Design A: \{D_1, D_2, D_3\}
Design B: \{D_1, D_2, D_3\}

Overall Score and Design Preference

Robust Multi-Criteria Decision Making

Targets & Preferences

Scott Duncan, PhD ME Student
Advisor: Dr. Bert Bras
Case Studies: Ford Motor Co.
**Proposal: Design for Robustness with “Not Much” Known About Input Uncertainty**

**Input Parameters**
- Deterministic: \{X_1, X_2, X_3\}
- Probabilistic: X_4

**Analysis Models**
- Cost ($)
- LCA (m, E)
- Function (speed, strength)
- Etc. (weight)

**Performance**
- Instead of maximizing, pick an acceptable worst case performance, \( r_c \), that you could settle for if that performance were guaranteed (or better)

Q: What if input deviation could, to the designer’s limited knowledge, be any of a large range of sizes?

A: Design for robustness to your

For each design option, compute the max level of input variation that it can sustain and still guarantee \( r_c \).

**Preferred**
- Design A: \{D_1, D_2, D_3\}
- Design B: \{D_1, D_2, D_3\}

**Targets & Preferences**
- Robust Multi-Criteria Decision Making

Scott Duncan, PhD ME Student  Advisor: Dr. Bert Bras  Case Studies: Ford Motor Co.
Key ECDM Concepts

- Environmental issues can be considered earlier in the development cycle if we move from reactionary analysis of existing systems to developing predictive models.

- Incorporating industry internships and case studies with academic research provides a richer experience and lessons that are applicable to academia and industry.