System analysis and optimization in design for digital manufacturing

Guiping Hu (IMSE)
Randy Boeckenstedt (InTrans)
Need and Industrial Relevance

Research Thrust Area: Thrust III: Design Optimization (Supply Chain Models)

- Assess transportation dependency
  - truck and rail
- Prelude to optimization
  - siting, scaling, positioning
- Premise:
  - Cost of heavy-duty trucking will rise relative to rail
    - Energy and Infrastructure
Project Goals

- **Initiate interdisciplinary study**
  - IMSE and InTrans

- **Develop new measures**
  - Link freight dependencies to consumer markets

- **Initiate optimization methods**
  - Macro and enterprise

- **Position e-design as a fuel alternative**
Objectives

- **Define a predictive model**
  - Calculate “benchmark” freight flow dependencies
    - Key base materials
    - Traditional systems
    - Traditional consumer markets

- **Use the model to formulate:**
  - Performance metrics
  - Analyses
  - Preliminary optimization methods
Approach and Methods

- **Intrans will assemble data**
  - IMSE will supervise / guide application

- **Origin and destination data**
  - Commodity Flow Survey …
  - BEA Input-Output Accounts, Census Reports, etc.

- **Indexed to longitude and latitude**
  - Supply side at county level (3000 points)
  - Demand side (i.e., retail) at “place” level (25000)

- **Cumulative freight flows**
  - ton-miles by rail or truck …
Approach and Methods

- **Predictive model**
  - Origins of base materials
  - Movement through sequential processing and distribution
  - Destination = consumer markets
  - Generate input data for optimization
    - Tested against aggregate totals
  - Extract and analyze targeted characteristics:
    - Optimize shipping level (25-ton semi or 100-ton rail car?)
    - By population density, region, input material … etc.
Outcome/Deliverables

- Peer reviewed publications, final report, Quarterly updates
- Centralized or Localized?
  - Finished products distributed broadly by truck
    .... or bulk material positioned by consumers via rail?
  - What are key transportation criteria?
    • e.g., How does population density affect operating scale?
    • How can issues be measured, understood, and accepted by a broad constituency?
Impact

- e-Design = fuel and infrastructure alternative

Mass Production/ JIT

- Common Base Materials
- Common Applications
- Moved about in SMALL BATCHES (By Truck)

Desired Project Outcome

- Common Base Materials
- Multiple Applications
- Distributed in BULK (By Train)
- Local Materials? ... Recycling? ... Bio-based?
# Project Duration & Proposed Budget

- **12 months**
- **$65,000**

Project Duration (plan and timeline):

<table>
<thead>
<tr>
<th>Milestone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary survey of data and literature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data formulation strategy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictive Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision and Optimization Modeling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Conclusions, Report and Presentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>