Inventory Management
Multi-Items and Multi-Echelon

Chris Caplice
ESD.260/15.770/1.260 Logistics Systems
Nov 2006
Advanced Topics

- So far, we have studied single-item single location inventory policies.
- What about . . .
  - Multiple Items
    - How do I set aggregate policies?
    - What if I have to meet a system wide objective?
  - Multiple Locations – Multi-echelon
    - Deterministic demand
    - Stochastic demand
Inventory Planning Hierarchy

**Inputs**
- Transportation costs
- Facility fixed and variable costs
- Inventory costs
- Service levels

**Plan**
- Network Design

**Results**
- Inventory flow
- Network configuration
- Capacity

**Strategic**
- Annual/Quarterly

**Tactical**
- Quarterly/Monthly

**Operational**
- Weekly/Daily/Hourly

---

Jeff Metersky, Vice President Chainalytics, LLC
Rosa Birjandi, Asst. Professor Air Force Institute of Technology

MIT Center for Transportation & Logistics – ESD.260
Inventory Policies for Multiple Items

- Aggregate constraints are placed on total inventory
  - Avg total inventory cannot exceed a certain budget ($ or Volume)
  - Total number of replenishments per unit time must be less than a certain number
- Inventory as a portfolio of stocks – which ones will yield the highest return?
- Cost parameters can be treated as management policy variables
  - There is no single correct value for holding cost, \( r \).
  - Best \( r \) results in a system where inventory investment and service level are in agreement with overall strategy.
  - Cost per order, \( A \), is also not typically known with any precision.
  - Safety factor, \( k \), is set by management.
- Exchange Curves
  - Cycle Stock - Trade-off between total cycle stock and number of replenishments for different \( A/r \) values
  - Safety Stock – Trade-off between total safety stock and some performance metric for different \( k \) values
Exchange Curves

Set notation for each item:
- \( A = \) Order cost common for all items
- \( r = \) Carrying cost common for all items
- \( D_i = \) Demand for item \( i \)
- \( v_i = \) Purchase cost of item \( i \)
- \( Q_i = \) Order quantity for item \( i \)

Need to find:
Total average cycle stock (TACS) and Number of replenishments (N)

\[
TACS = \sum_{i=1}^{n} \frac{Q_i v_i}{2} = \sum_{i=1}^{n} \left( \sqrt{\frac{2AD_i}{rv_i}} \right) v_i
\]

\[
TACS = \sum_{i=1}^{n} \sqrt{\frac{AD_i v_i}{2r}} = \sqrt{\frac{A}{r}} \frac{1}{\sqrt{2}} \sum_{i=1}^{n} \sqrt{D_i v_i}
\]

\[
N = \sum_{i=1}^{n} \frac{D_i}{Q_i} = \sum_{i=1}^{n} \frac{D_i}{\sqrt{2AD_i}}
\]

\[
N = \sum_{i=1}^{n} \sqrt{\frac{rD_i v_i}{2A}} = \sqrt{\frac{r}{A}} \frac{1}{\sqrt{2}} \sum_{i=1}^{n} \sqrt{D_i v_i}
\]
Exchange Curves

Exchange curve for 65 items from a hospital ward.
Current operations calculated from actual orders.
Allows for management to set $A/r$ to meet goals or budget,
Suppose TACS set to $20,000 – we would set $A/r$ to be $\sim100$
Exchange Curves

- Now consider safety stock, where we are trading off SS inventory with some service metric.
- Different k values dictate where we are on the curve.
  Suppose that we only have budget for $2000 in SS – what is our CSL?
Exchange Curves

Set notation for each item:
- \( \sigma_{Li} \) = RMSE for item \( i \)
- \( k_i \) = Safety factor for item \( i \)
- \( D_i \) = Demand for item \( i \)
- \( v_i \) = Purchase cost of item \( i \)
- \( Q_i \) = Order quantity for item \( i \)

Need to find:
- Total safety stock (TSS) and
- Some service level metric
  - Expected total stockout occasions per year (ETSOPY)
  - Expected total value short per year (ETVSPY)

\[
TSS = \sum_{i=1}^{n} k_i \sigma_{Li} v_i
\]

\[
ETSOPY = \sum_{i=1}^{n} \frac{D_i}{Q_i} P[SO_i]
\]

\[
ETVSPY = \sum_{i=1}^{n} \frac{D_i}{Q_i} \sigma_{Li} v_i G(k_i)
\]
Exchange Curves

Exchange curve for same 65 items from a hospital ward.
Allows for management to set aggregate k to meet goals or budget,
Suppose TSS set to $1,500 – we would expect ~100 stockout events per year and would set $k = 1.6$
Replenishment in a Multi-Echelon System
What if I Use Traditional Techniques?

In multi-echelon inventory systems with decentralized control, lot size / reorder point logic will:

- Create and amplify "lumpy" demand
- Lead to the mal-distribution of available stock, hoarding of stock, and unnecessary stock outs
- Force reliance on large safety stocks, expediting, and re-distribution.
Impact of Multi-Echelons

Layers of Inventory Create Lumpy Demand
What does a DRP do?

Premises
- Inventory control in a distribution environment
- Many products, many stockage locations
- Multi-echelon distribution network
- Layers of inventory create "lumpy" demand

Concepts
- Dependent demand versus independent demand
- Requirements calculation versus demand forecasting
- Schedule flow versus stockpile assets
- Information replaces inventory

"DRP is simply the application of the MRP principles and techniques to distribution inventories"

Andre Martin
DRP Requirements

Information Requirements:
- Base Level Usage Forecasts
- Distribution Network Design
- Inventory Status
- Ordering Data

DRP Process:
- Requirements Implosion
- Net from Gross Requirements
- Requirements Time Phasing
- Planned Order Release
A Distribution Network Example

Plant

Central Warehouse

Regional Warehouse 1
- Retailer A
- Retailer B
- Retailer C

Regional Warehouse 2
- Retailer D
- Retailer E

Regional Warehouse 3
- Retailer G
- Retailer H
- Retailer I
# The DRP Plan

**Central Warehouse Facility**

<table>
<thead>
<tr>
<th>Q=200, SS=0, LT=2</th>
<th>NOW</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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Period Usage</strong></td>
<td></td>
<td>100</td>
<td>20</td>
<td>50</td>
<td>30</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td><strong>Gross Rqmt</strong></td>
<td></td>
<td>150</td>
<td>50</td>
<td>30</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Begin Inv</strong></td>
<td></td>
<td>150</td>
<td>50</td>
<td>30</td>
<td>180</td>
<td>50</td>
<td>50</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td><strong>Sched Recpt</strong></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Net Rqmt</strong></td>
<td></td>
<td>-</td>
<td>-</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Planned Recpt</strong></td>
<td></td>
<td>0</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>200</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>End Inv</strong></td>
<td></td>
<td>150</td>
<td>50</td>
<td>30</td>
<td>180</td>
<td>50</td>
<td>50</td>
<td>200</td>
<td>150</td>
</tr>
<tr>
<td><strong>Planned Order</strong></td>
<td></td>
<td>200</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Regional Warehouse One**

<table>
<thead>
<tr>
<th>Q=50, SS=15, LT=1</th>
<th>NOW</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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gross Rqmt</strong></td>
<td></td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td><strong>Begin Inv</strong></td>
<td></td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td><strong>Sched Recpt</strong></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Planned Recpt</strong></td>
<td></td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td><strong>End Inv</strong></td>
<td></td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td><strong>Planned Order</strong></td>
<td></td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

**Regional Warehouse Two**

<table>
<thead>
<tr>
<th>Q=30, SS=10, LT=1</th>
<th>NOW</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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Period Usage</strong></td>
<td></td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td><strong>Gross Rqmt</strong></td>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Begin Inv</strong></td>
<td></td>
<td>20</td>
<td>10</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td><strong>Sched Recpt</strong></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Net Rqmt</strong></td>
<td></td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>20</td>
<td>10</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td><strong>Planned Recpt</strong></td>
<td></td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td><strong>End Inv</strong></td>
<td></td>
<td>20</td>
<td>10</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td><strong>Planned Order</strong></td>
<td></td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

**Regional Warehouse Three**

<table>
<thead>
<tr>
<th>Q=20, SS=10, LT=1</th>
<th>NOW</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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Period Usage</strong></td>
<td></td>
<td>5</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td><strong>Gross Rqmt</strong></td>
<td></td>
<td>15</td>
<td>25</td>
<td>20</td>
<td>20</td>
<td>10</td>
<td>25</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td><strong>Begin Inv</strong></td>
<td></td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>25</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Sched Recpt</strong></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Net Rqmt</strong></td>
<td></td>
<td>-</td>
<td>15</td>
<td>5</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td><strong>Planned Recpt</strong></td>
<td></td>
<td>0</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td><strong>End Inv</strong></td>
<td></td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>25</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Planned Order</strong></td>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

---

**Note:**

Gross Rqmt = Period Usage + SS
Example: The DRP Plan

Regional Warehouse One
Q=50, SS=15, LT=1

<table>
<thead>
<tr>
<th></th>
<th>NOW</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>
</tr>
</thead>
<tbody>
<tr>
<td>Period Usage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Rqmt</td>
<td></td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Begin Inv</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Sched Rcpt</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Net Rqmt</td>
<td></td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan Rcpt</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>End Inv</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>POR</td>
<td></td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Forecast
Example: The DRP Plan

Regional Warehouse Two
Q=30, SS=10, LT=1

<table>
<thead>
<tr>
<th>NOW</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>
</tr>
</thead>
<tbody>
<tr>
<td>Period Usage</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Gross Rqmt</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Begin Inv</td>
<td>20</td>
<td>10</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Sched Rcpt</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Net Rqmt</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Plan Rcpt</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>30</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>End Inv</td>
<td>20</td>
<td>10</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>POR</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>
Example: The DRP Plan

Regional Warehouse Three
Q=20, SS=10, LT=1

<table>
<thead>
<tr>
<th>NOW</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>
</tr>
</thead>
<tbody>
<tr>
<td>Period Usage</td>
<td>5</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Gross Rqmt</td>
<td>15</td>
<td>25</td>
<td>20</td>
<td>20</td>
<td>10</td>
<td>25</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>Begin Inv</td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>25</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Sched Rcpt</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Net Rqmt</td>
<td>15</td>
<td>5</td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Plan Rcpt</td>
<td>0</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>End Inv</td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>25</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>POR</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>
## The DRP Plan for All Locations

### Rolling Up Orders

<table>
<thead>
<tr>
<th></th>
<th>NOW</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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CENTRAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period Usage</td>
<td>100</td>
<td>20</td>
<td>50</td>
<td>30</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>POR</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>REGION ONE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POR</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>REGION TWO</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period Usage</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>POR</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td></td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>REGION THREE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period Usage</td>
<td>5</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>POR</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>
Example: The DRP Plan

<table>
<thead>
<tr>
<th></th>
<th>NOW</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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Period Usage</strong></td>
<td></td>
<td>100</td>
<td>20</td>
<td>50</td>
<td>30</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td><strong>Gross Rqmt</strong></td>
<td></td>
<td>100</td>
<td>20</td>
<td>50</td>
<td>30</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td><strong>Begin Inv</strong></td>
<td></td>
<td>150</td>
<td>50</td>
<td>30</td>
<td>180</td>
<td>150</td>
<td>50</td>
<td>50</td>
<td>150</td>
</tr>
<tr>
<td><strong>Sched Rcpt</strong></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Net Rqmt</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td><strong>Plan Rcpt</strong></td>
<td></td>
<td>0</td>
<td>0</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>200</td>
<td>0</td>
</tr>
<tr>
<td><strong>End Inv</strong></td>
<td></td>
<td>150</td>
<td>50</td>
<td>30</td>
<td>180</td>
<td>150</td>
<td>50</td>
<td>50</td>
<td>150</td>
</tr>
<tr>
<td><strong>POR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>200</td>
</tr>
</tbody>
</table>
Results and Insights

- DRP is a scheduling and stockage algorithm -- it replaces the forecasting mechanism above the base inventory level
- DRP does not determine lot size or safety stock -- but these decisions must be made as inputs to the process
- DRP does not explicitly consider any costs -- but these costs are still relevant and the user must evaluate trade-offs
- DRP systems can deal with uncertainty somewhat -- using "safety time" and "safety stock"
Evolution of Inventory Management

💎 Traditional Replenishment Inventory:
- Lot Size/Order Point Logic
- Single item focus
- Emphasis on cost optimization
- Long run, steady state approach

💎 The MRP/DRP Approach:
- Scheduling emphasis
- Focus on quantities and times, not cost
- Multiple, inter-related items and locations
- Simple heuristic rules
Evolution of Inventory Management

- MRP / DRP have limited ability to deal with:
  - Capacity restrictions in production and distribution
  - “set-up” costs
  - fixed and variable shipping costs
  - alternative sources of supply
  - network transshipment alternatives
  - expediting opportunities

- Next Steps in MRP/DRP
  - Establish a time-phased MRP/MPS/DRP network
  - Apply optimization tools to the network
  - Consider cost trade-offs across items, locations, and time periods
  - Deal with shortcomings listed above
A DRP Network Plan

What happens when actual demand in the short term doesn’t follow the forecast exactly....

How should I re-deploy my inventory to take the maximum advantage of what I do have?
A DRP Network Reality

- Plant
  - RDC1
    - LDC1
      - R1
    - LDC2
      - R2
      - R3
      - R4
  - RDC2
    - LDC3
      - R5
      - R6
    - LDC4
      - R7
      - R8

Higher than expected demand
Lower than expected demand
Optimal Network Utilization
### Information and Control Impacts

<table>
<thead>
<tr>
<th></th>
<th>Centralized Control</th>
<th>Decentralized Control</th>
</tr>
</thead>
</table>
| **Global Information** | ✓Vendor Managed Inventory (VMI)  
                        ✓DRP (some cases)  
                        ✓Extended Base Stock Control Systems | ✓DRP (most cases)  
                        ✓Base Stock Control |
| **Local Information**  | N/A                                                                                 | ✓Standard Inventory Policies: (R,Q), (s,S) etc. |
Questions?