Overview

- Manufacturing systems can be understood like any complex engineered system.

- Engineers must have intuition about these systems in order to design and operate them most effectively.

- Such intuition can be developed by studying the elements of the system and their interactions.

- Using intuition and appropriate design tools can have a big payoff.
Basic Issues

• Frequent new product introductions.
• Product lifetimes often short.
• Process lifetimes often short.

This leads to short factory lifetimes and frequent building and rebuilding of factories.

There is little time for improving the factory after it is built; it must be built right.
Basic Issues

- Tools to predict performance of proposed factory design.
- Tools for optimal real-time management (control) of factories.
- Manufacturing Systems Engineering professionals who understand factories as complex systems.
Basic Issues

- Factories are full of random events:
  - machine failures
  - changes in orders
  - quality failures
  - human variability

- The economic environment is uncertain:
  - demand variations
  - supplier unreliability
  - changes in costs and prices
Basic Issues

Therefore, factories should be

- *designed* and *operated*

to minimize the

- *creation, propagation, or amplification*

doing uncertainty, variability, and randomness.
• **Analysis:** given a proposed design, predict its performance.
  ★ production rate, inventory, lead time, quality, etc.

• **Design:** given a partial design, select specified items for best performance or profitability.
  ★ buffer sizes, machine selection.
Factory Analysis and Design

• Start with small, simple, “toy” systems. Understand them thoroughly.
• Add features and complexity step by step to make our methods increasingly realistic and practical.
• Two-machine lines: production rate, inventory.
• Long lines by decomposition.
• Quality modeling and yield analysis.
What can you say about the optimal buffer size?

How should it be related to $r_i$, $P_i$?
Decomposition breaks up systems and then reunites them.

Conceptually: put an observer in a buffer, and tell him that he is in the buffer of a two-machine line.

Question: What would the observer see, and how can he be convinced he is in a two-machine line? Construct the two-machine line. Construct all the two-machine lines.
Factory Analysis and Design

Decomposition

Line Design

Solution

![Graph showing buffer sizes for different cases]

- **Case 1** - All Machines Identical
- **Case 2** - Machine 5 Bottleneck - MTTF = 100
- **Case 3** - Machine 5 Bottleneck - MTTR = 21

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<tr>
<th>Line</th>
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<tr>
<td>Case 1</td>
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<tr>
<td>Case 2</td>
<td>485</td>
</tr>
<tr>
<td>Case 3</td>
<td>523</td>
</tr>
</tbody>
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Versions:

- The **Good** state has 100% yield and the **Bad** state has 0% yield.

- The **Good** state has high yield and the **Bad** state has low yield.
Factory Operation

- Evaluate various policies by decomposition, including kanban, CONWIP, etc.
- Real-time scheduling of setup changes.
Industry Collaboration and Impacts

- HP
- GM
- Peugeot
- Philips
- ... and others.