Optimizing Cycle Stock and Lot Sizes: Balancing the Costs of Changeovers with Inventory

The Webinar will begin shortly.

Your phone has been muted, so please submit any questions via the Webex chat window.
## Invistics Company Overview

- **Software & Services to Optimize Cycle Stock and Lot Sizes**

- **Proven results with numerous customers:**
  - Reducing inventory 25-40%
  - Improving customer service by 10-15% points
  - Maximize use of capacity

- **Quick, low-risk fix for lot sizing problems**
  - Lot Size Optimization in both high-volume and high-mix facilities
  - Lot Size Optimization using web-based software and existing data

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### Introducing Our Speaker

**Tom Knight**  
Founder and CEO
Poll Question 1

**Question 1:** What is your Primary Improvement Objective for attending this Webinar?

- a.) Reduce Changeover costs
- b.) Reduce Inventory Holding costs
- c.) Improve Customer Service
- d.) All of the Above
- e.) Personal Education
Agenda

- Urgent Supply Chain Challenges
  - Beyond EOQ: Best Practices for Lot Size Optimization
    - Case Study
  - Sequencing Issues: Best Practices for Rhythm Wheels
    - Case Study
- Questions & Discussion
Urgent Supply Chain Challenges

– Complex global supply networks
– Fierce offshore competition
– More product variants and SKUs
– Shorter product life cycles
– More complexity within each plant and across the global supply chain
Product Proliferation is Hitting Every Industry

Increased demands by customers:
Consumer Products adding 20% more SKUs each year
Chemicals experiencing 60% volatility in some SKUs
Every Company Is Being Forced to Change

<table>
<thead>
<tr>
<th>Then</th>
<th>Now</th>
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<tbody>
<tr>
<td>• Stable demand</td>
<td>• Highly variable demand</td>
</tr>
<tr>
<td>• Repetitive</td>
<td>• Responsiveness</td>
</tr>
<tr>
<td>• Long runs</td>
<td>• Short runs</td>
</tr>
<tr>
<td>• High utilization</td>
<td>• Faster changeovers</td>
</tr>
<tr>
<td>• Dedicated equipment</td>
<td>• Shared equipment</td>
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</table>

High-volume

High-mix
Poll Question 2

Question 2: What Best Describes Your Product Mix?

- a.) High Volume, High Mix
- b.) High Volume, Low Mix
- c.) Low Volume, High Mix
- d.) Low Volume, Low Mix
Quick Notes on Terminology

Three similar terms that we will collectively refer to as ‘Lot Sizes’:

- **Lot Size**: Generally used in discrete industries to signify how many units of a product to make before changing over to a different product.

- **Batch Size**: Common term in chemicals, food, beverage and other process industries to denote the amount of product made at one time (often related to vessel or tank sizes).

- **Campaign Size**: Used by metals, pharmaceutical, and other industries, this indicates the number of individual lots or batches to produce before changing over to another product.
The Basic Lot Sizing Challenge

Find the “sweet-spot” between 3 objectives:

- Customer Service
- Changeover Costs
- Inventory Costs
Agenda

- Urgent Challenges
- Beyond EOQ: Best Practices for Lot Size Optimization
  - Best Practices for Implementing Rhythm Wheels
- Case Study
- Questions & Discussion
Four Levels of Maturity for Lot Size Optimization

Level 1: “Acoustical Lot Sizes”

Level 2: Economic Order Quantity

Level 3: Enterprise Resource Planning Heuristics

Level 4: Lot Size Optimization

Quality of Results
Maturity Level 1: Acoustical Lot Sizes

Increase lot sizes until the yelling stops

- Never allows root causes of manufacturing or supply chain performance to be addressed
- Risks significant excess inventory and increased cycle times
- May result in infeasible capacity plan
- Stressful for all involved
- Enables endless loop of ‘firefighting’
Maturity Level 2: Economic Order Quantity (EOQ)

Quantity = \sqrt{\frac{2 \times \text{Annual Sales} \times \text{Ordering Cost}}{\text{Carrying Cost}}}

- Holding Cost
- Ordering/Changeover Costs
- Total Costs

Annual Cost

$30,000

$25,000

$20,000

$15,000

$10,000

$5,000

$0

Order Quantity (units)

100

500

1,000

1,500

2,000

2,500

3,000

3,500

4,000

4,500

5,000

5,500

6,000

6,500

7,000

7,500

8,000

8,500

9,000

9,500

10,000

10,500

11,000

11,500

12,000

12,500

13,000

13,500

14,000

14,500

15,000

15,500

16,000

16,500

17,000

17,500

18,000

18,500

19,000

19,500

20,000

20,500

21,000

21,500

22,000
Where EOQ falls short

- EOQ drowns in high mix environments. It assumes:
  - Single Product - no product mix
  - No variability in Demand
  - Replenishment is Instantaneous
  - Infinite Capacity
  - No notion of customer service level

Quantity = $\sqrt{\frac{2 \times \text{Annual Sales} \times \text{Ordering Cost}}{\text{Carrying Cost}}}$
The effect of variability and high utilization

CT_q \approx V \times U \times t
\approx \left( \frac{c_a^2 + c_e^2}{2} \right) \left( \frac{u^{\sqrt{2(m+1)}-1}}{m(1-u)} \right) t_e

In a high mix plant, a line with utilizations above \sim 90\% begins to require infinitely large lot sizes and infinite inventory.
Maturity Level 3: Enterprise Resource Planning Heuristics

- Deterministic approaches (aka ‘Dynamic’ in SAP)
  - Assumes demand is known
  - Most ERP systems have multiple deterministic lot size approaches (Part-Period Balancing, Lot-for-Lot, Groff, etc.)
  - These are easy to understand and implement, but fail in the presence of any appreciable variability

- Stochastic approaches in ERP typically have one or more of the following issues
  - Lack consideration of both supply and demand variability
  - No way to visibly analyze results in a way that makes sense to the user
  - Often ignore capacity
  - Require inputs that are confusing to the user

- In both cases, the largest advantage is that these approaches are built right into existing ERP systems
Maturity Level 4: Lot Size Optimization

- Best-of-breed lot sizing approaches allow the following
  - Include both supply and demand variability
  - As a required step, conduct capacity analysis of the process
  - Analyze entire product mix concurrently
  - Require minimal special-expertise
  - Present results in an easy-to-visualize format
  - Use data already in ERP when at all possible
  - As an option: Include analysis of stocking levels as well
Total Cost Curve
Tradeoff of Holding Costs and Setup Costs
Poll Question 3

Question 3: Which Maturity Level for Lot Sizing is Your Company using?

a.) Level 1: “Acoustical” Lot Sizes
b.) Level 2: Economic Order Quantity
c.) Level 3: Enterprise Resource Planning Heuristics
d.) Level 4: Lot Size Optimization
Invistics Lot Sizer
Optimizes lot sizes, batch sizes, and/or campaign sizes

Current State: Effective Utilizations

<table>
<thead>
<tr>
<th>Process</th>
<th>Effective Utilization (%)</th>
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<tbody>
<tr>
<td>Weigh-in and MixD</td>
<td>88.6</td>
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<tr>
<td>Reactor</td>
<td>100.1</td>
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<tr>
<td>Semi-Finished Stg</td>
<td>42.4</td>
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<tr>
<td>Packaging</td>
<td>72.8</td>
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</table>

Recommendations

<table>
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<tr>
<th>Material Number</th>
<th>Material Description</th>
<th>Number of Setups</th>
<th>Setup Cost</th>
<th>Lead Time</th>
<th>Lot Size</th>
<th>Reorder Point</th>
<th>Target Service</th>
<th>Avg Inventory Level</th>
<th>Avg Inventory Cost</th>
<th>Total Cost</th>
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<td>VARIANT BL 3175A 0215.00 KG D09</td>
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<td>34625.77</td>
<td>386.95</td>
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<td>0.95</td>
<td>48113.99</td>
<td>466.77</td>
<td>753.21</td>
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</tbody>
</table>

Total Cost (Inv + Setups)
- Current Conditions: $26,816.66
- Optimized Value: $14,980.64
- Improvement: $11,836.02
Lot Size Optimization
Typical Inputs and Outputs

**Inputs**

**Product Data**
- Demand (mean and std dev.)
- Holding Cost
- Unit Cost

**Routing Data**
- Process Times (mean and std dev)
- Setup Times (mean and std dev)
- Changeover cost
- Min/Max allowable Lot Sizes

**Work Center Data**
- Reliability (MTTF/MTTR)
- Crewed Hours

**Target Performance**
- Customer Service
- Inventory

**Projected Performance**
- Setups Per Week
- Inventory
- Setup costs

**Outputs**
- Lot Sizes
- Inventory Targets

**Lot Sizer**
Agenda

- Urgent Challenges
- Beyond EOQ: Best Practices for Lot Size Optimization
  - Case Study
- Sequencing Issues: Best Practices for Rhythm Wheels
  - Case Study
- Questions & Discussion
# Case Study: Lot Size Optimization Best Practices

<table>
<thead>
<tr>
<th>Company</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td><strong>Products:</strong> High-Mix Specialty chemicals</td>
<td></td>
</tr>
<tr>
<td><strong>Characteristics:</strong></td>
<td></td>
</tr>
<tr>
<td>▪ Few raw materials transformed into many finished products</td>
<td></td>
</tr>
<tr>
<td>▪ Excessive working capital</td>
<td></td>
</tr>
<tr>
<td>▪ Suboptimal lot sizes contributed to</td>
<td></td>
</tr>
<tr>
<td>▪ Excessive cycle times due to too-large lot sizes for many SKUs</td>
<td></td>
</tr>
<tr>
<td>▪ Too frequent changeovers due to small lot sizes for some SKUs</td>
<td></td>
</tr>
<tr>
<td>▪ Capacity Concerns due to high utilizations</td>
<td></td>
</tr>
<tr>
<td>▪ Lot Sizing: Using Part-Period-Balancing (SAP Heuristic)</td>
<td></td>
</tr>
</tbody>
</table>
Approach Taken

1. Gathered needed data- *Not as intimidating as it appeared*
2. Performed lot size analysis- *Used Invistics software*
3. Analyzed results- *Big projected improvements*
4. Entered results into ERP- *Continued running their supply chain as usual, but with optimized lot sizes*
5. Measured the Results – *reduced change-over costs and inventory significantly*
## Lot Sizer Overall Summary

### Results: Summary

<table>
<thead>
<tr>
<th></th>
<th>Current Conditions</th>
<th>Optimized Value</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cycle Time (days)</td>
<td>203</td>
<td>166</td>
<td>37.02</td>
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<tr>
<td>Total Avg Inventory (Qty)</td>
<td>28,528,767</td>
<td>26,145,884</td>
<td>2,482,883</td>
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<tr>
<td>Total Avg Inventory ($)</td>
<td>$75,957,506</td>
<td>$69,765,615</td>
<td>$6,191,891</td>
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<tr>
<td>Total Weekly Setup Cost</td>
<td>$60,365</td>
<td>$57,691</td>
<td>$10,673</td>
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<tr>
<td>Total Weekly Inventory Holding Cost</td>
<td>$255,597</td>
<td>$234,761</td>
<td>$20,836</td>
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<tr>
<td>Total Weekly Cost (Inv Holding + Setups)</td>
<td>$323,962</td>
<td>$292,453</td>
<td>$31,509</td>
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</tbody>
</table>

### Chart:

- **Select Chart:** Cost Summary
- **Show Point Labels:**
- **Show X Axis Margins:**
- **Show as 3D:**

### Graph:

- **Result Summary**
  - Total Cost:
    - Current Condition: $68,365
    - Optimized Value: $57,691
  - Total Weekly Inventory Holding Cost: $255,597
  - Total Weekly Setup Cost: $234,761
LotSizer Overall Utilizations

<table>
<thead>
<tr>
<th>Workcenter Description</th>
<th>Workcenter Number</th>
<th>Availability (%)</th>
<th>Time to Process a Batch (hrs)</th>
<th>Avg. Setup Times (hrs) of Batches per Week</th>
<th>Calendar Hours</th>
<th>Crewed Hours</th>
<th>Uncrewed Hours</th>
<th>Setup Hours in Setup</th>
<th>Percentage of Setup</th>
<th>Processing Time (Hours)</th>
<th>Remaining Hours Available</th>
<th>Current Case Processing Time</th>
<th>Case: Setup and Downtime</th>
<th>Cur Case Avg Cap</th>
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<td>1,494</td>
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<td>11.8</td>
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<td>Mixing</td>
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<td>1.0</td>
<td>0.888</td>
<td>168</td>
<td>168.0</td>
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<td>Filling</td>
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<td>61.0</td>
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<td>19.2</td>
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<td>Packaging</td>
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<td>10</td>
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</table>

Chart Type: StackedColumn
Show Point Labels: ❑
Show X Axis Margins: ❑
Show as 3D: ❑
### Sample Output from Lot Sizer

<table>
<thead>
<tr>
<th>Material Number</th>
<th>Material Description</th>
<th>Recommended Lot Size</th>
<th>Current Lot Sizes (PPB)</th>
<th>Difference Between Recommended and Current Lot Sizes</th>
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<td>51,482</td>
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<td>74,528</td>
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<td>89,297</td>
<td>99,290</td>
<td>10,003</td>
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</table>
Optimized Lot Sizes:
Fewer very short runs, Fewer very long runs

Product Line B

Current:
PPB Avg Lot Size: 80,579
Recommended:
Avg Lot Size: 42,265
Analysis Summary

Capacity Constrained Line

- Annual Savings = $479,306

<table>
<thead>
<tr>
<th>SAP Lot Sizes</th>
<th>Recommended Lot Sizes</th>
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<td>$1,400,000</td>
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<tr>
<td>$1,200,000</td>
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<td>$200,000</td>
</tr>
<tr>
<td>$200,000</td>
<td>$0</td>
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‘What if’: Adding a Holding Tank

- Annual Savings = $6,000

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<th>2 Tanks</th>
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<tbody>
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<td>$60,000</td>
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<td>$40,000</td>
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<td>$20,000</td>
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<tr>
<td>$20,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>$10,000</td>
<td>$0</td>
</tr>
</tbody>
</table>

Recommendations show fewer changeovers for the less expensive materials. This frees up capacity, and ends up saving money overall (even though the qty of less expensive material on hand actually increases).

The additional tank allows less changeovers, but more material will be held. The overall cost impact using optimal lot sizes (sometimes less than a full tankful) allows for cost savings.
Results

- Within the next 12 months, the inventory levels decrease by $4.5 million without any sacrifice to customer service.

- These improvements were all realized by simply changing the lot size values in SAP to the values calculated by Lot Sizer.

- In addition, overall costs were decreased by $500k annually. This improvement was due to a combination of the improved lot sizes and reconfiguring of the tank farm as recommended during the project.
Agenda

- Urgent Challenges
- Beyond EOQ: Best Practices for Lot Size Optimization
  - Case Study
- Sequencing Issues: Best Practices for Rhythm Wheels
  - Case Study
- Questions & Discussion
Question 4: What software, if any, are you using to manage Cycle Stock and Lot Sizing?

a.) ERP System (SAP, Oracle, JDE, etc.)
b.) Homegrown Company Software
c.) Third Party Software
d.) No Software
Sequencing Issues

Some manufacturing plants have “sequence-dependent” change-over costs/times. Examples:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Sequence-Dependent Changeover Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food &amp; Beverage</td>
<td>Label changes are faster than flavor changes</td>
</tr>
<tr>
<td>Consumer Packaged Goods</td>
<td>Label changes are faster than container changes</td>
</tr>
<tr>
<td>Discrete Part Fabrication</td>
<td>Group similar sized parts together to avoid lengthy setups</td>
</tr>
<tr>
<td>Electronic Assembly</td>
<td>Group similar board sizes together to avoid lengthy setups</td>
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</tbody>
</table>

These plants need to optimize both lot sizes and production sequences
Introduction to Rhythm Wheels

- Sequences products on a repeating pattern or “wheel” to minimize changeovers times/costs
- Levels production and lowers demand volatility, while encouraging rapid wheel “frequency”
- Allows the plant to run optimized lot sizes while replenishing inventory stocking levels
- Enables the supply chain to find the sweet-spot that minimizes total costs
Best Practices for Designing a Rhythm Wheel

1. Establish initial policies and conditions:
   A) Decide minimum production quantities by SKU family (sometimes called min. campaign size)
   B) Determine initial sequence (assuming every part every interval (EPEI) to start)
   C) Optional: Estimate initial (non-sequence dependent) lot sizes

2. Optimize Cycle Stock - Design Rhythm Wheel by balancing load across time periods to minimize overall cost:
   A) Select a potential Rhythm Wheel Run Frequency (aka Cycle Length or Cadence)
   B) Group low volume SKU families into selected time periods (not EPIE => skip in some periods)
   C) Optional: Fine-tune sequence within each time period
   D) Recalculate load in each time period. If not balanced/acceptable: return to step 1A, 2A or 2B

3. Optimize Safety Stock - Right-size inventory levels by SKU
1. Update Materials Requirements Planning (MRP) with these parameters:
   A) Minimum/expected lot sizes
   B) Inventory min/max/safety stocks

2. Streamline implementation and Measure success & conformance:
   A) Automate replenishment using optimized inventory stocking levels
   B) Measure/reduce days Between production
   C) Celebrate success, and look for ways to further accelerate Rhythm Wheel Run Frequency

3. Refresh the parameters regularly, at least quarterly
# Cadence Advisor

## Designs Rhythm Wheels and Expected Benefits & Costs

### invistics  Cadence Advisor: Weekly Workbench

<table>
<thead>
<tr>
<th>Workcenter</th>
<th>Secondary Workcenter (override)</th>
<th>Weeks between runs (Freq. (Cases))</th>
<th>Production Per Run</th>
<th>Total Units per Cadence Cycle</th>
<th>Total shift-hrs per Cadence Cycle</th>
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<tbody>
<tr>
<td>5 Product 1</td>
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<td>5,417</td>
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</tbody>
</table>
Cadence Advisor Software to Design Rhythm Wheels

Inputs

Product Data
- Demand (mean)
- Holding Cost
- Unit Cost
- Sequencing attributes (for setups)

Routing Data
- Process Times (mean)
- Setup Times (mean)
- Setup costs and time (mean)
- Primary/Secondary work centers

Work Center Data
- Crewed Hours
- Minimum production times/quantities

Historical Data
- Historical Orders/Production Qtys and sequences by date

Current Performance

- Current Cadence (Frequency & Sequencing)
- Current Lot/Campaign Sizes by SKU
- Current Min. Production times & quantities

Outputs

- Updated Rhythm Wheel (Frequency & Sequencing)
- Updated Lot Sizes by SKU
- Updated Min. Production times & quantities
- Projected costs (cycle stocks + changeovers)

Projected Performance

- Projected Utilization by Line & Time Period
- Projected Setups Per Week & Setup Costs
- Projected Inventory & Inventory Costs
Cadence Advisor
Compare past change-overs/utilizations to expected future benefits, by Line

<table>
<thead>
<tr>
<th></th>
<th>Baseline Data</th>
<th>Workbench Data</th>
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<tbody>
<tr>
<td>Unutilized Hours</td>
<td>118.3</td>
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<td>Unplanned Downtime</td>
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<tr>
<td>Changeover Hours</td>
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<tr>
<td>Production Hours</td>
<td>39.6</td>
<td>38.4</td>
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</table>
**Cadence Advisor**
Helps Plants Update Their Rhythm Wheels & Sustain the Benefits Long-Term

---

**Cadence Advisor: Sequencer**

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<th>Wk #</th>
<th>Req’d</th>
<th>Seq #</th>
<th>SKU</th>
<th>Case Size</th>
<th>Bottle Size</th>
<th>Flavor</th>
<th>CO Type</th>
<th>CO Cost</th>
<th>CO Hrs</th>
<th>Approx Run Hrs</th>
<th>Approx Cases</th>
<th>Remaining Capacity</th>
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<td>$ 618</td>
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<td>22,181</td>
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</tbody>
</table>
Agenda

- Urgent Challenges
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  - Case Study
- Questions & Discussion
## Case Study: Best Practices for Rhythm Wheels

### Company Details

<table>
<thead>
<tr>
<th>Products: Consumer Packaged Goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics:</td>
</tr>
<tr>
<td>• Many finished goods SKUs running on a few shared production work centers</td>
</tr>
<tr>
<td>• Sequence dependent setups require thoughtful production sequencing</td>
</tr>
</tbody>
</table>

### Challenges

- Create a more level, repeatable production “cadence”
- Minimize overall costs (cycle stock carrying costs + changeover costs)
- Avoiding over-utilized lines
- When possible, shift production from one work center to another to balance utilization
Using Cadence Advisor

1. Create ‘from-to’ Changeover matrix, classifying each changeover by code
2. Determine overall Cadence Cycle
3. Create estimate of lot sizes for each SKU
4. Fill up capacity of each week in Cadence Cycle by allocating SKUs to acceptable periods
5. Sequence within each week to minimize changeover costs
6. Iterate as needed to arrive at cadence with minimal overall costs
## Cadence Advisor: Recommendations

Single view allows users to allocate products to a given week while sequencing on the fly.
In the case above, there were many extremely expensive setups, resulting in a recommendation for longer runs overall and fewer setups, with slightly higher cycle stock.
Agenda

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Poll Question 5

Question 5: What was the most relevant part of this Webinar for you?

- a.) Best Practices
- b.) Case Study
- c.) Introduction to Software Tools
- d.) Q&A
Thank You! Questions?

To learn more:
visit www.invistics.com

or call 800-601-3456

Tom Knight
Founder and CEO