Agenda

Web Resources
Schedule
Factory Physics

(New Assignment
Chapter 11: Study Q’s 1-4
Chapter 12: Problems 1, 2, 4, 5)

Web Resources
http://sdmines.sdsmt.edu/sdsmt/directory/courses/2009fa/tm663M021-099
I have most of your exams graded.
Have entered results in D2L.
The Human Element in Operations Management

For as laws are necessary that good manners may be preserved, so there is a need of good manners that laws may be maintained.

– Machiavelli

We hold these truths to be self-evident.

– Thomas Jefferson

Operations Management Frameworks

Traditional Optimization Framework:
- perfect information
- perfect control
- leverage in quality of solution (policy)

Factory Physics Framework:
- information captured in key measures (e.g., SCV's)
- intuition more important than control
- leverage from working with system's natural tendencies

ICB Portfolio Framework:
- information system part of management problem
- control not always optimal
- buffers explicitly acknowledged

Tentative Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Chapters Assigned</th>
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ICB Portfolio Contrasts

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<th>CONWIP</th>
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<td>Information</td>
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<td>MPS</td>
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<td>WIP position</td>
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<td>output tally</td>
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<td>dispatching</td>
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<td>Controls</td>
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<td>leadtimes</td>
<td>WIP level</td>
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<td>PORs</td>
<td>production qty</td>
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<td>lot sizing</td>
<td>work ahead window</td>
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<td>expediting</td>
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<td>MPS smoothing</td>
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<td>Buffers</td>
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<td>safety lead time</td>
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<td>safety stock</td>
<td>capacity</td>
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<td>excess WIP</td>
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Human Connections

Information:
- complexity
- “off line” information

Control:
- skill levels
- learning curves

Buffers:
- conceptual understanding
- flexibility
- Incentives:
- piecework
- “real” measures

Implementing Change:
- burnout
- champions

Self-Interest

Self-Interest Law: People, not organizations are self-optimizing.

Implications:
- “Optimal” strategies may not produce optimal results.
- Constraints can be good!
Diversity

**Individuality Law:** People are different.

**Theory X vs. Theory Y:**
- empowerment
- officer vs. enlisted mentality

**Incentive Systems:**
- team-oriented incentives
- social component of work

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**Toyota Sewn Products System**

Note: performance best when workers arranged slowest to fastest (i.e., because blocking is minimized).
Advocacy

Advocacy Law: For any program, there exists a champion who can make it work—at least for a while.

Upside of Champions:
• selling the “vision”
• motivating the troops

Downside of Champions:
• risk of oversell
• overreliance can prevent institutionalization of change

---

Burnout

Burnout Law:

People get burned out.

Why?

Can you blame them?

---

Planning vs. Motivating

Question: How high to set the bar?
Responsibility and Authority

Responsibility Law: Responsibility without commensurate authority is demoralizing and counterproductive.

Example: Deming's Red Bead Experiment

Deming’s Red Bead Experiment

Human Element Takeaways

1. People act according to self-interest.
2. Individuals are different.
3. Champions can have powerful positive and negative consequences.
4. People can burn out.
5. There is a difference between planning and motivating.
6. Responsibility should be commensurate with authority.
Total Quality Manufacturing

Saw it on the tube
Bought it on the phone
Now you’re home alone
It’s a piece of crap.

I tried to plug it in
I tried to turn it on
When I got it home
It was a piece of crap.

– Neil Young

The Opportunity

Rhetoric:
• customer-driven quality
• quality circles
• SQC courses
• “quality speak”

Reality:
• many poor products
• unbelievably rude service
• uncoordinated use of SQC
• complacency?

The Opportunity (cont.)

Quality Implications:
• quality promotes cycle time reduction and vice versa
• quality promotes variability reduction and vice versa
• quality promotes better management and vice versa
Attributes of Quality

Quality Definitions:

- **Transcendent**: innate excellence or “I know it when I see it” view.
- **Product-based**: function of product attributes or “more is better” view.
- **User-based**: customer satisfaction or “beauty is in the eye of the beholder” view.
- **Manufacturing-based**: conformance to specifications, related to “do it right the first time” view.
- **Value-based**: price/performance or “affordable excellence” view.

Attributes of Quality (cont.)

Customer Orientation:
- customer satisfaction depends on **external** quality
- external quality depends on **internal** quality
- quality must address product, process, system

Promoting Internal Quality:
- error prevention
- inspection improvement
- environment enhancement

Dimensions of Quality

- Quality of **design**: Performance, Features, Serviceability, Aesthetics, Perceived Quality, Reliability, Conformance, Durability
- Quality of **process** conformance to design = process capability
Statistical Quality Control

Acceptance Sampling:
- 100% inspection
- statistical sampling

Process Control:
- continuous monitoring
- indication of “out of control”

Design of Experiments:
- trace causes of problems
- many tools (factorial, block, nested designs, Taguchi, etc.)

Statistical Process Control

Natural Variation
- relatively small
- due to uncontrollable sources

Assignable Cause Variation
- larger
- can be traced to causes
- cause process to be out of control

Challenge of SPC: separate assignable cause from natural variation.

Basic SPC Mechanics

Null Hypothesis: samples are coming from a process with mean \( \mu \) and standard deviation \( \sigma \)

Procedure:
1) Observe samples of size \( n \). Under null hypothesis, these will have mean \( \mu \) and standard deviation \( \sigma_{s} = \sigma / \sqrt{n} \).
2) Compare sample mean, \( \overline{x} \) to control limits:
   - LCL = \( \mu - 3\sigma_{s} \)
   - UCL = \( \mu + 3\sigma_{s} \)
3) If sample mean is outside of range between LCL and UCL, then observation is designated as assignable cause variation, indicating out-of-control situation.
SPC Example

Problem: control diameter of hole in steel castings
- desired nominal diameter of \( \mu = 10 \) mm
- observations have shown \( \sigma = 0.025 \) mm

Process: every 2 hours a casting is randomly selected, so

\[
\sigma_x = \sigma / \sqrt{n} = 0.025 / \sqrt{1} = 0.025
\]

\[
\text{LCL} = \mu - 3\sigma_x = 10 - 3(0.025) = 9.925
\]

\[
\text{UCL} = \mu + 3\sigma_x = 10 + 3(0.025) = 10.075
\]

Note: variability would be reduced by taking \( n>1 \), due to pooling.

SPC Example Chart

Control Chart Patterns

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Description</th>
<th>Possible Causes</th>
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<tbody>
<tr>
<td>Normal</td>
<td>Random Variation</td>
<td></td>
</tr>
<tr>
<td>Lack of Stability</td>
<td>Assignable (or special) causes e.g. tool, material, operator, overcontrol</td>
<td></td>
</tr>
<tr>
<td>Cumulative trend</td>
<td>Tool Wear</td>
<td></td>
</tr>
<tr>
<td>Cyclic</td>
<td>Different work shifts, voltage fluctuations, seasonal effects</td>
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Continuous Improvement

**SQC monitoring**

**Lower Control Limit**

**Hypothesized process mean**

**Upper Control Limit**

**F(z)**

99.74%

**Signal that a special cause has occurred**

Control

Improve

Uses of SPC

**Product Quality**

- dimensions and other physical attributes
- fraction nonconforming
- range of attributes (for monitoring variability)

**Times**

- process times
- repair times

**Other Non-Quality Applications**

- tracking throughput
- due date quoting

Six Sigma Foundations

Centered process

Process defined by 1.5σ

**Percent Nonconforming**

Centered: 4.6%

Skewed: 10.9%
Six Sigma Terms

DMAIC: Define, Measure, Analyze, Improve, Control

Five Roles:

Executive Leadership

Champions: from ranks of upper management, mentor black belts

Master Black Belts: Support Black Belts in Statistics & 6σ

Black Belts: Lead 6σ projects

Green Belts: Common training level, may lead projects

Yellow Belts: Common training level, but not lead projects

White Belts: Minimal introductory training level
Quality and Logistics

Quality and Cost:
- cost increases with quality? (e.g., better materials)
- cost decreases with quality? (e.g., less correction cost)
- reality is a balance

Quality Promotes Logistics:
- Law: Variability degrades performance
- Law: Congestion affects increase nonlinearly with utilization
- yield loss and rework are major sources of variability and lost capacity.

Logistics Promotes Quality:
- excess WIP obscures problems and delays/delays diagnosis
- excess WIP magnifies losses
- excess cycle time degrades quality of service

Rework

Rework Law: For a given throughput level, rework increases both the mean and standard deviation of the cycle time of a process.

Implications: degraded performance through
- lost capacity
- increased variability

Possible Cures:
- eliminate rework
- use non-bottleneck for reworking
- shorten rework loop

Rework on a Single Station

\[ r = \frac{1}{3} \quad t = 1 \quad 1 - p \]

\[ p \]

Mean Cycle Time

0 10 20 30 40 50 60
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
Rework in a Line

Defect Detection

Quality and the Supply Chain

Quality and the Supply Chain

Importance:
• all manufacturing systems involve purchased parts
• trend toward outsourcing and "virtual manufacturing"
• a chain is only as good as its weakest link

Vendor Quality:
• product quality
• service quality

Assembly Systems:
• magnify impacts of vendor quality problems
• require effective vendor selection/management
Safety Lead Times in Assembly Systems

Required Service:

- Single Component: 95% service level
- 10 Component Assembly: If each has 95% service then

\[ \text{Prob(All components arrive on time)} = 0.95^{10} = 0.5987 \]

so to get 95% service on the assembly we need each component to have

\[ p = 0.95^{10} = 0.9949 \]

Consequences:

- Single Component:
  - Supplier 1: 14 day lead time
  - Supplier 2: 23 day lead time
- 10 Component Assembly:
  - Supplier 1: 16.3 day lead time
  - Supplier 2: 33.6 day lead time

Effect of Variability on Purchasing Lead Times

PDF of Delivery Time

Supplier 1

Supplier 2
Effect of Variability on Purchasing Lead Times (cont.)

Circuitize: Current Situation

Basic Problems:
- failure to make 3000 boards per day
- long CT (substantial part of 34 day CT)

Symptoms:
- high WIP
- 6% defect level
  - scrap at IP
  - send aheads, test panels, rework at EP
- highly variable expose times (20 min for some operators, 40 min for others)
- clean room not very clean

Circuitize: Layout
Circuitize: Capacity Analysis

Detractors: must account for setups, failures, rework, operator unavailability.

IP Line:
- IP has tighter capacity than EP.
- Trouble spots are preclean/lamination/punch and expose.

EP Line:
- EP has capacity for 3000 panels/day at 6% recycle (but not 10%).
- WIP is comparable to IP. EP is a variability bottleneck!
- Can’t make close to 3000 if first job is held for send aheads.
- Holding second job for send aheads has minor impact on capacity.

Circuitize: Recommendations

Keep IP DES loaded as fully as possible
- Never starve for lack of operator.
- This controls IP throughput.

Ensure capacity of IP Preclean/Lamination/Punch
- Cover preclean though breaks when room for WIP in clean room.
- Buy extra punch and maintain parallel dies to eliminate setup.

Circuitize: Recommendations (cont.)

Improve IP Expose Capacity
- Certify operators (6 no recycle jobs 3 days in a row)
- Involve operators in hiring process
- Tighten shift changes and use floaters to cover lunches.
- Use lead technicians to oversee flow (diazos, problems, etc.).
- Pursue extended life diazo program
- Add extra machine if necessary.

Quality
- Improve cleanliness to increase yield
- Preserve old diazos to trace cause of defects
- Document effectiveness of policies (e.g., send aheads).
Circuitize: Outcome

Steps:
• Better housekeeping/training reduced recycle below 2%, making send aheads unnecessary.
• Extended life diazo and better personnel management made extra IP exposure machine unnecessary.
• Line replicated in improved format to accommodate growing demand.

Results:
• Capacity increased to near 3000 panels/day
• Dramatic decrease in CT to approximately one day.
• Improved line replicated to accommodate increased demand.

Conclusions
• Good quality supports good logistics
• Good logistics supports quality improvement
• Good quality at the supplier level promotes good logistics and quality at the plant level