Demand Driven Performance - Using Smart Metrics

Presented By:  Debra A. Smith, CPA, EMBA, Partner
Constraints Management Group

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Our Journey of Exploration

1995

The Power of Decoupling:
- $35M inventory decrease
- Lead time 90 to 14 days

1997

The Power of Vertical Integration:
- $30M inventory decrease
- ROI from 4 to 18%
- Lead time 3 weeks to 3 days

2010

Analyze Deep and Broad Product & Project Structures:
- ROI from 5 to 22%
- Lead time 24 to 10 weeks
- 6 X revenue .8 inventory increase

2011 - 2014

The Prioritized Share Equation & Hybrid Distribution:
- 45% decrease finished goods
- 18% decrease raw and pack
- 99.7% service levels
Becoming Demand Driven

Step 1  Accept The New Normal – Variability, Volatility and Complexity are here to stay.

Step 2  Embrace Flow and its implications for ROI.

Step 3  Design an operational model for flow.

Step 4  Bring the Demand Driven model to the organization – Implement.

Step 5  Use smart metrics to operate, sustain and drive improvement.
The New Normal Principles

Principle One – Flow is the first Law:
• The current focus of people and systems on unit cost minimization has little to no connection to driving Return on Investment (ROI).
• The way to drive ROI has everything to do with protecting, driving and increasing the flow of relevant materials and information.

Principle Two – Supply chain complexity & Volatility:
• Supply chain complexity has changed dramatically in the past three decades.
• Today’s supply chains are complex adaptive systems, CAS.
• CAS rules and math models are different and many are the opposite of the linear and additive assumptions embedded in today’s ERP information, costing and reporting systems.
The Game Has Changed

Principle 1 combined with Principle 2 have completely changed the game for supply chains.

Protecting and maintaining flow requires:

- Understanding Complex Adaptive System - CAS rules to manage variability and speed flow.
- New thinking and new rules to build the right tools.
- The right rules and tools are a prerequisite to Smart Metrics.
# CAS Rules Are Very Different

## System Traits

<table>
<thead>
<tr>
<th>The Method to Understand the System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Linear</strong></td>
</tr>
<tr>
<td>Linear systems can be understood by studying the individual part; the whole is the sum of its parts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System Predictability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Linear</strong></td>
</tr>
<tr>
<td>Linear system “state” is stable and predictable</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>System Output Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Linear</strong></td>
</tr>
<tr>
<td>The output of a linear system is proportional to its inputs</td>
</tr>
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<table>
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<th><strong>Complex</strong></th>
</tr>
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<tbody>
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<td>The output of nonlinear system is governed by a few critical points – the “lever point phenomena”</td>
</tr>
</tbody>
</table>
# CAS Are Very Different

<table>
<thead>
<tr>
<th>System Traits</th>
<th>Linear</th>
<th>Nonlinear Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematical Models of the System</strong></td>
<td>Gaussian statistical models (normal bell shaped distribution curve) - The sum of the averages are a predictable model of the system and the tails of the statistical distribution are ignored as anomalies.</td>
<td>Paretian statistical models – The tails of the distribution identify the few critical points that define the relevant information predict and manage nonlinear complex systems. They contain the “lever point phenomena”.</td>
</tr>
<tr>
<td><strong>System Output Maximization</strong></td>
<td>A linear system can be optimized.</td>
<td>A nonlinear system cannot be optimized but it can continually learn and improve. It can emerge to a higher order.</td>
</tr>
</tbody>
</table>
CAS and The Power of Pareto

The ratio rule of Paretian distribution models explain the large effects of the very few relevant system factors:

• 80/20 rule applies to linear systems;
• 99.9+/.1- applies to nonlinear systems;

These few points/factors determine system coherence and ultimately its success!
An Operational Model For Flow

Position and Pull requires getting the positioning “right”:

• Decoupling Points – to break variation accumulation.
• Control Points – to simplify managing a complex system.
• Consider how best to protect them from the effects of variation.
A System Without Decoupling Points

Coupled System Lead time = 8 weeks

- Raw stocks
- shear
- saw
- laser
- weld
- machining
- plate
- assembly
- heat treat
- paint
- configure
- purchased component stocks
- Outsource operation

Customer
Poll Question: Are you Experiencing the Bi-modal Effect?

Three Effects:
1. Persistent Unacceptable Inventory Performance
2. Service Challenges
3. High Expedite and Waste Related Expenses
Benefits of Decoupling Lead Times

1. The customer experiences a tremendously shorter and reliable lead time.

2. Decoupling implications for planning:
   - The planning lead time shrinks.
   - The forecast error over the planning lead time also shrinks.

Remember CAS are dynamic – the shorter the lead time the more predictable and stable the system is:
   - Predictable = planning delivers a demand driven schedule
   - Stable = execution delivers more reliable performance/service
Decoupling Point Positioning Factors

<table>
<thead>
<tr>
<th>Demand Driven Material Requirements Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic Inventory Positioning</td>
</tr>
</tbody>
</table>

Decoupling Point Positioning Factors

<table>
<thead>
<tr>
<th>Customer Tolerance Time</th>
<th>The amount of time potential customers are willing to wait for the delivery of a good or a service.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Potential Lead Time</td>
<td>The lead time that will allow an increase of price or the capture of additional business either through existing or new customer channels.</td>
</tr>
<tr>
<td>Demand Variability</td>
<td>The potential for swings and spikes in demand that could overwhelm resources (capacity, stock, cash, etc.).</td>
</tr>
<tr>
<td>Supply Variability</td>
<td>The potential for and severity of disruptions in sources of supply and/or specific suppliers. This can also be referred to as supply continuity variability.</td>
</tr>
<tr>
<td>Inventory Leverage &amp; Flexibility</td>
<td>The places in the integrated BOM structure (the Matrix BOM) or the distribution network that leave a company with the most available options as well as the best lead time compression to meet the business needs.</td>
</tr>
<tr>
<td>Critical Operation Protection</td>
<td>The minimization of disruption passed to control points, pace-setters or drums.</td>
</tr>
</tbody>
</table>

A Decoupled System

Lead time = 4 week

Decoupled System With 1 week Market Lead Time

Lead time = 3 weeks

Market lead time = 1 week

Outsource operation
plate

= Strategic Decoupling points

Raw stocks
shear
saw
laser

weld
machining

assembly
heat treat

paint
configure

purchased component stocks

Customer

Raw stocks

Market lead time = 1 week

= Strategic Decoupling points

Customer
DDMRP Strategically Decoupled

MRP Everything Dependent

DDMRP Strategically Decoupled

You can learn more and obtain free white papers, videos, and podcasts on DDMRP at www.demanddrivenmrp.com.
## Parts Assigned a Lead Time Buffer Profile

### Buffer Profiles and Levels

<table>
<thead>
<tr>
<th>LT Profile</th>
<th>Lead Time Range</th>
<th>Red Base %</th>
<th>Safety Protection %</th>
<th>Yellow Base %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-5</td>
<td>90</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>6-8</td>
<td>80</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>9-12</td>
<td>70</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>13-16</td>
<td>60</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>17-20</td>
<td>50</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>21-24</td>
<td>45</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>25-30</td>
<td>40</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>31-36</td>
<td>35</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>9</td>
<td>37-45</td>
<td>30</td>
<td>25</td>
<td>50</td>
</tr>
</tbody>
</table>

### Dynamic Adjustments

- Buffer zones & sizes are a function of both the part lead time profile
- Individual Part Attributes

### Demand Driven Planning

- The green zone sets the upper limit and the heart of the supply order generation process. It determines average order frequency and typical order size: MOQ or an order cycle in days

### Visible and Collaborative Execution

- The yellow zone is the heart of the coverage and shock absorption: 100% of average daily usage over the full lead time
- The red zone is the risk mitigation embedded in the buffer and has two calculations. First is a % of the yellow zone and establishes the base. Second is safety based on the variability

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## Buffer Zone Sizing Calculations

### Lead Time Categories for Parts

<table>
<thead>
<tr>
<th>LT Profile</th>
<th>Category</th>
<th>Lead Time Range From</th>
<th>Lead Time Range To</th>
<th>Red Base %</th>
<th>Safety Protection % Low</th>
<th>Safety Protection % Medium</th>
<th>Safety Protection % High</th>
<th>Yellow Base %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cat 1</td>
<td>1</td>
<td>5</td>
<td>90</td>
<td>25</td>
<td>50</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Cat 4</td>
<td>6</td>
<td>15</td>
<td>60</td>
<td>25</td>
<td>50</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>Cat 8</td>
<td>17</td>
<td>36</td>
<td>35</td>
<td>25</td>
<td>50</td>
<td>90</td>
<td>100</td>
</tr>
</tbody>
</table>

### Part Attributes

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Buffer LT Profile</th>
<th>LT Days</th>
<th>ADU</th>
<th>Variability</th>
<th>MOQ</th>
<th>Order Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>r457</td>
<td></td>
<td>1</td>
<td>2</td>
<td>Low</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>r672</td>
<td></td>
<td>4</td>
<td>14</td>
<td>Med</td>
<td>3</td>
<td>3 days</td>
</tr>
<tr>
<td>h654</td>
<td></td>
<td>8</td>
<td>31</td>
<td>High</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

### Minimum Order Quantity

- **Green**: (Average Daily Usage x order cycle days)
- **Yellow**: Average Daily Usage x Lead time (usage over full lead time)
- **Red Safety**: Safety % x Red Base
- **Red Base**: Average Daily Usage x Lead time x base red %

### Calculations

- **Part r457**
  - Minimum Order Quantity: 30 (MOQ)
  - ADU X 2 DAYS: 36
  - 25% X 41 = 10
  - 18 ADU X 2 DAYS X 90% = 41

- **Part r672**
  - Minimum Order Quantity: 120 ADU X 14 DAYS 360
  - 50% x 1008 = 504
  - 120 ADU X 14 DAYS X 60% = 1008

- **Part r654**
  - Minimum Order Quantity: 3 ADU X 31 DAYS 93
  - 90% x 33 = 30
  - 3 ADU X 31 DAYS X 35% = 33

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Demand Driven Planning

Demand Driven Material Requirements Planning

<table>
<thead>
<tr>
<th>Strategic Inventory Positioning</th>
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<th>Dynamic Adjustments</th>
<th>Demand Driven Planning</th>
<th>Visible and Collaborative Execution</th>
</tr>
</thead>
</table>

Available Stock = on-hand + open supply – qualified demand

<table>
<thead>
<tr>
<th>Part</th>
<th>Open Supply</th>
<th>On-hand</th>
<th>Demand</th>
<th>Available Stock</th>
<th>Recommended Supply Qty</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>r457</td>
<td>5453</td>
<td>4012</td>
<td>1200</td>
<td>8265</td>
<td>0</td>
<td>No Action</td>
</tr>
<tr>
<td>f576</td>
<td>3358</td>
<td>4054</td>
<td>540</td>
<td>6872</td>
<td>3128</td>
<td>Place New Order</td>
</tr>
<tr>
<td>h654</td>
<td>530</td>
<td>3721</td>
<td>213</td>
<td>4038</td>
<td>2162</td>
<td>Place New Order</td>
</tr>
<tr>
<td>r672</td>
<td>2743</td>
<td>1732</td>
<td>623</td>
<td>3852</td>
<td>0</td>
<td>Expedite Open Supply (Execution)</td>
</tr>
</tbody>
</table>

Qualified demand = Current and past due plus qualified near term spikes

Order Spike Horizon

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DDMRP Replenishment Basics

DDMRP uses buffered “Decoupling Points” to establish independent planned and scheduled horizons.

DDMRP creates resupply signals based on the “available stock” status of each buffer. This provides a prioritized sequence based on actual need.
Demand Driven Execution

Demand Driven Material Requirements Planning

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</table>

On-the-floor priority is then determined by the real time buffer status of the decoupling points that the open orders are feeding.
Introducing Control Points

- Places to transfer, impose, and amplify control through a system.
- *SOME* control points are called a “Drum” in TOC or a Pacesetter in Lean.
- Control points are the heart of execution metrics.
Placing Control Points

Placed between decoupling points with the objective of better controlling the lead-time zones between those points. A shorter and less variable lead time results in less stock required at the decoupling point (a working capital reduction).
4 Factors When Choosing Control Points

1. *Points of Scarce Capacity* determine the total system output potential.

2. *Exit and Entry Points* are the boundaries of your effective control.

3. *Common Points* are points where one place controls many things.

4. *Points that Have Notorious Process Instability* can be planned for and controlled better when visibility and focus is placed on the resource and its variability.
Control points are placed between decoupling points and a customer when decoupling the end item is not possible or in a mixed mode operation (MTS & MTO).
In this case better scheduling and execution is required to synchronize and prioritize the make to stock and make to order business.

Better lead time and less variability within the plant will reduce the end item buffer.
Placing a Control Point

In this case we have a resource that is both the slowest pace resource as well a major integration point in the routings.
A Decoupled System With Control Points

Lead time = 4 week

Lead time = 3 weeks

Lead time = 1 week

Outsource operation

plate

= Strategic Decoupling points

= Control point

Raw stocks

shear

saw

laser

weld

assembly

paint

configure

Customer

Raw stocks

purchased component stocks

configure

Customer

Raw stocks

purchased component stocks

configure

Customer

Lead time = 1 week

= Control point

= Strategic Decoupling points

lead time = 3 weeks

Lead time = 4 week

Lead time = 1 week

= Control point

= Strategic Decoupling points

Lead time = 3 weeks

Lead time = 4 week

Lead time = 1 week
Protecting Decoupling & Control Points

Stock

Time

Capacity

Early

Green

Yellow

Red

Late

20%

80%
Protecting With Stock Buffers

- Shock absorption
- Lead-time compression
- Supply order generation
Protecting With Time Buffers

• Shock absorption
• Visual Status of Flow
• Execution focus
• Smart Metric focus

Example: 9 hour buffer

Upstream Processes

Scheduled Entry to Buffer

Early

Green Yellow Red Late

Example: 9 hour buffer

Shock absorption
Visual Status of Flow
Execution focus
Smart Metric focus
Protecting With Capacity Buffers

- Capacity buffers protect control and decoupling points
- The ability to sprint and recover determines the sizing of both time and stock buffers (variation factor in the red safety zone)

The “Unit Cost Myth” *misuses* spare capacity =

Responsiveness  
Lead times  
Inventory levels  

ROI
Demand Driven Design Model

- Raw stocks
- shear
- saw
- laser
- machining
- plate
- weld
- assembly
- paint
- configure
- purchased component stocks
- Customer

- Lead time = 3 weeks
- Lead time = 4 weeks
- Lead time = 1 week

- Stock buffer
- Time buffer
- Capacity buffer

- Control point
Scheduling a Control Point

The control point is finitely scheduled with both MTS and MTO orders.

Loading is important to see for lead time quotation.

Sales Order Demand

Capacity

1 2 3 4 5 6 7 8 9 10 11 12

Replenishment orders

Sales orders

Purchased Components

Supplier

Replenishment

10

5

10

5

Supplier

10

5

10

15

10

Customer

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Synchronizing Material Release

Schedule material release to the control point schedule
Late release will jeopardize the control point schedule
Early release raises WIP levels unnecessarily
We now have five schedules – all synchronized around a resource Control Point schedule (Drum)
Protecting the Schedule

We must insulate the schedules against the accumulated variability that occurs in the sequences preceding the schedule – delays are passed on, gains are not.

How can we make sure that the schedules are maintained (not rescheduled)?

Note: the purchased part stock buffers protect the material release schedules against supplier variability.
Time Buffers Inserted

Time buffers are inserted into each part’s routing and all queue and move time removed.

We track and measure buffer penetration at each control point buffer *NOT one buffer for the whole routing.*
The 10 Zone Buffer Board – Pareto Power

Scheduled Entry to Buffer

Scheduled Start at Control Point

Yet to be Received

Early

Green

Yellow

Red

Late

Received

Early

Green

Yellow

Red

Late

Example: 9 hour buffer

WO 1626

Green OK

Yellow Investigate

Red ACT

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Each of these building blocks require real time visibility and reporting tools to monitor system flow status and variation.
CAS Coherence = System Efficiency

Maintain flow and system coherence:

• Aligns operations tactics to market pull and that eliminates forecast error and its bullwhip effect;

• Creates a finite, realistic and executable schedule;

• Dampens or negates variation and protects control point stability and schedule execution;

• Provides a framework to deliver both relevant information and materials to plan, schedule and execute a flow centric strategy;

• Eliminates the cost/flow conflict and its contribution to the bullwhip effect.
The Right Rules & Tools

The Organization:

− Operating model is designed for system flow. Complex Adaptive System - CAS rules are used to both protect and speed flow.

− Systems thinking and the new rules were used to build tools with visibility to the status of flow.

− Implementation is complete with real time buffer status of flow to and through the decoupling and control points.

The Organization is ready for Step 5 and smart metrics.
# Metrics For Short Run Tactics

<table>
<thead>
<tr>
<th>Strategic or Tactical</th>
<th>Plan Time Period</th>
<th>Schedule of Resources</th>
<th>Execute Schedule</th>
<th>Metrics - Financial &amp; Nonfinancial</th>
<th>Metric Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>Annually</td>
<td>Capacity plan</td>
<td></td>
<td>Financial &amp; Non</td>
<td>ROI</td>
</tr>
<tr>
<td>Tactical</td>
<td>Quarterly</td>
<td>Capacity plan</td>
<td></td>
<td>Financial &amp; Non</td>
<td>ROI</td>
</tr>
<tr>
<td>Tactical</td>
<td>Monthly</td>
<td>Capacity plan</td>
<td></td>
<td>Financial &amp; Non</td>
<td>ROI &amp; Flow</td>
</tr>
<tr>
<td>Tactical</td>
<td>Weekly</td>
<td>schedule</td>
<td>Weekly</td>
<td>Non-financial</td>
<td>Flow</td>
</tr>
<tr>
<td>Tactical</td>
<td>Daily</td>
<td>schedule</td>
<td>Daily</td>
<td>Non-financial</td>
<td>Flow</td>
</tr>
<tr>
<td>Tactical</td>
<td>Hourly</td>
<td></td>
<td>Hourly</td>
<td>Non-financial</td>
<td>Flow</td>
</tr>
</tbody>
</table>

Managers can vary “some” fixed costs inside their annual plan and a few inside their quarter.

What overhead costs can be varied inside a month, a week, a day?
### The Gap Formula Between Flow and Cost Centric Strategies

<table>
<thead>
<tr>
<th>Visibility</th>
<th>Variability</th>
<th>Core Conflict Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>Cash Velocity</td>
<td>Net Profit / Investment</td>
</tr>
</tbody>
</table>

- Visibility is defined as relevant information for decision making.
- Variability is defined as the summation of the differences between what we plan to have happen and what happens.
- Flow is the rate at which a system converts material to product required by a customer.
- Cash velocity is the rate of net cash generation; sales dollars minus truly variable costs (also known as throughput dollars or contribution margin) minus period operating expense.
- Net profit/investment is, of course, the equation for ROI

Plossl’s First Law of Manufacturing:
A Demand Driven Design & Smart Metrics Solve the Core Conflict Area

Visibility to the relevant information of materials across the supply chain ensures system coherence and speeds flow:

- Aligns priorities and schedules
- Speeds conflict resolution
- Defines when and where to act
- People will self organize to solve/act

You can’t measure what you can’t see!

\[ \Delta \text{Visibility} \rightarrow \Delta \text{Variability} \]

Core Conflict Area

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Demand Driven Model Objectives

Opportunities to Drive Improvements

\[ \Delta \text{Flow} \to \Delta \text{Cash Velocity} \to \Delta \left( \frac{\text{Net Profit}}{\text{Investment}} \right) \to \Delta \text{ROI} \]

Plossl’s First Law of Manufacturing

Demand Driven Model

Core Conflict Area

\[ \Delta \text{Visibility} \to \Delta \text{Variability} \]

Operating the Demand Driven Model

- Demand Driven Flow map of connections and interconnections
- Create Short, independent planning horizons
- Strategic control points govern and leverage the system output
- All buffers use Paretian models to identify lever point phenomena events to signal action, priority and opportunity.
- Visible buffer and control point status use a Paretian view to create a learning feedback loop to drive improvement.
Understand the System

Nonlinear systems can only be understood by mapping the dependencies and interconnections
Nonlinear system “state” is dynamic and no predictions remain valid “too” long

Create Short, independent planning horizons

Lead time = 3 weeks

Lead time = 4 weeks

Lead time = 1 week

= Stock buffer
The output of nonlinear system is governed by a few critical points – the “leverage point phenomena”

Strategic control points govern and leverage the system output

= Stock buffer
= Control point
The output of nonlinear system is governed by a few critical points – the “leverage point phenomena”

Protect the strategic control points protects and leverages the system output

- Stock buffer
- Control point
- Time buffer
- Capacity buffer

Diagram:
- Raw stocks
- Saw
- Laser
- Weld
- Machining
- Assembly
- Paint
- Heat treat
- Purchased component stocks
- Customer

Control points (C):
- Outsource operation
- Plate

Equations:
- Control point = C
- Time buffer = C
- Capacity buffer = C

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Making the Model Adaptive

Paretian statistical models – The tails of the distribution contain the “lever point phenomena”. The lost opportunity for positive gains and early warning to future disasters!

A nonlinear system cannot be optimized but it can continually learn and improve. It can emerge to a higher order.

The buffer tails delineate the “Edge of Chaos”. A safe haven where learning and innovation can occur - EXPLORATION

All buffers use Paretian models to identify lever point phenomena events to signal action, priority and opportunity.

Visible buffer and control point status use a Paretian view to create a learning feedback loop to drive improvement.
Demand Driven Model

ΔVisibility → ΔVariability →

Core Conflict Area

Operating the Demand Driven Model (Tactical Time Frame)

ΔFlow → ΔCash Velocity → Δ (Net Profit / Investment) → ΔROI

Plossl’s First Law of Manufacturing

Smart Metrics – The bridge to the status of flow and ROI focuses on 6 Metric Objectives

- All buffers use Paretian models to identify lever point phenomena events to signal action, priority and opportunity.
- Strategic control points govern and leverage the system output.
- Demand Driven Flow map of connections and interconnections.
- Visible buffer and control point status use a Paretian view to create a learning feedback loop to drive improvement.
- Create Short, independent planning horizons.
## The Three Tactical Metric Objectives

<table>
<thead>
<tr>
<th>Metric Objectives</th>
<th>The Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Reliability</td>
<td>Execute to the plan/schedule/market expectation;</td>
</tr>
<tr>
<td>System Stability</td>
<td>Pass on as little variation as possible;</td>
</tr>
<tr>
<td>System Speed/Velocity</td>
<td>Pass the right work on as fast as possible;</td>
</tr>
<tr>
<td>System Improvement &amp; Waste (Opportunity $)</td>
<td>Point out and prioritize lost ROI opportunities.</td>
</tr>
<tr>
<td>Local Operating Expense</td>
<td>Spend minimization to capture the market opportunity</td>
</tr>
<tr>
<td>Strategic Contribution</td>
<td>Maximize throughput dollar rate and throughput volume according to relevant factors</td>
</tr>
</tbody>
</table>
System Reliability

Execute to the plan/schedule/market expectation

Outsource operation

plate

shear

weld

assembly

paint

configure

Customer

Raw stocks

saw

machining

laser

heat treat

purchased component stocks
System Reliability

Measure execution to the plan/schedule/market expectation

Monitor on-hand and available stock statuses at decoupling points

<table>
<thead>
<tr>
<th>Part</th>
<th>Open Supply</th>
<th>On-hand</th>
<th>Demand</th>
<th>Available Stock</th>
<th>Recommended Supply Qty</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>B897</td>
<td>16359</td>
<td>12000</td>
<td>8000</td>
<td>20000 (7%)</td>
<td>14743</td>
<td>Create Work Order</td>
</tr>
<tr>
<td>H275</td>
<td>900</td>
<td>5532</td>
<td>960</td>
<td>5472 (42%)</td>
<td>2128</td>
<td>Create Work Order</td>
</tr>
<tr>
<td>C283</td>
<td>1530</td>
<td>3721</td>
<td>713</td>
<td>4538 (48%)</td>
<td>1594</td>
<td>Create Work Order</td>
</tr>
<tr>
<td>P100</td>
<td>1200</td>
<td>1350</td>
<td>870</td>
<td>1280 (58%)</td>
<td>2206</td>
<td>Create purchase order</td>
</tr>
</tbody>
</table>

Monitor, release, sequence and on-time status of work at control points

<table>
<thead>
<tr>
<th>Part</th>
<th>Start</th>
<th>Full Duration</th>
<th>End</th>
<th>Sales Order Qty</th>
<th>Work Order Qty</th>
<th>Status</th>
<th>Sales Order Qty</th>
<th>Work Order Qty</th>
<th>Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>B897</td>
<td>2/13/2014 17:57</td>
<td>11:05</td>
<td>2/14/2014 5:02</td>
<td>356010</td>
<td>356010-5</td>
<td>Released, awaiting start</td>
<td>0</td>
<td>22</td>
<td>2003</td>
</tr>
<tr>
<td>B275</td>
<td>2/14/2014 5:02</td>
<td>8:35</td>
<td>2/14/2014 13:37</td>
<td>356009</td>
<td>356009-2</td>
<td>Released, awaiting start</td>
<td>0</td>
<td>17</td>
<td>2003</td>
</tr>
<tr>
<td>C283</td>
<td>2/14/2014 13:37</td>
<td>9:05</td>
<td>2/14/2014 22:42</td>
<td>356009</td>
<td>356009-1</td>
<td>Released, awaiting start</td>
<td>0</td>
<td>18</td>
<td>2003</td>
</tr>
<tr>
<td>H287</td>
<td>2/14/2014 22:42</td>
<td>9:05</td>
<td>2/15/2014 7:47</td>
<td>356010</td>
<td>356010-8</td>
<td>Released, awaiting start</td>
<td>0</td>
<td>18</td>
<td>2003</td>
</tr>
<tr>
<td>P100</td>
<td>2/15/2014 3:10</td>
<td>2/15/2014 16:18</td>
<td>505001</td>
<td>505001-1</td>
<td>Released, awaiting start</td>
<td>0</td>
<td>15</td>
<td>5001</td>
<td></td>
</tr>
<tr>
<td>P101</td>
<td>2/18/2014 13:14</td>
<td>2:12</td>
<td>2/18/2014 15:26</td>
<td>505001</td>
<td>505001-1</td>
<td>Released, awaiting start</td>
<td>0</td>
<td>15</td>
<td>5001</td>
</tr>
</tbody>
</table>
System Stability

Pass on as little variation as possible

Outsource operation

plate

shear

weld

assembly

paint

configured

Customer

Raw stocks

saw

machinging

laser

heat treat

purchased component stocks
System Stability

Measure the extent, where and when variation is occurring

Measure:
Create a stable schedule. Monitor capacity buffers in non-control point resources looking for and resolving potential schedule overloads.

Monitor penetrations to time buffers focusing on red and preventing late zone penetration.

Monitor on-hand, available stock and projected on-hand at decoupling points. Expedite priorities are determined by % penetration.
System Speed Velocity

Pass the right work on as fast as possible

- Outsource operation
  - plate
  - shear
  - weld
  - assembly
  - paint
  - configure

- Raw stocks
  - saw
  - laser
  - machining
  - heat treat

- Purchased component stocks

Customer
System Speed Velocity

Measure status and speed of the planned work to the execution

Measure:

Monitor Over the Top of Green (OTOG)

Monitor backlog status and dispatch list sequence of control points

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
<th>Sales Order</th>
<th>Work Order</th>
<th>Status</th>
<th>Sales Order Qty</th>
<th>Work Order Qty</th>
<th>Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/13/2014</td>
<td>17:57 - 11:05</td>
<td>356010</td>
<td>356010-5</td>
<td>Arrived, LATE to Start</td>
<td>0</td>
<td>22</td>
<td>2003</td>
</tr>
<tr>
<td>2/14/2014</td>
<td>5:02</td>
<td>356009</td>
<td>356009-2</td>
<td>Arrived, LATE to Start</td>
<td>0</td>
<td>17</td>
<td>2003</td>
</tr>
<tr>
<td>2/14/2014</td>
<td>13:37</td>
<td>356009</td>
<td>356009-1</td>
<td>Released, awaiting start</td>
<td>0</td>
<td>18</td>
<td>2003</td>
</tr>
<tr>
<td>2/14/2014</td>
<td>22:42</td>
<td>356010</td>
<td>356010-8</td>
<td>Released, awaiting start</td>
<td>0</td>
<td>18</td>
<td>2003</td>
</tr>
<tr>
<td>2/15/2014</td>
<td>13:08</td>
<td>505001</td>
<td>505001-1</td>
<td>Released, awaiting start</td>
<td>0</td>
<td>15</td>
<td>5001</td>
</tr>
<tr>
<td>2/18/2014</td>
<td>13:14</td>
<td>505001</td>
<td>505001-1</td>
<td>Released, awaiting start</td>
<td>0</td>
<td>15</td>
<td>5001</td>
</tr>
</tbody>
</table>

Monitor early buffer entry
The Fourth Strategic Metric Objectives

<table>
<thead>
<tr>
<th>Metric Objectives</th>
<th>The Message</th>
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<tr>
<td>System Reliability</td>
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<td>Strategic Contribution</td>
<td>Maximize throughput dollar rate and throughput volume according to relevant factors</td>
</tr>
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The ability of a CAS to innovate is more a mechanism of exploration than exploitation.
Mathematical Models of The System

Paretian statistical models – The tails of the distribution identify the few critical points that define the relevant information to predict and manage nonlinear complex systems. They contain the “lever point phenomena”.

Point out and prioritize lost ROI opportunities

All buffers use Paretian models to identify lever point phenomena events to signal action, priority and opportunity.

Opportunities to reduce plan variation

Opportunities to reduce execution variation
System Improvement

Point out and prioritize lost ROI opportunities

Real time view

Stock buffer limit

Target on-hand

Light Blue

Green

Yellow

Red

Scarlett Red

Quantity

0

Trend reporting focuses on parts with the greatest opportunity for a working capital reduction.

Trend reporting focuses on parts with the greatest opportunity for a reduction in expedite related waste.

Part r643

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System Improvement

Point out and prioritize lost ROI opportunities

Trend Green and Over Top Of Green (OTOG) zones – Parts with unacceptable flow performance over the past 180 days

- C290
- C283
- C287
- H274
- H270
- R973
- R871

Green Zone
OTOG ADU Days <15
OTOG ADU Days > 15

ADU = Average Daily Usage
Point out and prioritize lost ROI opportunities

Trend critical red, stock out and stock out with demand – Parts with unacceptable service performance over the past 35 days

Component parts

<table>
<thead>
<tr>
<th>Part</th>
<th>Critical red</th>
<th>Stock out</th>
<th>Stock out with demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>R270</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H981</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C488</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H130</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H275</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B897</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total days on hand inventory resided in the zone over the past 180 days
Quantify Cash Flow Opportunity/Investment

- How much = the variable cost per part \( \times \) (target on-hand – actual on-hand)

- How long = (target on-hand - actual on-hand) average daily usage
System Improvement

Point out and prioritize lost ROI opportunities

Reporting:

Trend the reason codes of work order penetrations into the red and late zones

Trend the reason codes for work orders for early buffer entry

Yet to Be Received

<table>
<thead>
<tr>
<th>Early</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Late</th>
</tr>
</thead>
</table>

Received

<table>
<thead>
<tr>
<th>Early</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Late</th>
</tr>
</thead>
</table>

Yet to Be Received

<table>
<thead>
<tr>
<th>Early</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Late</th>
</tr>
</thead>
</table>

Received

<table>
<thead>
<tr>
<th>Early</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
<th>Late</th>
</tr>
</thead>
</table>
### Pareto of Reason Codes Target Variation

#### Reason Code Analysis for Late Zone

<table>
<thead>
<tr>
<th>Reason</th>
<th># of Occurrences</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set-up Delay at CNC #7</td>
<td>23</td>
<td>59%</td>
</tr>
<tr>
<td>Equipment failure</td>
<td>8</td>
<td>21%</td>
</tr>
<tr>
<td>Late release of work order</td>
<td>5</td>
<td>13%</td>
</tr>
<tr>
<td>Tooling not available</td>
<td>3</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Total # Occurrences</strong></td>
<td><strong>39</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

#### Buffer Receipts by Zone

- **Green, 156, 28%**
- **Red, 54, 10%**
- **Yellow, 245, 42%**
- **Late, 39, 7%**
- **Early, 73, 13%**

#### Zone Receipt

<table>
<thead>
<tr>
<th>Zone Receipt</th>
<th># of Occurrences</th>
<th>Reason</th>
<th>Recommended Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>LATE</td>
<td>23</td>
<td>Set-up delay at CNC-Lathe 7</td>
<td>Set-up Reduction at CNC-Lathe 7</td>
</tr>
<tr>
<td>RED</td>
<td>27</td>
<td>CNC-Mill 18 down</td>
<td>Preventative Maintenance at Mill 18</td>
</tr>
<tr>
<td>EARLY</td>
<td>52</td>
<td>Released on time – beat standard</td>
<td>Clean up standards on named routings – evaluate changes on ropes and buffers</td>
</tr>
</tbody>
</table>
Variability Reduction Improvement = Stock Buffer Remodel

BEFORE

Variability reduction

Max
Avg
Min

Zones are sized as a function:
- MOQ = 60
- ADU = 10
- lead time = 18
- Red base factor %= 37%
- Red safety factor %= 50%

Green Zone = 60
Yellow zone = 180
Red base = 67
Red safety = 33
Average on-hand inventory target = 130

Improvement

Red safety ↓ 25%

AFTER

Red zone safety ↓

Max
Min

Zones are sized as a function:
- MOQ = 60
- ADU = 10
- lead time = 18
- Red base factor %= 37%
- Red safety factor %= 25%

Green Zone = 60
Yellow zone = 180
Red base = 67
Red safety = 33
Average on-hand inventory target = 112
Lead Time Reduction = Stock Buffer Remodel

BEFORE

Lead Time 18 days

Zones are sized as a function:
- MOQ = 60
- ADU = 10
- lead time = 18
- Red base factor % = 37%
- Red safety factor % = 50%

Green Zone = 60
Yellow zone = 180
Red base = 67
Red safety = 33
Average on-hand inventory target = 130

Improvement

↓ 4 days

AFTER

↓ 4 = new lead time 14 days

Zones are sized as a function:
- MOQ = 60
- ADU = 10
- lead time = 14
- Red base factor % = 37%
- Red safety factor % = 50%

Green Zone = 60
Yellow zone = 140
Red base = 52
Red safety = 26
Average on-hand inventory target = 108

Lead Time Reduction = Stock Buffer Remodel
**Minimum Order Quantity Reduction = Stock Buffer Remodel**

**BEFORE**

Note: Green Zone set to MOQ

MOQ reduction

MOQ

Zones are sized as a function:
- MOQ = 60
- ADU = 10
- lead time = 18
- Red base factor %= 37%
- Red safety factor %= 50%

Green Zone = 60
Yellow zone = 180
Red base = 67
Red safety = 33
Average on-hand inventory target = 130

**Improvement**

**AFTER**

MOQ

Zones are sized as a function:
- MOQ = 40
- ADU = 10
- lead time = 18
- Red base factor %= 37%
- Red safety factor %= 50%

Green zone = 40
Yellow zone = 180
Red base = 67
Red safety = 33
Average on-hand inventory target = 120
Total of Reduction Improvements = Stock Buffer Remodel

BEFORE
Green Zone = 60
Yellow zone = 180
Red base = 67
Red safety = 33
Average on-hand inventory target = 130

AFTER
Green Zone = 40
Yellow zone = 140
Red base = 52
Red safety = 13
Average on-hand inventory target = 85

Variability ↓ 25%
Lead Time ↓ 4 days
MOQ ↓ 20 units
Total average inventory ↓ 45 units

32% reduction in inventory and better market lead time
Flow Index Summary & Batching

### Flow Index Summary - Buffered Components

<table>
<thead>
<tr>
<th>Flow Index Rating</th>
<th>Flow Index Range (Days)</th>
<th>% of Parts by Flow Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From</td>
<td>To</td>
</tr>
<tr>
<td>Poor = 1</td>
<td>25</td>
<td>&gt; 25 Days</td>
</tr>
<tr>
<td>Slow = 2</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td>Moderate = 3</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Good = 4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Excellent = 5</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flow index =** the minimum order quantity (MOQ) / Average Daily Usage (ADU)

The higher the days of coverage the lower the flow rating.
### Flow Index for Buffered Components

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Flow Index</th>
<th>Current Coverage Days</th>
<th>Ideal Batch Quantity</th>
<th>Current Batch Quantity</th>
<th>Average Daily Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>B897</td>
<td>5</td>
<td>2</td>
<td>124</td>
<td>60</td>
<td>31</td>
</tr>
<tr>
<td>C150</td>
<td>5</td>
<td>3</td>
<td>35</td>
<td>30</td>
<td>9</td>
</tr>
<tr>
<td>R871</td>
<td>2</td>
<td>16</td>
<td>10</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td>H210</td>
<td>3</td>
<td>9</td>
<td>9</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>C290</td>
<td>1</td>
<td>27</td>
<td>7</td>
<td>45</td>
<td>2</td>
</tr>
<tr>
<td>C283</td>
<td>3</td>
<td>12</td>
<td>10</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>C287</td>
<td>2</td>
<td>23</td>
<td>9</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>H275</td>
<td>5</td>
<td>4</td>
<td>15</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>H270</td>
<td>2</td>
<td>19</td>
<td>4</td>
<td>20</td>
<td>1</td>
</tr>
</tbody>
</table>

**Ideal batch quantity = ADU X 4 days coverage**

On average B897 will generate an order every two days and C150 every three days!
Both B897 and C150 also have unacceptable service levels and are a major source of expedite variation.

Both B897 and C150 have MOQs less than the ideal flow.
Both R871 and H270 also have unacceptable flow levels and are a source of materials and capacity opportunity.

Both R871 and H270 have MOQs or batch sizes 4X the ideal flow.
Smart Metrics Drive Model Improvements

- Production control
- Model manager
- Modeling team
- Application owner

- Planning/purchasing
- Buffer managers
- Operations managers
- Sales

Schedule with new/improved model

Execute model plan

Improve and Adjust model

Collect Information
Trend/Analyze Variation

Model analyst
Model manager

POOGI

(Plan)

(Take Action )

(Do)

(Pareto Focus)

- Process improvement
- Model team
- Managers
Questions?

Debra A. Smith, CPA, TOCICO, EMBA
and Founding Partner
Constraints Management Group, LLC
dsmith@thoughtwarepeople.com
The green zone sets the upper limit and the heart of the supply order generation process. It determines average order frequency and typical order size: MOQ or an order cycle in days.

The yellow zone is the heart of the coverage and shock absorption: 100% of average daily usage over the full lead time.

The red zone is the risk mitigation embedded in the buffer and has two calculations. First is a % of the yellow zone and establishes the base. Second is safety based on the variability.
Minimum Order Quantity
or
(Average Daily Usage x order cycle days)

Average Daily Usage x Lead time
(usage over full lead time)

Safety % x Red Base

Average Daily Usage x Lead time
x base red %

Green
Yellow
Red Safety
Red Base
1. Why Change?

2. What to Change?

3. What to Change to?

4. How to cause the change?

5. How to create POOGI?