Standard Work for Optimal Inventory Management

Putting practical science to work
Presenter

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COO, Factory Physics Inc.

- 27 years in manufacturing
  - JVC – manufacturing engineering
  - Honeywell (AlliedSignal) – general management
  - Three entrepreneurial ventures – executive management

- Education et al
  - BSME, MSME, MBA
  - President-Elect IIE Work Systems Division
  - Plays tennis, paddle, golf, softball all to varying levels of average, likes fly fishing

- Factory Physics for Managers, with Bell and Spearman, April 2014
Agenda

- Practical Science
- Inventory Planning Policy
- Information Technology Usage
- Using Your Own System
Goals

1. Provide a quick overview of Factory Physics Science.

2. Review inventory practice as a source for standard work controls.

3. Provide an outline for a different approach to manage inventory with your own systems.
Factory Physics Science

An overview
Answers from science ...

- What to make
- When to make it
- How much to make
- How many people and machines needed.
- How much inventory to have.

High On-time delivery, low cost, low inventory
What are the right questions?

High Long Term Profitability

Low Costs

Low Unit Costs

High Throughput

High Utilization

Low Inventory

Less Variability

Short Cycle Time

Low Utilization

High Inventory

More Variability

High Sales

Quality Product

Fast Response

High Customer Service

Many products

Management typically bounces back and forth and calls it continuous improvement.
The Fundamental Factory Physics Framework

Two essential components
- Demand
- Transformation
  - Flows
  - Stocks

Buffers develop when variability is present.

Only three buffers:
1. Inventory
2. Time
3. Capacity

A practical, scientific approach.
Operations Strategy: Choose the future!

Operations strategy is selecting the “portfolio” of:

- Inventory Buffer—money tied up in inventory
- Time Buffer—responsiveness to customer (backorder time, fill rate)
- Capacity Buffer—replenishment frequency (setups, purchase orders)
- Variability—in demand, forecast, and replenishment

Portfolio management determines performance and profitability.
How it Works

There’s physics behind Factory Physics science. Behind generic IT and continuous improvement, not so much.

\[
\begin{align*}
    dp &= (\{p, H\} - \eta p) \, dt + \beta dW \\
    dq &= \{q, H\} \, dt \\
    p(0) &= p_0 \\
    q(0) &= q_0
\end{align*}
\]
Inventory Planning Policy

What's the big deal?
Goals of Inventory Planning

- High Customer Service
  - On-time delivery

- Low Inventory Levels
  - Raw Material and Finished Goods

- High Utilization
  - Keep the lines running (RM)
When to Order?
How Much to Order?

- Order early enough to get on time … but not so early to increase inventory.

- Order enough for efficiency … but not so much to increase inventory.
Policies

- Many different policies
  - ROP, ROQ aka \((Q,r)\)
  - MRP—time-phased reorder point
    - Days of supply, safety stock, etc.
  - Order up-to, Min-max
  - Periodic review, continuous review

- Illustrate concepts with continuous review \((Q,r)\) policies
  - Can translate to other policies as well
  - Implement Time-phased reorder point or \((Q,r)\)
(Q, r) Policies

- Order Q items when the Inventory Position hits or goes below r

- Inventory Position = 
  \[ \text{On Hand} + \text{On Order} - \text{Backorders} \]

- Track Inventory Position not on hand only!
(Q,r) Policies (cont’d)

- Q represents cycle stock

- \( r = \text{Avg Replenishment Time Demand} + \text{Safety Stock} \)

- Safety Stock considers
  - Variability in demand
  - Variability in supply (LT)
  - Amount ordered
Inventory Terminology

\[ r = \text{reorder point}; \quad Q = \text{reorder quantity} \]
\[ RT = \text{average replenishment time} \]
Inventory Position Example

Inventory Position = On Hand + On Order - Backorder

New orders based on Inventory Position

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Inventory Position Provides System Control

Always between \( r+1 \) and \( r+Q \). Completely in planner’s control.
Determining Control Limits: Setting Optimal Policies

Too simple:
- EOQ does not consider randomness

Wrong:
- Traditional safety stock model,
  Safety Stock = \( z \) \( \text{SD(Replenishment Time Demand)} \)
  where \( z \) is from normal table

Wrong and Too Simple:
- ABC with fixed periods of supplies
Case Study: Fortune 500 Discrete Manufacturer with 100s of Plants Worldwide

- Use traditional ABC-like method for inventory control
- Such methods are “enshrined” in ERP systems such as SAP and Oracle
- What is the impact?

<table>
<thead>
<tr>
<th>Product Classes</th>
<th>% Demand Value</th>
<th>Days of Lot Size</th>
<th>Days of Safety Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>0-50%</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>A</td>
<td>50-80%</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>80-95%</td>
<td>45</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>95-100%</td>
<td>90</td>
<td>20</td>
</tr>
<tr>
<td>D</td>
<td>No demand</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>
Case Study: Actual ABC Policy vs. Optimal Policy
Assuming the same customer service levels

Potential for reduction in inventory investment is huge!

*LT = Lead Time

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Inventory Behavior

› Key Driver—Variance of Replenishment Time Demand—VRTD

› As VRTD goes up
  • Average inventory goes up
  • Fill rate goes down

\[
\sigma^2 = \ell \sigma_D^2 + d^2 \sigma_L^2
\]

Inflation term due to demand variability
Inflation term due to supply variability

Must take all components into account for optimal control.
Efficient Frontiers for Inventory Policy

Set Strategy with Optimal Global Policies

Execute with Item Specific Policies
Information Technology Usage

“Think? Why think! We have computers to do that for us.”
- Jean Rostand, French biologist and philosopher.
Classic Scheduling—MRP/ERP

- **Benefits** —
  - Simple paradigm, hierarchical approach
  - Computers handle a tremendous amount of detail

- **Problems** —
  - MRP assumes that lead times are an attribute of the part, independent of the status of the shop or supplier
    - MRP uses pessimistic lead time estimates
  - MRP performs lot sizing without considering capacity
    - Lot sizes are often too large
    - No optimization of PO quantities

- **Spreadsheets Everywhere!**
Modern Scheduling—APO/APS

- Advanced Planning and Scheduling
  - **Benefits** – Better for complex situations
  - **Problems** –
    - Does not consider randomness
    - Cannot be optimal—must use heuristics
    - Schedule the average—the Happy Path
    - Promotes nervousness
      - □ Reschedule often
The MRP Planning and Control World

Pretty straightforward, nothing complicated about it.
Responding to change.

Supplier’s going to be late.

MRP message: Pull in!

Customer delays shipment.

MRP message: Push out!
Natural Behavior of Operations Logistics

The world is full of uncertainty.

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ERP/MRP model response

The ability to respond quickly does not guarantee good control.
Using Your Own System

“Computers are useless. They can only give you answers.”
- Pablo Picasso
Standard Work for Inventory Control

1. Determine expected ranges of demand and replenishment time.

2. Set policies to achieve required goals of:
   - Fill Rate
   - Customer service
   - Cost

3. Control system to ensure daily execution is within control limits.

4. Adjust only when out of control
Control

- Stock points
  - Inventory position below lower limit
    - Release optimal order size
  - Inventory position above upper limit
    - Cancel orders
    - Sell inventory
    - Wait for burn off
## Policy Monitor: \((Q,r)\) Approach

<table>
<thead>
<tr>
<th>SKU</th>
<th>Inventory</th>
<th>On Order</th>
<th>Back Orders</th>
<th>Reorder Point</th>
<th>Reorder Qty</th>
<th>Q+r</th>
<th>Inv Position</th>
<th>Delta</th>
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</thead>
<tbody>
<tr>
<td>Item 1</td>
<td>60,300</td>
<td>0</td>
<td>0</td>
<td>80,000</td>
<td>30,000</td>
<td>110,000</td>
<td>60,300</td>
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<td>1,239</td>
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<td>0</td>
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<td>10,000</td>
<td>35,000</td>
<td>11,239</td>
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<td>0</td>
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<td>10,000</td>
<td>45,000</td>
<td>24,407</td>
<td>-10,593</td>
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<td>0</td>
<td>20,000</td>
<td>10,000</td>
<td>30,000</td>
<td>9,521</td>
<td>-10,479</td>
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<td>0</td>
<td>15,210</td>
<td>6,310</td>
<td>21,520</td>
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<td>-10,210</td>
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<td>Item 6</td>
<td>5,948</td>
<td>40,000</td>
<td>0</td>
<td>50,000</td>
<td>20,000</td>
<td>70,000</td>
<td>45,948</td>
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<td>30,000</td>
<td>22,091</td>
<td>0</td>
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<td>Item 10</td>
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<td>80,000</td>
<td>20,000</td>
<td>100,000</td>
<td>95,872</td>
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<td>Item 11</td>
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<td>648</td>
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<td>3,000</td>
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<td>2,000</td>
<td>2,604</td>
<td>604</td>
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<td>Item 16</td>
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<td>0</td>
<td>5,500</td>
<td>12,000</td>
<td>17,500</td>
<td>18,160</td>
<td>660</td>
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</tbody>
</table>

Policy Compliance (1) Number of Part Numbers

Number of Parts By Policy Range

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Policy Compliance (2)
Quantity of Noncompliant Pieces

Quantity of Units Outside of Policy Compliance

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of Units</th>
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</thead>
<tbody>
<tr>
<td>16-Mar-2012</td>
<td>17,194</td>
</tr>
<tr>
<td>19-Mar-2012</td>
<td>20,128</td>
</tr>
<tr>
<td>23-Mar-2012</td>
<td>18,987</td>
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<td>25-Mar-2012</td>
<td>31,977</td>
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<tr>
<td>28-Mar-2012</td>
<td>26,958</td>
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<tr>
<td>23-Apr-2012</td>
<td>8,803</td>
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Policy Compliance (3)
Dollars of Noncompliant Pieces

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Policy Compliance (4) Quantity of Noncompliant Pieces by Buyer

Policy Compliance Units (Einstein)

124 Part Numbers

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Policy Compliance (5)
Dollars of Noncompliant Pieces by Buyer

Policy Compliance $$
(Einstein)

124 Part Numbers

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In Conclusion...

- The science and applied math of the Factory Physics framework provides an authentic advance in inventory control.
  1. Set expected response ranges for demand and replenishment ranges—a management decision.
  2. Use policies that provide acceptable performance in those ranges.
  3. Maintain control of your IT system. Manage by exception. Respond only to out of bounds change.

- The Factory Physics approach standardizes the framework so that strategies can be evaluated and tactics executed quickly to improve performance and profitability.
  - The very essence of standard work
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