Important

This document is not to be released to any third party without the prior consent of Asset Acumen Consulting. It contains copyright information, the disclosure of which would likely cause material financial harm to Asset Acumen Consulting, prejudice its competitive position and interfere with its ongoing or future contractual or other negotiations. The document also contains personal information as defined in the Privacy Act (Canada).

© 2019 Asset Acumen Consulting
Presentation Agenda

• Day 1
  • Leadership and Control
    • Maintenance Parts Management Pyramid of Excellence Overview
    • An approach to creating a Maintenance Parts Management Strategic Plan
    • KPIs for Maintenance Parts Management
    • The importance of Maintenance Parts in 'effective' Maintenance Execution
  
  • Day 2
    • Inventory Policy Management Dynamics
      • Inventory Planning
      • Asset Life-cycle Integration
      • Inventory Optimization
      • Procure and Repair
  
  • Day 3
    • Implementing Maintenance Parts Management
      • Technology and Maintenance Parts Management
      • Impact of Change Management in Asset Management Initiatives
    • Spares Provisioning & Inventory Optimization
      • Key Inventory Issues
      • Types of production inventory
  
• Day 4
  • Managing Risk and Cost in Parts Management (with case studies)
    • Risk and Cost Management
    • Setting the Reorder Point
    • Setting the Reorder Quantity
    • Reliability-Based Spare Parts Management
    • Determining Excess Inventory
    • Developing Store Room Layouts, Improvement Projects, Reorganization,
    • Storeroom Measures and KPIs
    • Maintenance Parts Purchasing Insights
  
• Day 5
  • Going Deeper in Asset Life-cycle Initial Spare Parts Tactics Setting and Monitoring Goals
    • Partnering with Others
    • Benchmarking performance
    • Managing repairable spares
    • Managing capital spares
  • Putting the 5-Day Maintenance Parts Excellence Course into Practice
    • Next Steps

Training Mapping Models and Icons

• Models will be shown throughout the training.
  • To assist in understanding the flow and relationships

• Reminder Icons are to help you understand the intent of the presented materials
  • Examples ➔
  • Hints ➔
  • Exercises ➔
My biggest Parts challenge!

- See results from Day 1

Presentation Agenda

Inventory Policy Management Dynamics

- Procure and Repair
  - Leading procurement scope for strategic commodity sourcing, supplier relationship management and transaction execution
  - Maturity matrix for a procurement operation
  - Leading KPIs for a maintenance parts procurement support operation
  - Example of an improvement plan for an existing maintenance procurement operation
  - Dynamics of a rotatable & repairable parts operation
  - Leading KPIs for a parts repair support operation
  - Example of how used parts and repair costs can be treated in a parts repair operation

- Inventory Planning
  - Fundamental responsibilities of an Inventory Planner
  - Leading Parts Process Flow Management Systems attributes (Replenishment, Mobility)
  - Case Study on how to prioritize maintenance parts needs in the journey towards leading practice
  - Maintenance Parts stocking influences and approaches (including ABC stocking level management)
  - Managing high and medium demand maintenance parts inventories
  - Defining and defending the inventory value and service levels in an enterprise
  - Developing the elements of inventory policy

Inventory Policy Management Dynamics (continued)

- Asset Life-cycle Integration
  - Understanding the requirements and impact of successful initial spare parts list creation
  - The role of the manufacturer in creating your initial spare parts list
  - The role that risk and reliability insights influence the early asset and maintenance parts life-cycle
  - Defining the spare parts policy ownership in an asset life-cycle
  - Process elements that contribute to initial spare parts list creation
  - Spare parts netting

- Inventory Optimization
  - An approach to optimizing inventory levels
  - Strategic cost management of maintenance parts – what is realistically achieved?
  - Inventory policy netting
  - Data elements of a leading "Maintenance Parts Optimizer" solution
In this session we will focus on key elements of Control and Continuous Improvement

Areas of Focus for this session:

- Procure and Repair
- Inventory Planning
- Inventory Optimization
- Asset life-Cycle Integration

Exercise – Self Assessment

- Complete the standard self-assessment questionnaire
  - Will take about 30 minutes
- Sections –
  - Procure and Repair,
  - Inventory Planning
  - Asset Life-cycle Integration
  - Inventory Optimization
- Plot your scores on the spider diagram
- Where are your largest gaps?
Parts Procurement and Repair

Inventory Planning and Parts Procurement must work closely to efficiently execute effective inventory placement.

Many elements of the Maintenance Parts Value Chain need to be well managed to meet business asset demands.

Suppliers
- Manufacture
- Reutilize
- Product Tear Down

Logistics Value Influence

<table>
<thead>
<tr>
<th>Unit Sourcing Costs</th>
<th>Inventory Management</th>
<th>Delivery</th>
<th>Key Performance Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Management</td>
<td>Demand Management</td>
<td>Emergency cycle times</td>
<td>Parts Availability</td>
</tr>
<tr>
<td>Substitutions</td>
<td>Service specific forecasting algorithms</td>
<td>Parts Acquisition Time</td>
<td>Parts Availability</td>
</tr>
<tr>
<td>Category Management</td>
<td>Part Criticality</td>
<td>Systems Availability</td>
<td>Parts Availability</td>
</tr>
<tr>
<td>Vendor Managed Inventory</td>
<td>Inventory Effectiveness</td>
<td>Distribution Quality</td>
<td>Parts Availability</td>
</tr>
<tr>
<td>Supplier Warranty Redemption</td>
<td>(Multiple replenishment) Inventory Policies</td>
<td>Parts Quality</td>
<td>Parts Costs</td>
</tr>
<tr>
<td>Re-utilization Strategies</td>
<td>Automated replenishment plans</td>
<td>Inventory Turnover</td>
<td>Inventory Turnover</td>
</tr>
<tr>
<td></td>
<td>Inventory Surplus Management</td>
<td>Inventory Reserves</td>
<td>Inventory Reserves</td>
</tr>
</tbody>
</table>

Adapted from IBM Parts Management Case Study – Don Barry
Today most companies provide a workplace solution with a single point of access to an employee’s suite of work tools for procurement.

How do we ensure sustainability of procurement?

Supply chain focus has shifted from previous emphasis on maximising output and purchasing cheaply to maximizing efficiency and responsiveness to boost overall profit.

How can you tell if procurement in your organisation is effective?

Scope of benefits depend on this maturity profile - every client is different but the issues are not!
Strategic commodity sourcing, supplier relationship management and transaction execution, are common best practices once the stocking or replenishment requirement is established.

Parts Procurement starts with a parts request

**Procurement steps of a Parts Request in a system**

- The system should be able to display items that are already defined with its related attribute data such as:
  - specifications;
  - alignment to the equipment being supported;
  - preferred vendors identified with inspection requirement documents (for the receiving group to perform);
  - product/supplier/vendor performance service level agreements and evaluation criteria documented;
  - order approval processes; and
  - invoice approval processes.
### Challenging the Procurement processes

- There are four primarily useful steps in a procurement transaction:
  - identifying the material need;
  - confirming we do not already have the part (in surplus);
  - notifying the vendor; and
  - paying for the materials received.

*Inventory Planning and Parts Procurement must work closely to efficiently execute effective inventory placement*
Procurement should fundamentally understand the Inventory Policy

• Insights that will influence stocking policy and sourcing can be:
  • What is the Initiate Spare Parts list for each specific asset?
  • Should parts be stocked or not stocked locally?
  • Can the service for a specific asset be outsourced and with that the stocking of the required parts?
  • Can parts of sourced from multiple vendors?
  • Can the part be co-sourced?
  • Can the part be managed as vendor owned inventory?
  • Can the part be repaired – as new- and returned to stock?
  • Do surplus assets exist that can be used to extract like new parts?

Procurement should be working with the Inventory Planner, and the Asset Design engineer to understand inventory stocking plans (policy) and what would be acceptable alternatives for supporting a specific piece of equipment in a specific operating context.

Strategic commodity sourcing, supplier relationship management and transaction execution, are common best practices once the stocking or replenishment requirement is established.
**Scope of a typical Procurement group**

![Diagram showing the scope of a typical Procurement group]

**Examples of Procurement Performance Measures**

<table>
<thead>
<tr>
<th>Performance Metric Considerations</th>
<th>Performance Metric Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• $ spend</td>
<td>• Out of stocks (&amp; reason)</td>
</tr>
<tr>
<td>• $ value extracted</td>
<td>• Process improvement</td>
</tr>
<tr>
<td>• % influenceable spend on contract</td>
<td>• Quality variation</td>
</tr>
<tr>
<td>• Additional services obtained</td>
<td>• Rebates</td>
</tr>
<tr>
<td>• Automated transactions</td>
<td>• Safety</td>
</tr>
<tr>
<td>• Category Management</td>
<td>• Savings versus target</td>
</tr>
<tr>
<td>• Communication/relationship success with supplier &amp; internal unit</td>
<td>• Service levels</td>
</tr>
<tr>
<td>• Contract performance - life cycle management, innovation, value add</td>
<td>• Shareholder value</td>
</tr>
<tr>
<td>• Contract reviews with strategic suppliers</td>
<td>• Sourcing - good process, visibility, reporting, well managed transition, realising the value of a ‘great deal’</td>
</tr>
<tr>
<td>• Cost variance to standard</td>
<td>• Supplier development</td>
</tr>
<tr>
<td>• Culture survey</td>
<td>• Supplier differentiation</td>
</tr>
<tr>
<td>• Customer satisfaction</td>
<td>• Supplier rationalisation</td>
</tr>
<tr>
<td>• Establishing &amp; renegotiating preferred supplier arrangements</td>
<td>• Supply market understanding</td>
</tr>
<tr>
<td>• Inventory optimisation</td>
<td>• Supply rate</td>
</tr>
<tr>
<td>• New tenders transition through policy and board</td>
<td>• Transaction costs</td>
</tr>
<tr>
<td>• Number of departments using contracted vendors</td>
<td>• Unit price</td>
</tr>
<tr>
<td>• Number of contracted vendors</td>
<td>• Working capital</td>
</tr>
</tbody>
</table>

*Source: IBM Procurement Relationship Survey Australia / New Zealand, May 2004*
Leading Supplier Relationship Management Practices

The methods for receiving supplier feedback include:
• Part of regular formal review process and meetings.
• Annual supplier conference.
• Supplier survey.

Supplier Collaboration types of activities include:
• Collaborative managed inventory
• Managed obsolescence
• Workshops with suppliers to determine solutions
• Collaboration on regulation control
• Partnering in capital expenditure or construction projects
• E-procurement or electronic data interchange
• Sharing forecasts
• Co-development of new products or components
• Collaborative process improvement
• Distribution methodology
• Co-development of supply chain
• Worked with suppliers to bundle goods and services to provide one contract.

Leading Technology Assisted Procurement

To support supplier management and development
• Procurement system to record and report supplier performance measures
• Supply plan on web site for supplier to view
• Weekly dashboard reporting
• Spend analysis tool

The types of technology being used include:
• E-procurement, leveraging Electronic catalogues.
• Mobile technology support – regardless of type
• Procurement module. There is a mix between organisations which are using the procurement module to:
  • electronically file transfer purchase orders (POs) and receive consolidated electronic invoices or allow suppliers to self bill, and organisations which
  • E-mail or fax POs and have not got to electronic POs or invoices.
• Procurement within a new business system implementation.
• Software for supplier relationship management, request for proposal management, contract management, and expense management.
• Providing suppliers with direct access into inventory system for vendor managed inventory
• Collaborative portal.
• Use of supplier web sites to raise purchase orders.
• Data warehousing.
• Automated contracts.
• Advanced shipping notices.
• Assumed receipt.
Example of Automated Procurement

• Organisations fully automated with electronic catalogues, PO creation and approval, electronic PO transmission, and electronic invoicing and payment.
• Mobile Device order capability – integrated to the originator’s host system

The degree of automation includes:
• POs raised through in-house procurement application and either transmitted via electronic file, e-mail, auto fax or manual fax.
• Electronic quotes
• Purchasing through supplier web site
• Purchasing through third party e-procurement service
• Receipt of electronic catalogues for upload into procurement application or organisation intranet site. (Note – only the key supplier catalogues are received, rather than all suppliers.)
• Electronic invoicing and auto payment upon price matching. Few organisations have achieved for all suppliers however most are for key suppliers only.
• Electronic invoicing and manual payment, again for key suppliers only.
• Reverse auctions
• Limited ‘punching out’ from their procurement application to vendor applications

<table>
<thead>
<tr>
<th>Item #</th>
<th>Framework key requirements</th>
<th>Relevant framework area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Standard process across whole procurement value chain</td>
<td>All</td>
</tr>
<tr>
<td>2</td>
<td>Procurement involved in entire procurement process, commencing with BU budgeting and strategic planning (own processes)</td>
<td>All</td>
</tr>
<tr>
<td>3</td>
<td>Staff skills development and retention</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Internal client management and ongoing education/management</td>
<td>3, 5, 6</td>
</tr>
<tr>
<td>5</td>
<td>Commodity strategies developed and implemented</td>
<td>3, 4</td>
</tr>
<tr>
<td>6</td>
<td>Compliance measurement and remediation</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Supplier relationship and performance management is a part of the procurement framework</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>Scorecard established</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>Measurement of procurement performance against KPIs</td>
<td>6, 7</td>
</tr>
<tr>
<td>10</td>
<td>Emerging market analytics, intelligence gathering and performance benchmarking/continuous improvement</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>Supporting tools and templates</td>
<td>All</td>
</tr>
<tr>
<td>12</td>
<td>Technology streamline tactical procurement (eg. masterpieces and supporting strategic procurement (eg. compliance, analytics, data etc.)</td>
<td>3, 6, 8 (4, 5)</td>
</tr>
</tbody>
</table>

Introduce a procurement framework to sustain results

<table>
<thead>
<tr>
<th>Source, transact and manage</th>
<th>Measure and enhance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 Develop and retain staff</td>
<td>3.0 Create and implement sourcing strategy, and operationalise commodity</td>
</tr>
<tr>
<td>4.0 Manage, enhance and review supplier relationships and performance</td>
<td>5.0 Engage client base and manage change</td>
</tr>
<tr>
<td>6.0 Monitor internal compliance and educate stakeholders</td>
<td>7.0 Measure and benchmark procurement performance</td>
</tr>
</tbody>
</table>

Procurement framework first level

1.0 Develop and retain staff

Example
Introduce a procurement framework to sustain results

1.0 Develop and retain staff- second level

- 1.1 Plan and manage skills, resourcing requirements and reward structure
- 1.2 Recruit staff
- 1.3 Define individual staff career plans, KPIs and training requirements
- 1.4 Develop and maintain staff training programs
- 1.5 Conduct training and improve training approach
- 1.6 Measure staff performance and review skill requirements
- 1.7 Review staff, determine rewards and required improvement

Process purpose:
- Ensure appropriate staff placement
- Provide staff with a clear career path
- Develop staff skill sets in line with leading practice
- Attract and retain high calibre procurement professionals
- Reward performance and overcome skill deficiencies

2.0 Determine requirements, analyse expenditure / market- second level

- 2.1 Determine or verify commodity requirements
- 2.2 Conduct expenditure and supply base analysis
- 2.3 Define the market (high level)
- 2.4 Analyse market trends and competition (detail level)
- 2.5 Analyse key vendors
- 2.6 Document commodity analysis

Process purpose:
- Determine commodity requirements at initiation of procurement cycle (generally business unit planning)
- Understand company’s level of expenditure and relationship to market
- Understand market conditions and how they influence supplier behaviour
- Understand key supplier characteristics, and how they are influenced by the market and the company

3.0 Create and implement sourcing strategy- second level

- 3.1 Assess sourcing strategies and select preferred
- 3.2 Identify commodity measurement framework
- 3.3 Document commodity plan and go to market
- 3.4 Implement commodity
- 3.5 Manage supplier performance and requirements
- 3.6 Transition new supply arrangements into organisation
- 3.7 Commence transactional buying and manage

Process purpose:
- Determine the number of suppliers required for the commodity
- Determine optimal sourcing strategy eg
  - Best Price Evaluation
  - Product Redesign
  - Strategic Relationship
  - Volume Leveraging
  - Process Improvement
  - Global Sourcing
- Determine optimal method for sourcing (eg renegotiate vs tender)
- Determine and implement most appropriate supply base structure (eg panel vs sole supplier)
- Determine supplier performance measures and incorporate contractually
- Facilitate supplier adoption of company’s mode of engagement (eg eProcurement and content requirements)
- Transition commodity into organisation and commence business-as-usual purchasing
Introduce a procurement framework to sustain results

4.0 Manage / enhance supplier relationships and performance- second level

Process purpose
- Measure supplier performance and remedy performance variances
- Manage the supplier relationship based on commodity strategy (eg strategic supplier vs routine supplier)
- Work with key suppliers to identify development and improvement opportunities (eg joint process improvement)
- Ensure contract lifecycle requirements are tightly monitored

5.0 Engage client base and manage change- second level

Process purpose
- Constant engagement with internal clients to build a strong relationship
- Understand client requirements, and ensure early procurement involvement
- Identify and track problematic client areas
- Educate business units on the benefits of procurement involvement and their role in the procurement value chain
- Provide up to date business unit information to commodity councils

6.0 Monitor internal compliance and educate stakeholders- second level

Process purpose
- Measure and monitor compliance to procurement policy, procedures and Agreements
- Educate stakeholders or escalate issue depending on nature of compliance breach

(note that the term “stakeholder” is used as opposed to “client” in process 5.0, as compliance monitoring will cover all participants in the procurement value chain, including procurement staff)
7.0 Measure and benchmark procurement performance- second level

**External market intelligence analysis**

- 7a.1 Determine commodity intelligence requirements
- 7a.2 Identify intelligence sources and gathering protocols
- 7a.3 Document commodity intelligence plan and gain sign-off
- 7a.4 Educate responsible procurement staff on requirements
- 7a.5 Collate data and benchmark against organisation
- 7a.6 Provide periodic report to commodity staff
- 7a.7 Implement and update commodity intelligence requirements

**Procurement practice benchmarking and improvement**

- 7b.1 Identify organisation procurement benchmark areas and sources
- 7b.2 Design internal stakeholder feedback mechanism
- 7b.3 Design supplier feedback mechanism
- 7b.4 Create Benchmarking / improvement plan and gain sign-off
- 7b.5 Implement plan and determine enhancement opportunities
- 7b.6 Create enhancement proposal and gain sign-off
- 7b.7 Implement enhancements to operations
- 7b.8 Review procurement benchmark areas and sources

**Benefits realisation/ROI**

- 7c.1 Determine commodity financial and non-financial benefit targets
- 7c.2 Agree targets with relevant stakeholders and gain sign-off
- 7c.3 Adjust targets with relevant stakeholders and gain sign-off
- 7c.4 Track financial and non-financial benefits
- 7c.5 Periodic report on benefits realised
- 7c.6 Review targets
- 7c.7 Adjust budget in line with targets
- 7c.8 Review procurement benchmark areas and sources

**Introduce a procurement framework to sustain results**

Process purpose: Monitor true value of commodities, developing market trends/pressures and key supplier activity

Process purpose: Ensure the organisation is staying abreast of leading practice and incorporating stakeholder and supplier feedback into the ongoing development of procurement operations

Process purpose: Track benefits achieved versus the cost of operations for procurement and ensure that benefits are communicated to the appropriate stakeholders

**List of potential Procurement initiatives**

- Clearly define Procurement mission and business strategy
- Create a process to promote full Asset Lifecycle management at the time of new asset build
- Centralize all procurement across the enterprise to one management structure and set of defined processes
- Leverage global contracts to best leverage global spend and/or northern spend
- Establish a direct new product buy procedure
- Ensure key metrics (KPI’s) can be extracted from supply chain system (or Knowledge database)
- Share Corporate sourcing and commodity plans across the enterprise
- Develop a formal ‘Supplier Selection Process’ and deploy across the enterprise
- Create Supply Chain planning / forecasting capability to optimize required on hand inventory balances
- Create the capability to query inventory masters and history to develop information views of the spare parts assets.
- Link Procurement strategy with business strategy
- Promotes the development and empowerment of the procurement process and its people.
- Ensure recognition and rewards (Team / individual) are established that support the success of the Supply Chain and procurement process
- Look for opportunities to leverage supplier inventories and share data to minimize on hand inventory levels (Supplier Relationship Management integration)
- Create visibility of received inventory at the central site warehouse so that it will become ‘in-transit’ inventory on the system and then go to ‘on hand balance’ after it has been received and quantity verified at the network stock room warehouse sites.
- Develop key set of supplier performance metrics that can establish supplier monitoring and ranking
- Ensure regular access to an understanding of supply market environment and changes
- Link Procurement strategy with business strategy
Procurement Policies and Procedures Manual

- 1.0 Procurement Mission Statement
- 2.0 Organization Chart
- 1.0 Procurement Core Values and Ethical Conduct
- 1.1 Core Values
- 1.1.1 Understanding
- 1.1.2 Integrity and Teamwork
- 1.2 Ethical Conduct
- 1.2.1 Ethics and Conduct
- 1.2.2 Business Ethics and Conduct
- 1.2.3 Gifts and Gratuities
- 1.2.4 Selecting Contributions
- 4.0 Business Controls
- 3.0 Procurement Policies and Procedures
- 3.1 Procurement Commitments
- 3.1.1 Delegation of Authority
- 3.1.1.1 Delegation of Procurement Authority within Procurement Organization
- 3.1.1.2 Delegation of Procurement Authority to Non-Procurement Organizations
- 3.1.2 Approval of Commitments
- 3.1.2.1 Procurement Posting Approval Limits
- 3.1.2.2 Separation of Duties
- 3.1.3 Confidential Information
- 3.1.4 Supplier Relationships
- 3.2 Reciprocity and Bartering
- 3.2.1 Conflicts of Interest
- 3.2.2 Dealing with Former Employees, Relatives or Close Personal Friends of Current Employees
- 3.3 Contracts and Purchase Orders
- 3.3.1 Standard Agreements
- 3.3.2 Time and Material Contracts
- 3.3.3 Fixed Agreements
- 3.4 Legal Reviews
- 3.5.1 Contract Currency and Currency Fluctuation
- 3.5.2 Contract Publicity
- 3.5.3 Procurement Contract Owner Responsibilities
- 3.5.7 Documentation Requirements
- 3.5.8.1 Monitoring the Projected Value of a Contract
- 3.5.8.2 Contract Administration
- 3.5.12 Delegation of Corporate Funds
- 3.5.10 Special Situations
- 4.0 Supplier Selection and Price or Value Determination
- 4.1 General Requirements
- 4.2 Business Partners that Become Suppliers to TMC Ltd
- 4.3 Definitions
- 4.3.1 Competitive Evaluation
- 4.3.1.1 Competitive Evaluation with Price
- 4.3.1.2 Competitive Evaluation without Price
- 4.3.2 Analytical Techniques
- 4.3.2.1 Competitive-Bidding
- 4.3.2.2 Request for Quote / Request for Proposal (RFP / RRF)
- 4.3.2.3 Request for Information (RIN)
- 4.3.3 Early Involvement Partners
- 4.3.3.1 Transportation Cost
- 4.3.3.2 Special Situations
- 4.3.4 Local Source - only one known supplier exists in the world
- 4.3.5 Software / Licensing / Intellectual Property
- 4.3.6 Negotiation
- 4.3.7 Invitation to Bid and Feedback to Suppliers
- 4.3.8 Rapid Decisions to Buyers
- 4.3.9 Legal Requirements
- 4.3.10 Laws and Regulations specific to regional or local areas
- 4.3.11 Export and Re-exportation of United States Commodities, Technology and Software
- 4.3.12 Measurements
- 4.3.13 Key Performance Indicators
- 4.3.14 Systems Access
- 4.3.15 Change Log

Example of a simple Open Catalogues Interface (OCI) to a Maintenance Parts Procurement system
Many elements of the Maintenance Parts Value Chain need to be well managed to meet business asset demands.

Logistics Value Influence

<table>
<thead>
<tr>
<th>Unit Sourcing Costs</th>
<th>Inventory Management</th>
<th>Delivery</th>
<th>Key Performance Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Areas to Consider</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Content Management</td>
<td>• Demand Management</td>
<td>• Emergency cycle times</td>
<td></td>
</tr>
<tr>
<td>• Substitutions</td>
<td>• Service specific forecasting algorithms</td>
<td>• Parts Availability</td>
<td></td>
</tr>
<tr>
<td>• Category Management</td>
<td>• Part Criticality</td>
<td>• Parts Acquisition Time</td>
<td></td>
</tr>
<tr>
<td>• Vendor Managed Inventory</td>
<td>• Inventory Effectiveness</td>
<td>• Systems Availability</td>
<td></td>
</tr>
<tr>
<td>• Supplier SLAs</td>
<td>• (Multiple replenishment) Inventory Policies</td>
<td>• Distribution Quality</td>
<td></td>
</tr>
<tr>
<td>• Supplier Warranty Redemption</td>
<td>• Re-utilization Strategies</td>
<td>• Parts Quality</td>
<td></td>
</tr>
<tr>
<td>• Re-utilization Strategies</td>
<td>• Automated replenishment plans</td>
<td>• Parts Costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Inventory Surplus Management</td>
<td>• Inventory Turnover</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Emergency cycle times</td>
<td>• Inventory Reserves</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Parts Acquisition Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Systems Availability</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Distribution Quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Parts Quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Parts Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Inventory Turnover</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Inventory Reserves</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from IBM Parts Management Case Study – Don Barry

Rotatable and Repairable Parts process

Vendor / Supplier → Central Warehouse → Local Stock Room → Asset → Used Parts Disposition → Used Parts Repair → Vendor / Supplier
What are the dynamics of Parts Repair?

- Used Parts Return Management
- Parts Disposition
- Repair capture rate
- Repair Yields
- Out of Box Failures
- 2nd Return Rate
- Cost of component parts/services required for repair
- Total Value of Repair
Financial benefits of repairing used defective parts and returning to stock

- **Parts Repair processes in Maintenance Parts Management**
  - defective parts are repaired or refurbished and placed back into active inventory when deemed ‘like new’.
  - cost of repairing and re-using a part can be less than 25% to 50% of a new one.
  - recycling of these parts can greatly reduce the amount of purchased inventory a company has to keep on hand

- **Parts Repair Strategies compliment**
  - Procurement strategy
  - Inventory Management strategy

- **Financial Guidance**
  - account for the cost of the repair for a used repaired parts
  - consider some cost recovery for the collected, stocked and staged used defective parts when part is returned to stock

---

**Example Financial Approach**

- Repaired part value back to inventory = Repair Cost + Used Part Cost, when:
  - Weighted average cost of a new part in inventory: WAC
  - Average cost of a repaired defective part packaged for stocked: Repair Cost
  - Cost of a used carcass about to be repaired: Used Part Cost = 25% of WAC plus some logistics costs

---

**Note**

- in the repair cost would be accounting for:
  - the apportioned development costs to create a repair cost;
  - the sub-components and labor required to repair the part;
  - the packaging costs to prepare the part for being stocked into inventory
  - the infrastructure costs for the parts repair center.

- in the used part costs there would be accounting for:
  - 25% of a WAC part stocked at time of repair; and
  - apportioned logistics fees and overhead for getting the part returned and staged.

---

**Maintenance Parts Stocking Influences**

- Service Levels
- Inventory $

**Business Mission Driven**
What is Inventory Planning?

- **Maintenance Parts inventory planning** is the process of:
  - determining target inventory levels for each part at each stocking location (inventory planning); and
  - determining the appropriate replenishment policy for each part at each location (replenishment planning).

- **Role and Responsibilities of the Inventory Planner**
  - would lead the facilitation to develop an asset and location specific Inventory Policy for ISP/RSP, highly active and moving inventory, medium moving inventory and surplus inventory.
  - would be expected to forecast, facilitated and execute the inventory policy based on the mutually agreed to ISP/RSP levels provided by the Design Engineering team, Maintenance, Operations and Finance and the established disciplines for active inventory as a compliment to the policy success.

Maintenance Parts Stocking Influences

- **Maintenance**
  - Strategies
  - Culture
  - New Asset Ownership through Life-cycle
  - Discipline
  - Execution
  - End of Life support

- **Parts Support**
  - Logistics Strategy and Execution
  - Supplier Management and Service Levels
  - Parts Refurbishment Options
  - Inventory Policy, Planning and Execution
  - Surplus Management

- **Operations**
  - Operating strategies
  - Scheduling asset/equipment for planned maintenance
  - Operator TPM actions

- **Business Mission Driven**

- **Asset / Equipment**
  - Strategies
  - Quality
  - Capture/ Coverage

- **Design Engineering Support**
  - New Asset Documentation
  - OEM/Supplier Commitment and Execution
  - Initial Spare Parts Insights
  - Commissioning support and handoff

- **Finance**
  - Accounting Actions
  - Financial Planning for Inventory Provisions
  - Regulatory alignment

- **Government**
  - Regulatory Influences
  - Tax support
Many elements of the Maintenance Parts Value Chain need to be well managed to meet business asset demands.

Logistics Value Influence

<table>
<thead>
<tr>
<th>Unit Sourcing Costs</th>
<th>Inventory Management</th>
<th>Delivery</th>
<th>Key Performance Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Demand Management</td>
<td>• Emergency cycle times</td>
<td>• Parts Availability</td>
<td></td>
</tr>
<tr>
<td>• Service specific forecasting algorithms</td>
<td>• Kitting</td>
<td>• Parts Acquisition Time</td>
<td></td>
</tr>
<tr>
<td>• Part Criticality</td>
<td>• Vehicle / Remote Inventory</td>
<td>• Systems Availability</td>
<td></td>
</tr>
<tr>
<td>• Inventory Effectiveness</td>
<td>• Delivery strategies</td>
<td>• Distribution Quality</td>
<td></td>
</tr>
<tr>
<td>• Inventory Policies</td>
<td>• Reverse Logistics</td>
<td>• Parts Quality</td>
<td></td>
</tr>
<tr>
<td>• Automated replenishment plans</td>
<td>• Exception management</td>
<td>• Parts Costs</td>
<td></td>
</tr>
<tr>
<td>• Inventory Surplus Management</td>
<td>• Multi-echelon deployment</td>
<td>• Inventory Turnover</td>
<td></td>
</tr>
<tr>
<td>• Emergency cycle times</td>
<td>• Multi-echelon deployment</td>
<td>• Inventory Reserves</td>
<td></td>
</tr>
</tbody>
</table>

Common Areas to Consider
- Content Management
- Substitutions
- Category Management
- Vendor Managed Inventory
- Supplier SLAs
- Supplier Warranty Redemption
- Re-utilization Strategies
- Demand Management
- Service specific forecasting algorithms
- Part Criticality
- Inventory Effectiveness
- (Multiple replenishment) Inventory Policies
- Automated replenishment plans
- Inventory Surplus Management
- Emergency cycle times
- Kitting
- Vehicle / Remote Inventory
- Delivery strategies
- Reverse Logistics
- Exception management
- Multi-echelon deployment
- Parts Availability
- Parts Acquisition Time
- Systems Availability
- Distribution Quality
- Parts Quality
- Parts Costs
- Inventory Turnover
- Inventory Reserves

Many elements of the Maintenance Parts Value Chain need to be well managed to meet business asset demands across the Asset Life-cycle.
Striking a balance between Inventory levels and costs

![Graph showing inventory vs costs](image)

**What do we use parts for?**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Spares Needed?</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine / running repairs</td>
<td>Some</td>
<td>All of this work can be planned &amp; scheduled</td>
</tr>
<tr>
<td>Emergency repairs</td>
<td>Some</td>
<td>Some can be planned but none is scheduled</td>
</tr>
<tr>
<td>Shutdown repairs and projects</td>
<td>No</td>
<td>All of this work can be planned &amp; scheduled</td>
</tr>
<tr>
<td>Project work</td>
<td>No</td>
<td>All of this work can be planned &amp; scheduled</td>
</tr>
<tr>
<td>Proactive maintenance</td>
<td>Some</td>
<td>All of this work can be planned &amp; scheduled</td>
</tr>
</tbody>
</table>

Adapted from IBM Parts Management Case Study – Don Barry
Inventory Stocking Policy Strategies

- **Demand**
  - Order point, Max Stock Levels
  - Based on activity per quarter
- **Insurance Parts (ISPs / RSPs)**
  - Stocked based on Design Engineers
  - Recommended initial stock requirements (usually set to Qty 1)
- **Date Protect (minimums)**
  - Stock if new in past 12 months
  - Stock if used in past 12 months
- **Forces / Blocks**
  - Set by Inventory Manager based on seasonal, cost, EOL or phase-in strategies
  - Could override above settings
- **Local Settings**
  - Substitute Order point set by local warehouse (Limited to 5% of total WH Inventory)

**Inventory Oversight?**

*What role should do what? - Complete the "?"*
*We will take this up later!*********

Leading Practice Echelon Support

**Example of Leading Practice Echelon Hierarchy**

- **Repair Process / Alternative Supplier**
- **OEM Supplier**
- **Central Warehouse**
- **Local Stock Room**
- **Remote Location / Maintenance Site**

**Target Service Level**

- Level 3: 100%
- Level 2: 95%
- Level 1: 85%

*Note – Services levels are accumulative*

*Example – Combine support of level 1 and 2 targets 85%*
Inventory Carrying Costs

- The cost of carrying inventory includes the cost of:
  - storage facilities, store personnel for inventory handling,
  - transportation between stock locations (if applicable)
  - insurance and tax,
  - allowance for obsolescence due to engineering changes,
  - allowance for loss due to pilferage or spoilage, and
  - the time value of money (the lost opportunity for alternative investments).

- The cost for placing orders includes the cost of the whole transaction process, from purchasing to material receiving.
  - Including the cost of the materials purchased

Driving Optimal Inventory Policy

- What is Inventory Policy?
  - Setting inventory stocking guidance, by part number, for each stockroom for the specific assets and maintenance strategies they have been charged to support

- What variables can be included in an Inventory policy for a SKU?
  - Functional criticality of the asset supported
  - Understanding of the functional failure dynamics
  - Understanding of planned maintenance and frequency of scheduled activity
  - Recent unplanned activity
  - Understanding of the asset life-cycle
  - Surplus management
  - Scrap management
  - Parts repair infrastructure and policy
  - Warranty management
Planning levels in the spare parts supply chain

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>Spare Parts Support Activity</th>
<th>Program Cycle</th>
<th>Inventory Management Cycle</th>
<th>Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years</td>
<td>Asset Parts Life-cycle</td>
<td>Strategic</td>
<td>Asset/Parts Life-cycle Mgmt</td>
<td>Engineering, Maintenance, Inventory, Finance</td>
</tr>
<tr>
<td>Years</td>
<td>Parts Support Network Design</td>
<td>Tactical</td>
<td>Parts Inventory Optimization</td>
<td>Maintenance, Inventory, Finance</td>
</tr>
<tr>
<td>Months</td>
<td>Parts Supply Chain Planning</td>
<td>Tactical</td>
<td>Inventory Planning and Policy Mgmt</td>
<td>Inventory Planner, Finance</td>
</tr>
<tr>
<td>Months</td>
<td>Parts Supply Chain Optimization</td>
<td>Tactical</td>
<td>Parts Inventory Optimization</td>
<td>Maintenance, Inventory, Finance</td>
</tr>
<tr>
<td>Weeks / Days</td>
<td>Parts Supply Chain Execution</td>
<td>Execution</td>
<td>Inventory Planning and Policy Mgmt</td>
<td>Inventory Planner, Finance</td>
</tr>
</tbody>
</table>

Maintenance Parts Stocking Influences

**Maintaince Parts Inventory**

- Maintenance Parts Inventory Additions
  - Initial Spare Parts / Recommended Spare Parts
  - Surplus Asset Commissioning Parts
  - New Parts Returns from Customer or Technician
  - Parts Replenishment
  - Unique Parts Usage or Asset Enhancement
  - Warranty Replacements

- Maintenance Parts Disbursements
  - Technician Parts Usage on a Work Order
  - Parts Sale to External entity
  - Parts Warranty or Quality Issue
  - Surplus Sale
  - Parts Scrap

**Which Inventory inputs /outputs should be part of inventory policy?**
Stocking elements of an Inventory Policy

Each policy element is expected to be a compliment to the enterprise inventory management policy. Each asset will be supported by multiple sets of dynamic influences including:

- Local parts disbursement volumes (highly active or activity in the past year);
- The ISP/RSP settings;
- Or Inventory Optimized program overrides;
- Local history date related parameters; and
- Surplus management polices and activities
- Replenishment cycles
- Parts Returns policy

```
Stocking Inputs:
- Initial Spare Parts / Recommended Spare Parts
- Highly Active Parts (Min/Max/EOQ)
- Date Activity (Birth, last used)
- Dynamic Inventory Optimizer
- Substitution Order Points
- Parts Replenishment

Inventory Policy

Inventory Stocking Outputs:
- Surplus Mgmt
- Scrap Mgmt
- Parts Usage / Returns
- Parts Network support
- Found Parts, Commissioning surplus
```

```
Inventory Policy Management Process

Inventory Plan'r
- Local Date Protect Parameters
- Local Avgd, Min/Max, EOQ
- Weekly Policy Calculation
- Replenishment Transmissions
- Surplus Mgmt
- Optimizer Input to Inv Policy
- Optimizer Data Mgmt
- ISP/RSP Data Mgmt

Proc Mgr
- Optimizer Input to Inv Policy
- Optimizer

Design Eng
- ISP/RSP Input to Inv Policy
- Optimizer Data Mgmt

Mkt Lead
- Optimizer

Stock Room Lead
- Local Policy Override
- Surplus

Fin Mgr
- Surplus Mgmt Guidance

Inventory Mgmt System
```

26
### Inventory Management Policy Input Disciplines

<table>
<thead>
<tr>
<th>Inventory Policy Discipline</th>
<th>Description</th>
<th>How determined</th>
<th>Discipline owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Parts Management</td>
<td>Parts level support to parts most active by stock room location</td>
<td>Minimum, Maximo Economic Order Quantity, Safety Stock Elements for parts with 2 line disbursements within a rolling 3 month period</td>
<td>Inventory Planner</td>
</tr>
<tr>
<td>Initial Spare Parts (ISP) / Recommended Spare Parts (RSP)</td>
<td>Insurance parts settings provided by the Design Engineering group (Pre asset go-live) and Maintenance (post asset commissioning)</td>
<td>Continent wide usage, Asset Reliability requirements, Cost of part, picking, transportation of replenishment and expediting.</td>
<td>Design Engineering / Maintenance</td>
</tr>
<tr>
<td>Optimizer</td>
<td>All inclusive Min/Max, EOQ setting based on 40 – 50 dynamic variables</td>
<td>Data Protection Parts already in stock by location maintain a support quantity of 1 Replenished to 1 if used based on date last disbursed or date created in location less than target date set by location (i.e. 1 year, 2 years, etc.)</td>
<td>Community of Design Engineering / Maintenance, Operations, Finance and Inventory Planner</td>
</tr>
<tr>
<td>Date Protection</td>
<td></td>
<td>Local Override Local support override setting (usually 1) for local stock room risk needs Allowed to a maximum of a percentage of the total stockroom value (i.e. 2% for stock rooms)</td>
<td>Local Stock room, Local Maintenance Mgmt and Inventory Planner</td>
</tr>
<tr>
<td>Surplus</td>
<td>Parts in stock in a specific stock room that are not in policy</td>
<td>Parts on-hand – by location that are beyond the policy quantity or not in policy (as described above)</td>
<td>Inventory Planner</td>
</tr>
</tbody>
</table>

### 3 Level Echelon - Distribution Center or Warehouse

<table>
<thead>
<tr>
<th>Inventory Policy Lead</th>
<th>Potential Stock setting for Stock Room Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Parts</td>
<td>Max set to 12 weeks of stock</td>
</tr>
<tr>
<td>ISP/RSP</td>
<td>D Level ISP RSP</td>
</tr>
<tr>
<td>Optimizer</td>
<td>95% service level target</td>
</tr>
<tr>
<td>Date protected</td>
<td>2 years since last changed</td>
</tr>
<tr>
<td>Local Override</td>
<td>Manage to 4% of total value</td>
</tr>
<tr>
<td>Surplus</td>
<td>Manage to 20% of total value</td>
</tr>
</tbody>
</table>

### 2 Level Echelon – Local Stock Room

<table>
<thead>
<tr>
<th>Inventory Policy Lead</th>
<th>Potential Stock setting for Stock Room Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Parts</td>
<td>Max set to 8 weeks of stock</td>
</tr>
<tr>
<td>ISP/RSP</td>
<td>C Level ISP RSP</td>
</tr>
<tr>
<td>Optimizer</td>
<td>85% service level target</td>
</tr>
<tr>
<td>Date protected</td>
<td>1 year since last changed</td>
</tr>
<tr>
<td>Local Override</td>
<td>Managed to 2% of total value</td>
</tr>
<tr>
<td>Surplus</td>
<td>Manage to 10% of total value</td>
</tr>
</tbody>
</table>

### 1 Level Echelon – Asset Stock site (Technician managed)

<table>
<thead>
<tr>
<th>Inventory Policy Lead</th>
<th>Potential Stock setting for Stock Room Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Parts</td>
<td>Max set to 2 weeks of stock</td>
</tr>
<tr>
<td>ISP/RSP</td>
<td>B Level ISP RSP</td>
</tr>
<tr>
<td>Optimizer</td>
<td>55% service level target</td>
</tr>
<tr>
<td>Date protected</td>
<td>6 months since last changed</td>
</tr>
<tr>
<td>Local Override</td>
<td>Managed to 5% of total value</td>
</tr>
<tr>
<td>Surplus</td>
<td>Manage to 10% of total value</td>
</tr>
</tbody>
</table>

*Example of Inventory Policy approach set for a 3 level echelon stocking network*
Example of a Maintenance Parts Inventory Profile (by Stock room or total for a network)

### Stock Room Inventory Profile

#### Inventory On Hand Balance Summary

<table>
<thead>
<tr>
<th>Policy Categories</th>
<th>Item</th>
<th>Lines</th>
<th>Total</th>
<th>Pieces in Stock</th>
<th>Value in Stock</th>
<th>%</th>
<th>%</th>
<th>$ Value in Stock</th>
<th>%</th>
<th>$ Value in Stock</th>
<th>%</th>
<th>$ Value in Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>ISP/RSP</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Optimizer Res</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Local Override</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Date Protected</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Not in Policy</td>
<td>240</td>
<td>3144</td>
<td>4%</td>
<td>691,080</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5750</td>
<td>85264</td>
<td>100%</td>
<td>11,713,780</td>
<td>100%</td>
<td>26285</td>
<td>100%</td>
<td>63885</td>
<td>77%</td>
<td>6,422,550</td>
<td>54%</td>
<td></td>
</tr>
</tbody>
</table>

#### Inventory Policy Summary

<table>
<thead>
<tr>
<th>Policy Categories</th>
<th>Item</th>
<th>Lines</th>
<th>Total</th>
<th>Pieces in Stock</th>
<th>Value in Stock</th>
<th>%</th>
<th>%</th>
<th>$ Value in Stock</th>
<th>%</th>
<th>$ Value in Stock</th>
<th>%</th>
<th>$ Value in Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>ISP/RSP</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Optimizer Res</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Local Override</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Date Protected</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>35120</td>
<td>47%</td>
<td>188,000</td>
<td>5%</td>
<td>13000</td>
<td>5%</td>
<td>33520</td>
<td>40%</td>
<td>17,290</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Not in Policy</td>
<td>240</td>
<td>3144</td>
<td>4%</td>
<td>691,080</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5750</td>
<td>85264</td>
<td>100%</td>
<td>11,713,780</td>
<td>100%</td>
<td>26285</td>
<td>100%</td>
<td>63885</td>
<td>77%</td>
<td>6,422,550</td>
<td>54%</td>
<td></td>
</tr>
</tbody>
</table>

### Inventory Surplus Summary

<table>
<thead>
<tr>
<th>Policy Categories</th>
<th>Surplus Lines</th>
<th>Surplus Pieces</th>
<th>Surplus Value in Stock</th>
<th>% Surplus Lines</th>
<th>% Surplus Pieces</th>
<th>% Surplus Value in Stock</th>
<th>Note: Total in policy + Surplus values do not need to equal On Hand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>220</td>
<td>30170</td>
<td>36%</td>
<td>442,550</td>
<td>4%</td>
<td>442,550</td>
<td>On Hand Total</td>
</tr>
<tr>
<td>ISP/RSP</td>
<td>3000</td>
<td>60140</td>
<td>3%</td>
<td>1,732,240</td>
<td>10%</td>
<td>1,732,240</td>
<td></td>
</tr>
<tr>
<td>Optimizer Res</td>
<td>4125</td>
<td>75950</td>
<td>1%</td>
<td>1,973,480</td>
<td>17%</td>
<td>1,973,480</td>
<td></td>
</tr>
<tr>
<td>Local Override</td>
<td>480</td>
<td>752</td>
<td>1%</td>
<td>290,120</td>
<td>2%</td>
<td>290,120</td>
<td></td>
</tr>
<tr>
<td>Date Protected</td>
<td>400</td>
<td>696</td>
<td>1%</td>
<td>143,360</td>
<td>1%</td>
<td>143,360</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8815</td>
<td>46112</td>
<td>5%</td>
<td>4,483,270</td>
<td>38%</td>
<td>4,483,270</td>
<td></td>
</tr>
<tr>
<td>Not in Policy</td>
<td>2400</td>
<td>3144</td>
<td>4%</td>
<td>691,080</td>
<td>0%</td>
<td>691,080</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>12215</td>
<td>40156</td>
<td>59%</td>
<td>5,173,050</td>
<td>44%</td>
<td>5,173,050</td>
<td></td>
</tr>
</tbody>
</table>

### ABC Stocking Strategies

- **You may use ABC classification in the following areas:**
  - **Engineering:**
    - Engineering parts rationalization efforts should be focused on items with high usage value rather than on items with lower value;
  - **Procurement:**
    - Purchasing activities should concentrate on items with higher usage value for sourcing and negotiating. More sophisticated supply arrangements are applied to "A" items while "B" and "C" items can even be considered for outsourcing;
  - **Inventory replenishment:**
    - Sometimes the classification scheme may influence the inventory replenishment control method. It might be more economical to control some "C" items with a simple two-bin system. Scientific management techniques are applied to "A" items;
  - **Inventory cycle counting:**
    - When checking inventory record accuracy using cycle-counting method, "A" items should be verified more frequently than "B" or "C" items;
  - **Security:**
    - Although absolute unit price might be a better guideline than usage value, ABC analysis may also be used as an indicator of which items should be more tightly secured in locked stockrooms.
Example of some strategy options for Parts Inventory Management

<table>
<thead>
<tr>
<th>Stocking Strategies</th>
<th>ABC</th>
<th>Active vs. Insurance Stock</th>
<th>Criticality Stocking</th>
<th>Optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td></td>
<td>• Top 80% used items by $ value</td>
<td>• Top used parts (typically 2 usages in 3 months)</td>
<td>• Level 1 is supported through either of ABC or Active Level 1 process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Less than 10% of stocked items</td>
<td>• Less than 10% of stocked items</td>
<td>• Less than 10% of stocked items</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Low value parts that are deemed to used in asset life-cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Balanced with stocking and expediting costs</td>
</tr>
<tr>
<td>Level 2</td>
<td></td>
<td>• Next 15% used items by $ value</td>
<td>• New part in past year or at least one usage in past year</td>
<td>• High criticality, high usage parts not covered in level 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Less than 20% of stocked items</td>
<td>• Less than 20% of stocked items</td>
<td>• Can be 20% of parts stocked</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Cost effective stocking of parts expected to be used once a cycle (i.e. year)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Can be 60% of stocked items</td>
</tr>
<tr>
<td>Level 3</td>
<td></td>
<td>• Bottom 5% used items by $ value</td>
<td>• Parts deemed to be stocked 'Just in case'</td>
<td>• Lower criticality parts and lower usage parts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Can be than 70% of stocked items</td>
<td>• Can be 70% of stocked items</td>
<td>• Can be 70% of stocked items</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• High value low usage parts stocked, often at a consolidation centre</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td>• Often manual initial stock process with Min/Max support</td>
<td>• Often scientific initial stock process with Min/Max support</td>
<td>• Can have many levels of criticality and echelon support depending on the support network</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Considers all costs / impacts in stocking optimization calculations, by network location</td>
</tr>
</tbody>
</table>

Note - Parts deemed as 'critical' or required for 'insurance' typically part of level 3

Stocking elements of an Inventory Policy

Each policy element is expected to be a compliment to the enterprise inventory management policy. Each asset will be supported by multiple sets of dynamic influences including:

- Local parts disbursement volumes (highly active or activity in the past year);
- The ISP/RSP settings;
- Or Inventory Optimized program overrides;
- Local history date related parameters; and
- Surplus management policies and activities
- Replenishment cycles
- Parts Returns policy
Classical Sawtooth Model of Inventory Policy Management

- Introduction to Inventory Terminology
  - Quantity on Hand
  - Quantity on Order
  - Quantity in Transit
  - Quantity Reserved
  - Quantity Available
  - Unit cost

- Stocking Policy by Asset/SKU and Stock room
  - Weekly Average Demand
  - Maximum Stock Level
  - Minimum Stocking Level
  - Safety Stocking Level
  - Reorder Point
  - Economic Ordering Point

- Where used
- How used
- Impact if 'out of stock'
- Impact if 'not stocked'
- Planned vs. unplanned disbursements
- Surplus Management
- Inventory Turnover
Unit price and annual usage

• You can calculate and classify them by following these steps:
  • multiply usage by unit price to determine annual usage value in dollars;
  • rank items by annual usage value from highest to lowest (sort the spreadsheet if you are using a PC with standard office software);
  • calculate cumulative percentage of total annual usage value;
  • assign ABC categories by predetermined guidelines (For example, “A” for items holding 80 percent from the top, “B” for next 15 percent and “C” for others);
  • refine the categories by experienced judgement, but not too much.

• Many of the new information management systems do these calculations, and provide both customized and standard reports.

Scientific inventory management

• The two basic questions for inventory management are:
  • when to replenish and
  • how much to buy.

• The combinations of control schemes are:
  • fixed time interval; fixed reorder quantity (not too common except for items with very predictable and low variance of demand);
  • variable time interval; fixed reorder quantity;
  • variable time interval; variable reorder quantity;
  • fixed time interval; variable reorder quantity.
There are several methods used for determining the timing of replenishment orders of inventory items

- Two common methods are:
  - the reorder point system (variable time – fixed quantity) and
  - the Min-Max system (variable time – variable quantity)
- If inventory level reaches a certain point (the reorder point) the replenishment orders are triggered.
- The only difference between the two systems is the order quantity.
- The reorder point system
  - uses predetermined quantity in every order.
- The Min-Max system
  - the order quantity may be varied whenever orders are issued because the rule is: order enough to restore inventory to the Max level.

The economic order quantity (EOQ) model

- \( EOQ = \frac{2AS}{CI} \)
- Where:
  - A: annual usage
  - S: cost per order
  - C: unit price
  - i: percentage annual carrying cost

- What should the order quantity be?
- How do you determine this for each item?
- It’s starting to look like a lot of work even if the calculation is simple.

Every order quantity decision, even when done intuitively, is based on the comparison of two competing cost drivers – the cost to carry the inventory versus the cost to place orders.
Example EOQ Calculation

<table>
<thead>
<tr>
<th>Unit Cost ($)</th>
<th>Annual Usage</th>
<th>Cost per order ($)</th>
<th>% Carrying Cost</th>
<th>EOQ Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>5</td>
<td>50</td>
<td>0.25</td>
<td>4.472136</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>50</td>
<td>0.25</td>
<td>20</td>
</tr>
<tr>
<td>1000</td>
<td>5</td>
<td>50</td>
<td>0.25</td>
<td>1.414214</td>
</tr>
<tr>
<td>100</td>
<td>5</td>
<td>10</td>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>10</td>
<td>0.25</td>
<td>8.944272</td>
</tr>
<tr>
<td>1000</td>
<td>5</td>
<td>10</td>
<td>0.25</td>
<td>0.632456</td>
</tr>
<tr>
<td>100</td>
<td>5</td>
<td>50</td>
<td>0.25</td>
<td>4.472136</td>
</tr>
</tbody>
</table>

• Demonstrates the relationship between unit cost, cost of handling/shipping, inventory carrying cost and usage

Example EOQ potential impact on inventory turnover

<table>
<thead>
<tr>
<th>Unit Cost ($)</th>
<th>Annual Usage</th>
<th>Cost per order ($)</th>
<th>% Carrying Cost</th>
<th>EOQ Formula</th>
<th>Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>5</td>
<td>50</td>
<td>0.25</td>
<td>4.472136</td>
<td>2.236068</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>50</td>
<td>0.25</td>
<td>20</td>
<td>0.5</td>
</tr>
<tr>
<td>1000</td>
<td>5</td>
<td>50</td>
<td>0.25</td>
<td>1.414214</td>
<td>7.071068</td>
</tr>
<tr>
<td>100</td>
<td>5</td>
<td>10</td>
<td>0.25</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>10</td>
<td>0.25</td>
<td>8.944272</td>
<td>1.118034</td>
</tr>
<tr>
<td>1000</td>
<td>5</td>
<td>10</td>
<td>0.25</td>
<td>0.632456</td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td>5</td>
<td>50</td>
<td>0.25</td>
<td>4.472136</td>
<td>2.236068</td>
</tr>
</tbody>
</table>

A/(EOQ/2), where EOQ = 1

• Demonstrates the relationship between unit cost, cost of handling/shipping, inventory carrying cost, usage and turnover
Replenishment Dynamics Fundamentals

What should I consider in my stocking policy

- Why do I stock parts?
- What is my service strategy?
  - Planned vs, unplanned Mtce
  - NS vs. Out of Stocked parts
- What are the critical assets that I support?
  - Operating context
  - Business Impact, Safety, Environmental
  - Will the part keep the asset from performing it’s required function?
  - Can I forecast the parts need?
  - How often is the part used?
  - Where should I stock the part?

<table>
<thead>
<tr>
<th>Stocking Strategies</th>
<th>ABC</th>
</tr>
</thead>
</table>
| • Level 1           | • Top 80% used items by $ value  
                      | • Less than 10% of stocked items |
| • Level 2           | • Next 15% used items by $ value  
                      | • Less than 20% of stocked items |
| • Level 3           | • Bottom 5% used items by $ value  
                      | • Can be than 70% of stocked items |
| • Comments          | • Often manual initial stock process with Min/max support |
What should I consider in my stocking policy

<table>
<thead>
<tr>
<th>Stocking Strategies</th>
<th>ABC</th>
</tr>
</thead>
</table>
| • Level 1           | • Top 80% used items by $ value  
|                     | • Less than 10% of stocked items |
| • Level 2           | • Next 15% used items by $ value  
|                     | • Less than 20% of stocked items |
| • Level 3           | • Bottom 5% used items by $ value  
|                     | • Can be more than 70% of stocked items |
| • Surplus           | • Surplus to policy supported by ABC  
|                     | above as well as down level parts |

• Active Inventory
  - Leveraging Safety Stock, Order Point, Max Stock, EOQ, Average Demand algorithms

• Annual Activity (by location)
  - Leveraging Date Last Used, Date Stocked

• Initial Spare Parts Recommendations
  - Leveraging input from Manufacturer, Design Engineer, Maintenance Tech, Inventory Manager, or RCM Team

• Surplus Management Recommendations
  - Leveraging where used data, annual usage data, excess distribution within the enterprise, street sale value and market methods, or scrap

Example: Parts usage mix in a Maintenance Parts Stockroom

- More than 80% of the parts stocked are at a policy Max Stock of 1
Example: Parts Stocking Strategy

80-90% of the parts stocked are set to a policy Max stock of ‘1’

Strategies to support Parts Stocking business dynamics
How do we deal with the most active parts?

- **Introduction to Inventory Terminology**
  - Quantity on Hand
  - Quantity on Order
  - Quantity in Transit
  - Quantity Reserved
  - Quantity Available
  - Unit cost

- Stocking Policy by Asset/SKU and Stock room
  - Weekly Average Demand
  - Maximum Stock Level
  - Minimum Stocking Level
  - Safety Stocking Level
  - Reorder Point
  - Economic Ordering Point

- Where used
- How used
- Impact if 'out of stock'
- Impact if 'not stocked'
- Planned vs. unplanned disbursements
- Surplus Management
- Inventory Turnover

---

**Basic Item Master (Part Number) Data**

**Example: Base Parts for a Water Pump**

<table>
<thead>
<tr>
<th>Exercise Number</th>
<th>Part Number (Item Number)</th>
<th>Item Description</th>
<th>Quantity on Hand</th>
<th>Quantity on Order</th>
<th>Quantity in Transit</th>
<th>Total Available Quantity</th>
<th>Cost of Item / Part</th>
<th>Average Demand</th>
<th>Last Used Date</th>
<th>Date of Birth in System</th>
<th>ISP/RSP Stock Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2500109</td>
<td>Pump Casing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td></td>
<td>2019-01-01</td>
<td>2009-01-01</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2500104</td>
<td>Seal</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>12</td>
<td></td>
<td>2019-04-26</td>
<td>2009-01-01</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2500105</td>
<td>Impeller</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>500</td>
<td></td>
<td>2019-03-8</td>
<td>2009-01-01</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2500106</td>
<td>Bearing</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>200</td>
<td></td>
<td>2019-02-22</td>
<td>2009-01-01</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2500207</td>
<td>Shaft</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>400</td>
<td></td>
<td>2009-01-01</td>
<td>2009-01-01</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2500108</td>
<td>Motor coupling</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>150</td>
<td></td>
<td>2019-01-22</td>
<td>2009-01-01</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>2500201</td>
<td>Mount bolts</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td></td>
<td>2009-01-01</td>
<td>2009-01-01</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>2500110</td>
<td>Rubber base gasket</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>45</td>
<td></td>
<td>2019-03-01</td>
<td>2009-01-01</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>2500111</td>
<td>Pipe clamps</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>12</td>
<td></td>
<td>2019-04-12</td>
<td>2009-01-01</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>2500112</td>
<td>Coupling bolts</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>5</td>
<td></td>
<td>2019-01-11</td>
<td>2009-01-01</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>2500113</td>
<td>Coupling nuts</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>5</td>
<td></td>
<td>2019-01-11</td>
<td>2009-01-01</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>2500114</td>
<td>Coupler washers</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td></td>
<td>2019-01-11</td>
<td>2009-01-01</td>
<td>1</td>
</tr>
</tbody>
</table>

**Case Scenario:**
- In planning for the parts activity for a specific pump

**Questions:**
- How many parts are actually available for a Craft if ordered?
- How many parts should be considered available when calculating replenishment?
Another example on managing ‘active’ parts

- Example: Stocking Policy by Asset/SKU and Stock room

- Weekly Average Demand
  - Calculates the running average demand for the past 13 weeks
  - If disbursements more than 13 weeks apart then no Order Point, Max Stock or EOQ will be calculated

Example 1

<table>
<thead>
<tr>
<th>Week</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>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand</td>
<td>0.00</td>
<td>0.00</td>
<td>0.67</td>
<td>0.50</td>
<td>0.40</td>
<td>0.50</td>
<td>0.43</td>
<td>0.38</td>
<td>0.33</td>
<td>0.50</td>
<td>0.45</td>
<td>0.42</td>
<td>0.38</td>
<td>0.43</td>
<td>0.40</td>
</tr>
<tr>
<td>Avgd</td>
<td>0.00</td>
<td>0.00</td>
<td>0.67</td>
<td>0.50</td>
<td>0.40</td>
<td>0.50</td>
<td>0.43</td>
<td>0.38</td>
<td>0.33</td>
<td>0.50</td>
<td>0.45</td>
<td>0.42</td>
<td>0.38</td>
<td>0.43</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Example 2

<table>
<thead>
<tr>
<th>Week</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>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand</td>
<td>1.00</td>
<td>0.50</td>
<td>0.33</td>
<td>0.25</td>
<td>0.20</td>
<td>0.17</td>
<td>0.14</td>
<td>0.13</td>
<td>0.11</td>
<td>0.10</td>
<td>0.09</td>
<td>0.08</td>
<td>0.07</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>Avgd</td>
<td>1.00</td>
<td>0.50</td>
<td>0.33</td>
<td>0.25</td>
<td>0.20</td>
<td>0.17</td>
<td>0.14</td>
<td>0.13</td>
<td>0.11</td>
<td>0.10</td>
<td>0.09</td>
<td>0.08</td>
<td>0.07</td>
<td>0.06</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Example 3

<table>
<thead>
<tr>
<th>Week</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>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand</td>
<td>1.00</td>
<td>1.50</td>
<td>2.00</td>
<td>2.50</td>
<td>3.00</td>
<td>3.50</td>
<td>4.00</td>
<td>4.50</td>
<td>4.78</td>
<td>5.10</td>
<td>4.64</td>
<td>4.25</td>
<td>3.92</td>
<td>3.57</td>
<td>3.20</td>
</tr>
<tr>
<td>Avgd</td>
<td>1.00</td>
<td>1.50</td>
<td>2.00</td>
<td>2.50</td>
<td>3.00</td>
<td>3.50</td>
<td>4.00</td>
<td>4.50</td>
<td>4.78</td>
<td>5.10</td>
<td>4.64</td>
<td>4.25</td>
<td>3.92</td>
<td>3.57</td>
<td>3.20</td>
</tr>
</tbody>
</table>

Basic Item Master (Part Number) Data

Example: Planning for the parts activity for a specific Water Pump

Case Scenario:
- In planning for the parts activity for a specific pump

Question:
- If Average Demand is only formally used when two disbursements are observed in the past 13 weeks....
- ... Which weeks would start a ‘valid’ use of the ‘average demand’ as part of the active parts support calculation?

Actual demand history is shown in the top chart by week
Average demand from the past 13 weeks is calculated in the lower chart
Basic Item Master (Part Number) Data

Example: Planning for the parts activity for a specific Water Pump

Case Scenario:
- In planning for the parts activity for a specific pump

Question:
- Why is it suggested that 'Average Demand' be '0' for part 2500110 in the last column of this analysis (week 14)?

Actual week 2 disbursements in 13 weeks was recognized
Average demand calculated based on average disbursement history and '2 disbursements' gate

Another example on managing ‘active’ parts

- Example: Stocking Policy by Asset/SKU and Stock room
  - Weekly Average Demand
  - Maximum Stock Level
  - Minimum Stocking Level
  - Safety Stocking Level
  - Reorder Point
  - Economic Ordering Point
Another example on managing ‘active’ parts

Example: Stocking Policy by Asset/SKU and Stock room

- Example:
- Stocking Policy by Asset/SKU and Stock room

- Maximum Stock Level
- Minimum Stocking Level
- Safety Stocking Level
- Reorder Point
- Economic Ordering Point

Assumptions:
- Lead Time plus Safety Stock is equal to ‘9’ weeks
- Must have 2 history disbursements in 3 months to calculate Order Point for Active parts
- Order Point always rounds up to nearest whole number

Example 1

<table>
<thead>
<tr>
<th>Week</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>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Avgd</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Order Point</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>4.5</td>
<td>3.6</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td></td>
</tr>
</tbody>
</table>

EOQ:

- Weight Factor = 1
- Weight Factor = 2
- Weight Factor = 3

Minimum Stock Level:

- Order Point = Min Stock Level

Maximum Stock Level:

- Order Point = EOQ

Assumptions:
- Unit Cost is $255 => Weight Factor is 5
- Order Point and Max Stock always round up to nearest whole number

Example 2

<table>
<thead>
<tr>
<th>Week</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>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Avgd</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Order Point</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>4.5</td>
<td>3.6</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td></td>
</tr>
</tbody>
</table>

EOQ:

- Weight Factor = 1
- Weight Factor = 2
- Weight Factor = 3

Minimum Stock Level:

- Order Point = Min Stock Level

Maximum Stock Level:

- Order Point = EOQ

Assumptions:
- Unit Cost is $255 => Weight Factor is 5
- Order Point and Max Stock always round up to nearest whole number
Basic Item Master (Part Number) Data

Example: Planning for the parts activity for a specific Water Pump

<table>
<thead>
<tr>
<th>Exercise Number</th>
<th>Part Number (Item Number)</th>
<th>Item Description</th>
<th>Quantity in Hand</th>
<th>Quantity on Order</th>
<th>Quantity in Transit</th>
<th>Total Available Quantity</th>
<th>Cost of Item / Part</th>
<th>Average Demand</th>
<th>Last Used Date</th>
<th>Date of Birth in System</th>
<th>ISP/RSP Stock Level</th>
<th>Substitutes</th>
<th>Substitute Order Point</th>
<th>Optimizer Order Point</th>
<th>EOQ</th>
<th>Maximum Stock</th>
<th>Maximum Order Point</th>
<th>Min Order Point</th>
<th>Max Order Point</th>
<th>EOQ Value</th>
<th>If Parts Values is</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2500010</td>
<td>Pump casing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>2007-09-01</td>
<td></td>
<td>2007-09-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt; $5000</td>
</tr>
<tr>
<td>2</td>
<td>2500014</td>
<td>Seal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>2007-09-01</td>
<td></td>
<td>2007-09-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt; $1000</td>
</tr>
<tr>
<td>3</td>
<td>2500015</td>
<td>Impeller</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>2007-09-01</td>
<td></td>
<td>2007-09-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt; $100</td>
</tr>
<tr>
<td>4</td>
<td>2500016</td>
<td>Couplings</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>2007-09-01</td>
<td></td>
<td>2007-09-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt; $10</td>
</tr>
<tr>
<td>5</td>
<td>2500017</td>
<td>Couplings</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>2007-09-01</td>
<td></td>
<td>2007-09-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt; $10</td>
</tr>
</tbody>
</table>

Case Scenario:
1. Confirm the valid EOQ for items 2500106 and 2500114.
2. What should the full value of the Order Point and Maximum Stock level be for items 2500111 and 2500112?
3. What should be the Maximo Protected Inventory Policy for parts 2500103 and 2500104?
4. How many parts should be ordered to stock for parts 2500103, 2500112?

Basic Item Master (Part Number) Data

Example: Base Parts for a Water Pump

<table>
<thead>
<tr>
<th>Exercise Number</th>
<th>Part Number (Item Number)</th>
<th>Item Description</th>
<th>Quantity on Hand</th>
<th>Quantity on Order</th>
<th>Quantity in Transit</th>
<th>Total Available Quantity</th>
<th>Cost of Item / Part</th>
<th>Average Demand</th>
<th>Last Used Date</th>
<th>Date of Birth in System</th>
<th>ISP/RSP Stock Level</th>
<th>Substitutes</th>
<th>Substitute Order Point</th>
<th>Optimizer Order Point</th>
<th>EOQ</th>
<th>Maximum Stock</th>
<th>Maximum Order Point</th>
<th>Min Order Point</th>
<th>Max Order Point</th>
<th>EOQ Value</th>
<th>If Parts Values is</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2500019</td>
<td>Pump casing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>2007-09-01</td>
<td></td>
<td>2007-09-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt; $5000</td>
</tr>
<tr>
<td>2</td>
<td>2500024</td>
<td>Seal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>2007-09-01</td>
<td></td>
<td>2007-09-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt; $1000</td>
</tr>
<tr>
<td>3</td>
<td>2500025</td>
<td>Impeller</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>2007-09-01</td>
<td></td>
<td>2007-09-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt; $100</td>
</tr>
<tr>
<td>4</td>
<td>2500026</td>
<td>Couplings</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>2007-09-01</td>
<td></td>
<td>2007-09-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt; $10</td>
</tr>
<tr>
<td>5</td>
<td>2500027</td>
<td>Couplings</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,000</td>
<td>0</td>
<td>2007-09-01</td>
<td></td>
<td>2007-09-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt; $10</td>
</tr>
</tbody>
</table>

What data do you have?  What data are you missing?
Another example on managing ‘active’ parts

- Example: Stocking Policy by Asset/SKU and Stock room
  - Weekly Average Demand
  - Maximum Stock Level
  - Minimum Stocking Level
  - Safety Stocking Level
  - Reorder Point
  - Economic Ordering Point

Stocking elements of an Inventory Policy

Each policy element is expected to be a compliment to the enterprise inventory management policy. Each asset will be supported by multiple sets of dynamic influences including:

- Local parts disbursement volumes (highly active or activity in the past year);
- The ISP/RSP settings;
- Or Inventory Optimized program overrides;
- Local history date related parameters; and
- Surplus management polices and activities
- Replenishment cycles
- Parts Returns policy
### Inventory Stocking Policy Strategies

<table>
<thead>
<tr>
<th>Demand</th>
<th>Demand</th>
</tr>
</thead>
</table>
| • Order point, Max Stock Levels  
• Based of activity per quarter | • Managed by? |
| Insurance Parts | Insurance Parts |
| • Stocked based on Design Engineers  
• Recommended initial stock requirements (usually set to Qty 1) | • Managed by?  
• but set by Design Engineering or Operations / Maintenance  
• Requires workshop to develop ISP process |
| Date Protect (minimums) | Date Protect (minimums) |
| • Stock 1 if new in past 12 months  
• Stock 1 if used in past 12 months | • Set by? |
| Forces / Blocks | Forces / Blocks |
| • Set by Inventory Manager based on seasonal, cost, EOL or phase-in strategies  
• Could override above settings | • Set by? |
| Local Settings | Local Settings |
| • Substitute Order point set by local warehouse (Limited to 5% of total WH Inventory) | • Controlled by Local Warehouse Supervisor  
• Must keep controls within 5% allowable window |

#### Inventory Oversight?

What role should do what? - Complete the '?'

---

## Inventory Stocking Policy Strategies

<table>
<thead>
<tr>
<th>Demand</th>
<th>Demand</th>
</tr>
</thead>
</table>
| • Order point, Max Stock Levels  
• Based of activity per quarter | • Managed by Inventory Planner/Manager |
| Insurance Parts | Insurance Parts |
| • Stocked based on Design Engineers  
• Recommended initial stock requirements (usually set to Qty 1) | • Managed by Inventory Planner/Manager but set by Design Engineering or Operations / Maintenance  
• Requires workshop to develop ISP process |
| Date Protect (minimums) | Date Protect (minimums) |
| • Stock 1 if new in past 12 months  
• Stock 1 if used in past 12 months | • Set by Inventory Manager |
| Forces / Blocks | Forces / Blocks |
| • Set by Inventory Manager based on seasonal, cost, EOL or phase-in strategies  
• Could override above settings | • Set by Inventory Planner / Manager |
| Local Settings | Local Settings |
| • Substitute Order point set by local warehouse (Limited to 5% of total WH Inventory) | • Controlled by Local Warehouse Supervisor  
• Must keep controls within 5% allowable window |

#### Finance

---
Parts Management and the Asset Life-cycle

Initial Spare Parts Dynamics

Leading Maintenance Practices

**Maintenance Policy and Strategy**

- Clearly defined strategy, well articulated and well communicated.
- Appreciation of business plan and asset environment
- Long term objectives and vision.
- Current assessment of capabilities.
- Implicit mission or mandate.
- Key value drivers
- Implementation plan for improvement.
- Capital and maintenance expense budget integrated for optimal LCC (Life Cycle Costs).
What is a ‘Capital Spare’

• Typically a spare part that is recognized:
  • to have a relative long life and/or a small chance of failure,
  • would cause a long shutdown of equipment because it would take a long time to get a replacement for them.

• For the sake of inventory policy discussion
  • A capital spare is considered an ISP/RSP part

How Finance reports (or depreciates) capital spares or a portion of the capital spares is a separate discussion

The Design engineering’s role in support of a parts inventory strategy

• The Design engineer would have the responsibility to:
  • support the early asset life-cycle activities including the business case for the asset and its support strategy;
  • lead or at least, coordinate the asset design stages from conceptual design through to detailed design and actively support the asset construction, initial testing, commissioning (with Operations and Maintenance); and
  • declare a de-commissioning strategy and/or approach for the asset’s end of life.
  • optional play an active role in how the asset is performing against the original business case as the asset is in production OR,
    • hands-over the responsibility of the asset performance when starting the operations stage to the Operations and Maintenance business units.

The maintenance parts inventory support strategy should be to focus on minimizing the direct parts costs while maximizing the planned value from the supported asset.
Multiple business units will be needed to support an effective asset management life-cycle program.

- **Finance** is required across the entire life-cycle;
- **Design engineering** is most active from early analysis through to the end of asset commissioning;
- **Procurement** would need to be active from the detailed design stages through to end of the operate stage (but could also be involved earlier with engineering);
- **Inventory Management** would need to be active from the detailed design stages through to de-commissioning;
- **Maintenance and Operations** may be needed in the detail design stage if an early RCM program is used. In any event, they would be needed during the asset commissioning through to the start of the de-commissioning stage.

Source: Anatomy of Maintenance Parts Management Excellence, Don Barry, 2018
Asset Life-cycle service cycles by asset industry

Categories of products according to the length of their service lifecycles:

• **Short service lifecycle products** (0-2 years)
  Personal computers, consumer electronics, semiconductors

• **Moderate service lifecycle products** (2-7 years)
  Cars, medical devices, copiers, business servers, business office telecommunications equipment, consumer durables

• **Long service lifecycle products** (7+ years)
  Aircraft engines, heavy machinery, industrial equipment, telecom switching equipment

---

Asset Life-cycle example for multiple Industries

- **Business case**
- **Plant Design**
- **Product/Design Requirements**
- **Market Analysis**
- **Refineries**
- **Pipelines**
- **Exploration and Production**
- **Petrochemical & Oilfield Services**
- **Power Generation, T&D**
- **Water Production, Distribution**
- **OEM, Equipment Manufacturers**
- **Aircraft Manufacturers**

- **Specify Configuration**
- **Quality**
- **Procure**
- **Set Total Cost of Ownership**
- **Jointly work through product testing**
- **Execute Asset logs**
- **Maintain**
- **Repairs**
- **Modify / upgrade as business evolves**
- **Execute Equipment End of Life plan**
- **Facilitate a buyer for used asset**

- **Assist / oversee solution build and text**
- **Collect early spare parts lists**
- **Create End of Life plan**
- **Establish a buyer for used asset**
- **Jointly work through product testing**
- **Maintain**
- **Repairs**
- **Modify / upgrade as business evolves**
- **Execute Equipment End of Life plan**
- **Facilitate a buyer for used asset**

- **Build and test product to client order**
- **Aircraft Manufacturers**
- **EPA**

---

Source: AMR (Bijesse, Higgs, N/Clukey, O’Brien, 2002)

Source: Anatomy of Maintenance Parts Management Excellence, Dan Barry, 2018
Key information to collect from an OEM early in the life-cycle and prior to the committed purchase may be:

- To collaborate on how the asset design continues to be enhanced over the Operate and Maintain lifecycles;
- Confirming what is the expected equipment downtime (perhaps MTBF and other data points);
  - What is the production and maintenance cost of downtime?
  - What is the expected ratio of planned versus unplanned maintenance?
  - What parts need to be stocked close to mitigate downtime?
- Confirming how parts will be provided throughout the asset life-cycle:
  - Sold or supported through the equipment warranty;
- Confirming what the OEM’s experience has been in parts usage with like equipment at other clients;
  - Getting their recommended spare parts lists and fulfillment service level commitments.
- Confirm if the design specification is owned by the customer or equipment manufacturer;
- Confirming that the transfer of data needed to operate and maintain the equipment is provided from the detailed product design information by the equipment;
  - How is this done? Is it timely? Is it accurate?
- Confirming that there will there be a customer collaboration group in place that is responsible for key data transfer and customer feedback.

Source: Anatomy of Maintenance Parts Management Excellence, Don Barry, 2018

How the OEM (vendor) can support an ISP

- Manufacturers (OEM) make their reputation on the reliability of their products.
- However, the risks associated by only adopting the OEM input can create sub-optimal results given that:
  - The OEM seldom actually operates their assets and as a result cannot provide the spares insight most needed;
  - The OEM may be influenced by mitigating their risk more than mitigating a clients risk in the clients operating context;
  - The OEM makes more money the more you buy their parts as spares inventory;
  - An enterprise stocking more parts than needed is more likely to serve the OEM than the enterprise;
  - Not accepting installation surplus parts as a return to the OEM often influences the enterprise to stock the part, often when no effort is made to forecast it will ever be used.

Source: Anatomy of Maintenance Parts Management Excellence, Don Barry, 2018
Asset Life-cycle Management: Total installed cost

There is much more to consider than the original acquisition costs.

Asset Life-cycle Costing

Asset life-cycle costing will account for the economic life of the asset and should include costs beyond the initial acquisition costs. Additional costs can be:

- Maintenance Parts Management Spares support costs; as well as
  - Operating costs (personnel, facilities, energy spend);
  - Product supply chain costs (transportation, material handling);
  - Maintenance costs (Customer service, Field / supplier factory maintenance);
  - Test and support equipment costs;
  - Technical data costs
  - Software support costs (Operations and Maintenance and Maintenance Parts Management);
  - Training costs (of Maintenance and Operations staff); and
  - Asset disposition costs (De-commissioning).
What item numbers should be in the part system

• Asset component data in Maintenance Parts Management is essential in helping to understand what parts should be set up in their systems well before the asset is expected to start commissioning.

• *All parts that are ‘reasonably likely’ to be expected to be used in the asset’s life-cycle should be in the maintenance parts system.*

• As well, the Design engineer should provide a list of initial spare parts that should be in stock to support the asset stages from commissioning through the operating stages to the de-commissioning (end of life) stage.

---

Optimal Stocking Strategies

*Concept of Optimization*

**EXAMPLE: XXXXXX**
Initial Spare Parts

Each policy element is expected to be a compliment to the enterprise inventory management policy. Each asset will be supported by multiple sets of dynamic influences including:

- Local parts disbursement volumes (highly active or activity in the past year);
- The ISP/RSP settings;
- Or Inventory Optimized program overrides;
- Local history date related parameters; and
- Surplus management policies and activities
- Replenishment cycles
- Parts Returns policy

The Initial Spare Parts (ISP) list, once provided and in place, can be renamed the ‘Recommended Spare Parts’ (RSP) list once the maintenance team has formally accepted ownership for the on-going maintenance support of the asset and has completed the commissioning stage.

Source: Anatomy of Maintenance Parts Management Excellence, Don Barry, 2018

An Initial Spare Parts Categorization Approach

- Highly critical parts with high expected usage (Category 1)
  - are highly predictable in their demand could be considered as most likely to be added to an ISP list and kept there throughout the asset’s life-cycle.

- High criticality and low usage parts (Category 2)
  - have a high expectation (predictability) of demand and hold a lower expectation of parts usage cost but are still critical to the business;
  - should be part of an ISP list presented to the business from the Design Engineering group.

- Low criticality and high usage parts (Category 3)
  - with expected high predictability should be identified and set into an ISP at a higher echelon.

- Category 3 and category 4 parts would not likely be part of an ISP list
  - however, items with some expected criticality and some statistical usage should also be considered (particularly the low costs items)

Simple version:
- each cell can represent a different support strategy (categories one through four.)

Source: Anatomy of Maintenance Parts Management Excellence, Don Barry, 2018
The role of an Initial Spare Parts Support process

- Establish Asset Maintenance Plan (Design Eng, RCM, Maintenance / Operations etc.)
  - Determine Parts support requirements for this plan
- Compliment Parts Support for new Asset
  - Maintain / modify network locations
  - Forecast demand
  - Establish stock requirements
  - Procure inventory
  - Reclaim network surplus/excess if applicable
  - Position inventory
  - Fulfill work order requests
- Process ends with:
  - Withdrawal of the asset from support

An initial spare parts list to support the Maintenance Parts Management and policy can be derived from multiple sources.

- **It can come from:**
  - the Maintenance and Operations team’s insights and parts history when looking at previously installed similar assets (best guess);
  - the insights the Design engineer gains working with the OEM supplier’s experience and data; and/or
  - A co-developed Reliability Centered Maintenance program executed early in the asset’s design cycle.

The Inventory Planner would be expected to embrace the ISP input from the Design Engineer as one of many inputs on how it will achieve their business goals when setting the actual Inventory Policy to support an enterprise compliment of assets.

Once past the commissioning stage of the asset life-cycle, the ISP will become an RSP and the input owner would likely change to the maintenance team.
Asset Life-cycle Management and the Total Cost of Ownership

Managing longer useful asset life means:
- Greater resale value (higher NPV)
- Deferred capital investment

Original Cost Commitment

For more reliable and maintainable assets you may spend more here

Design for long life
Reliable & Maintainable and/or Use Best Practices

Extra Useful Life
Reduced spend

Design for long life
Reliable & Maintainable and/or Use Best Practices

Spending more up front can lower the slope of this spend curve, extend useful life and reduce total life cycle spend

What should I stock to support an asset?

- What is it expected to do and in what operating context?
- What is the impact of a failure?
- What components would fail and how often?
- What are the recommended initial spare parts required?
- Where should I stock the parts?
- How many of this specific part/pump do I need to support?
- How many parts should be stocked?
**Parts Catalogue**

Motor and Pump Assembly
- Motor assembly (rotatable)
  - Motor Shaft coupling
- Pump Assembly
  - Pump casing
  - Impeller
  - Input assembly
  - Output assembly
  - Impeller shaft
  - Pump shaft seal
  - Bearing
  - Shaft coupling

**Strategies for initial spare parts development**

- Manufacturer’s suggested spare parts
- Design engineer’s suggested spare parts
- Maintenance tech’s suggested spare parts
- Inventory Manager’s suggested spare parts
- Combined RCM approach
Who knows all the criteria for initial stocking parts?

- Manufacturer
- Design engineer
- Maintenance tech
- Inventory Manager
- RCM team
- RCM team with Inventory Manager
- Procurement Lead
- Manufacturer’s spare parts list
- Operating context?
- Business, environmental, safety impacts?
- Number of ‘like’ assets supported?
- Maintenance history and approach?
- Parts delivery and service level expectations?
- Parts procurement and repair strategies?

Airline industry experience

- 1960’s
  - 60 crashes per million take offs
  - 40 were equipment related
  - 85% of maintenance was fixed interval (overhauls)

- Today
  - 1.2 crashes per million take offs
  - 0.3 are equipment related
  - < 20% of maintenance is fixed interval (overhauls)

- RCM payback in other industries is usually less than 3 months and has been as low as 3 weeks
The Traditional Value of Asset Management

The role of the Design Engineer in Parts Support

- How RCM2/3 fits
  - Define the Asset Operating context
  - Proactively Define Functions, Functional Failures, Failure Modes
  - Do FMEA
  - Define Maintenance Strategy
  - Define Planned and Unplanned / Emergency Maintenance scenarios that drive parts demand

- Driving Planned Maintenance

  Planned Maintenance
  - PMs
  - Dbn
  - Overhaul

  Planned Maintenance Dynamics
  - Kits
  - Frequency
  - Tools needed

  Planned Parts Support
  - Kits
  - Inventory Placement Strategy

  Parts Support Strategies
  - Vendor SLAs
  - VMI
  - JIT

Source: Anatomy of Maintenance Parts Management Excellence, Don Barry, 2018
The role of the Design Engineer in Parts Support

- Driving Unplanned Corrective Maintenance
  - Planned Maintenance
    - Corrective Maintenance
    - Overhaul
  - Planned Maintenance Dynamics
    - Kits
    - Tools needed
  - Planned Parts Support
    - Kits
    - Parts Support Strategies
      - Inventory Placement Strategy
      - Replenishment ROPs

- Driving Emergency Corrective Maintenance
  - Planned Maintenance
    - Not Applicable
  - Planned Maintenance Dynamics
    - Critical Inventory Spares
  - Planned Parts Support
    - History based
    - Where / when used
    - Parts Support Strategies
      - Inventory Placement Strategy
      - Replenishment ROPs
      - Insurance Parts

113

Early view of failure

Traditional Age Model

- A small number of random failures
- Most items wear out at the same age

114
1970’s – we learned a lot

Pattern A: The “Bathtub Curve”
High infant mortality, then a low level of random failure, then a wear out zone.

Pattern B: The “Traditional View”
A low level of random failure, then a wear out zone.

Pattern C: A steady increase in the probability of failure.

Pattern D: A sharp increase in the probability of failure settling down to random failure.

Pattern E: Random Failure
No relationship at all between how old it is and how likely it is to fail.

Pattern F: The “Reversed J” curve
High infant mortality, then random failure.

Graphs of conditional probability of failure over time. From Nowlan and Heap & Moubray.

So how do we use this knowledge?

• Failures due to age effects
  • Patterns A, B and C
  • Do we know the age at which conditional probability of failure increases?
  • Is that age fairly constant? (it can be distributed)
  • Will refurbishment or replacement eliminate the failure?
  • Is the risk due to the failure (safety, environment or cost) reduced by the preventive action?

Preventive Maintenance
So how do we use this knowledge?

- Failures due to random effects
  - Patterns D, E and F
  - Can we see some sign of the failure when it begins?
  - Does it provide enough of a warning to take action?
  - Will the proposed action reduce the probability of the failure?
  - Is the risk (safety, environment or cost) due to the failure reduced by the action?

**Predictive Maintenance**

![Predictive Maintenance Diagram]

**Warning time**

- **Smooth operation**
- **First signs of trouble**
- **Failing**
- **Failure**

**Time**

**Performance**

**Time to failure**

**Warning Time**
What about generic maintenance programs?

- Generic maintenance programs come from manufacturers’ manuals
- Owner manuals
- Traditional maintenance practices
  - We’ve always done it this way

Generic maintenance policies can be developed for most types of physical assets

Traditional thinking suggests:
All should be maintained the same way

Manufacturer’s Recommendation:
Check Vibration and Replace Bearings when > 0.4 ips

Source: Reliability Centered Maintenance (RCM2), Moubry
Now let’s put these identical pumps into operating context...

- **Function**: To pump 300 l/min of water
- **Functional Failure**: Unable to pump at all
- **Failure Mode**: Bearing seized
- **Failure Effect**: Downstream process stops
- **Failure Consequence**: Affects operations

**Action**: Predict or Prevent the failure
Function: To pump 300 l/min of water
Functional Failure: Unable to pump at all
Failure Mode: Bearing seized
Failure Effect: If B fails switch to C
Failure Consequence: does not affect operations because Pump C starts
Action: Run it to Failure if most economic

Function: To pump 300 l/min of water
Functional Failure: Unable to pump at all
Failure Mode: Bearing seized
Failure Effect: Failure not evident to operators if B is still working
Failure Consequence: not relevant if pump B is still working
Action: Test periodically
Three identical pumps, three totally different maintenance policies!

<table>
<thead>
<tr>
<th>STAND ALONE</th>
<th>DUTY</th>
<th>STAND-BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
</tbody>
</table>

- **Function**: To pump 300 l/min of water
- **Functional Failure**: Unable to pump at all
- **Failure Mode**: Bearing seized
- **Failure Effect**: Downstream process stops

**Manufacturer's Recommendation:**
- Vibration analysis and replacement on high reading

**Predict / Prevent**
**Run to Failure**
**Testing**

Source: Reliability Centered Maintenance (RCM2), Moubry

---

**RCM**

**DEFINITION**
- RCM is a process used to determine what must be done to ensure that any physical asset continues to do what its users want it to do in its present operating context.

**RCM PROCESS**
- What are its functions (what do the users want it to do)?
- In what ways can it fail (the failed states)?
- What causes it to fail (the failure modes)?
- What happens when it fails (the effects)?
- In what ways does the failure matter (hidden, safety, environment, operational)?
- What can be done to prevent or predict the failure?
- If we can’t prevent or predict the failure – then what can we do?
Understanding how an asset can functionally fail

RCM information worksheet

Example

SHEET: RCM 2002

FUNCTION OF ASSET

Pump Assembly

Impeller

Bearing

Seal

New Maintenance

Output

Input

127

128

Source: IBM RCM2 Actual Study 2002
Consequences

- Hidden
- Safety
- Environment
- Operational
- Non-operational
RCM2 decision worksheet

<table>
<thead>
<tr>
<th>Decision</th>
<th>RCM2 Decision Worksheet</th>
<th>Probability</th>
<th>Impact</th>
<th>Impact</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictive Maintenance (PdM)</td>
<td>Condition monitoring</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Preventive Maintenance (PM)</td>
<td>Age or usage based restoration or replacements</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Failure Finding Tasks (FF)</td>
<td>Periodic checks to see if normally “dormant” devices are still functional</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>No Scheduled Maintenance (NSM)</td>
<td>Run the asset to failure if consequences (risks, costs, customer disruption) are more acceptable than being proactive (i.e.: it costs less &amp; has acceptable reliability impact)</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>One time changes</td>
<td>Design, procedural or training outputs that normally avoid the failures altogether or manage the consequences better than maintenance</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

Source: IBM RCM2 Actual Study 2002

RCM decision outcomes

- Predictive Maintenance (PdM) – condition monitoring
- Preventive Maintenance (PM) – age or usage based restoration or replacements
- Failure Finding Tasks (FF) – periodic checks to see if normally “dormant” devices are still functional
- No Scheduled Maintenance (NSM) – run the asset to failure if consequences (risks, costs, customer disruption) are more acceptable than being proactive (i.e.: it costs less & has acceptable reliability impact)
- One time changes – design, procedural or training outputs that normally avoid the failures altogether or manage the consequences better than maintenance

Source: Reliability Centered Maintenance (RCM2), Moubry
### Operating context, How used, where used all important to the maintenance strategy

<table>
<thead>
<tr>
<th>Audit Trail</th>
<th>Function</th>
<th>Functional Failure</th>
<th>FM</th>
<th>Failure Effect</th>
<th>Impact</th>
<th>Maintenance task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A1</td>
<td>Pump 300 l/min</td>
<td>Not able to pump 300 l/min</td>
<td>Seized bearing</td>
<td>XXXXXXXX</td>
<td>Operational</td>
<td>Corrective Action when failure detected</td>
</tr>
<tr>
<td>1A4</td>
<td>Pump 300 l/min</td>
<td>Not able to pump 300 l/min</td>
<td>worn / broken impeller</td>
<td>XXXXXXXX</td>
<td>Operational</td>
<td>Corrective Action when failure detected</td>
</tr>
<tr>
<td>1B2</td>
<td>Pump 300 l/min</td>
<td>Not able to pump 300 l/min</td>
<td>seal leaking</td>
<td>XXXXXXXX</td>
<td>Operational</td>
<td>Corrective Action when failure detected</td>
</tr>
<tr>
<td>2A1</td>
<td>Contain liquids controlled by seal</td>
<td>Liquid leaking through area</td>
<td>Seal leaking</td>
<td>XXXXXXXX</td>
<td>Environmental</td>
<td>PM every two years</td>
</tr>
</tbody>
</table>

### RCM Team / Design Engineer’s Findings
How does this translate into an Initial Spare Parts list?

<table>
<thead>
<tr>
<th>Audit Trail</th>
<th>Frequency</th>
<th>Performed by</th>
<th>Part needed</th>
<th>Part Number</th>
<th>Supported location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A1</td>
<td>5 years</td>
<td>Maintenance</td>
<td>Tech bearing</td>
<td>8521000</td>
<td>Main Stk</td>
</tr>
<tr>
<td>1A4</td>
<td>2 years</td>
<td>Maintenance</td>
<td>Tech impeller</td>
<td>8521005</td>
<td>Main Stk</td>
</tr>
<tr>
<td>1B2</td>
<td>as needed</td>
<td>Maintenance</td>
<td>Tech pump seal</td>
<td>8521007</td>
<td>Main Stk</td>
</tr>
<tr>
<td>2A1</td>
<td>2 years</td>
<td>Maintenance</td>
<td>Tech pump seal</td>
<td>8521007</td>
<td>Local Stk</td>
</tr>
<tr>
<td>2A1</td>
<td>as needed</td>
<td>Maintenance</td>
<td>Tech pump seal</td>
<td>8521007</td>
<td>Local Stk</td>
</tr>
</tbody>
</table>

Where do I stock the part?

How often do I expect to use the part?

What are the consequences of not stocking a part?

Do I stock for PM activity?

Do I stock for emergency use?

The combine recommendations for PM/Pdm and Corrective maintenance drive a need for planned and unplanned parts demands

- Support locations are typically identified to support maintenance strategy
- Parts activity that supports planned maintenance could be identified
- Parts with low probability for demand would not make the list
  - Coupling
  - Casing
The lists are netted to typically a quantity of one per location.

<table>
<thead>
<tr>
<th>ISP Qty</th>
<th>Part Number</th>
<th>Part Name</th>
<th>Supported Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8521000</td>
<td>bearing</td>
<td>Main Stk</td>
</tr>
<tr>
<td>1</td>
<td>8521005</td>
<td>impeller</td>
<td>Main Stk</td>
</tr>
<tr>
<td>1</td>
<td>8521007</td>
<td>pump seal</td>
<td>Main Stk</td>
</tr>
<tr>
<td>1</td>
<td>8521007</td>
<td>pump seal</td>
<td>Local Stk</td>
</tr>
</tbody>
</table>

Netting ISP List

Where high activity volume / frequency is expected an ISP quantity of greater than one could be generated.

Maintenance Inventory must service demand from three distinct sources

- New Capital Asset Demand
- RCM Scheduled Demand
- RCM Unscheduled Demand

- Demand Planning & Scheduling
  - To provide inventory availability of
    - Planned items
    - Unplanned items
      - Emergency
      - Routine
        - Critical
        - Non Critical

Note:
- Planned inventory requirements can be effectively passed to suppliers
- Unplanned requirements require significant planning to effectively predict
- New assets require asset lifecycle data to effectively assess initial support
The Asset Life-cycle focus

Legend
- Engineering
- Maintenance
- Operations
- Maintenance & Operations
- MO&E
- HR / Training
- Supply Chain (Inv., Purch.)
Using and RCM approach will influence the parts that should be stocked and where by understanding how the specific asset:

RCM Approach based of decisions that:

• drives value to the enterprise;
• Understand asset functionally works and how it could fail in its operating context;
• Understand failure impacts the business costs and risks;
• Understand asset failures that could be mitigated; and
• Understands the frequency of the planned maintenance tactic mitigation action.

RCM Team approach collects insights of asset failure impact:

<table>
<thead>
<tr>
<th>Business Unit / Team</th>
<th>Insights for Maintenance Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Equipment Manufacturer (OEM)</td>
<td>Manufacturer’s spare parts list</td>
</tr>
<tr>
<td>Design engineer</td>
<td>Asset Life-cycle costing approach</td>
</tr>
<tr>
<td>Maintenance tech</td>
<td>Business, environmental, safety impacts</td>
</tr>
<tr>
<td>Inventory Manager</td>
<td>Number of ‘like’ assets supported</td>
</tr>
<tr>
<td>RCM team</td>
<td>Number of ‘like’ parts supported by location</td>
</tr>
<tr>
<td>RCM team with Inventory Manager</td>
<td>Operating context</td>
</tr>
<tr>
<td>Procurement Lead</td>
<td>Maintenance history and approach</td>
</tr>
<tr>
<td></td>
<td>Parts delivery and service level expectations</td>
</tr>
<tr>
<td></td>
<td>Parts procurement and repair strategies</td>
</tr>
</tbody>
</table>

**No one Business Unit knows all the criteria for initial stocking parts**

**Simplified Work Process from an RCM Analysis**
**ISP/RSP data elements should be captured and managed by the ISP/RSP owner.**

- Partial list of data elements the ISP/RSP owner should look to collect for each part and supported asset

- If the ISP/RSP lists are well established and maintained:
  - these lists should allow the Inventory planner to execute a policy change by removing the supporting ISP/RSP list,
  - as equipment is no longer in the enterprise and with it identified as inventory surplus.

**ISP/RSP data element considerations**

<table>
<thead>
<tr>
<th>Generic ISP/RSP Data Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Number / Item number</td>
<td>As listed in the Maintenance Parts Management System</td>
</tr>
<tr>
<td>OEM Item Number</td>
<td>As provided by the vendor if different than above</td>
</tr>
<tr>
<td>Where used</td>
<td>Asset / equipment the part is supporting</td>
</tr>
<tr>
<td>Item costs</td>
<td></td>
</tr>
<tr>
<td>Criticality Factor</td>
<td></td>
</tr>
<tr>
<td>Predictability Factor</td>
<td></td>
</tr>
<tr>
<td>National Usage factor</td>
<td></td>
</tr>
<tr>
<td>Stocking echelon designation</td>
<td></td>
</tr>
<tr>
<td>Technology code</td>
<td>(electrical, mechanical, etc)</td>
</tr>
<tr>
<td>Stock control factor</td>
<td>Allowed for stock rooms vs satellite installation stock</td>
</tr>
<tr>
<td>Item compliment code</td>
<td>Unique part for the asset (can be swapped to less critical area of asset?</td>
</tr>
<tr>
<td>Stocked / not stocked part</td>
<td>Parts forced to not be stocked (Cost, health and safety issues etc)</td>
</tr>
<tr>
<td>Date ISP last updated</td>
<td>YYYYMMDD format</td>
</tr>
<tr>
<td>ISP/RSP owner code</td>
<td>Engineering / maintenance etc.</td>
</tr>
<tr>
<td>ISP/RSP method used</td>
<td>Like equipment / OEM collaboration / RCM / Other (name it)</td>
</tr>
<tr>
<td>OEM Collaborator name</td>
<td>If applicable</td>
</tr>
<tr>
<td>ISP Approver</td>
<td>Executive name</td>
</tr>
<tr>
<td>Finance Approver</td>
<td>Executive name</td>
</tr>
</tbody>
</table>

Source: Anatomy of Maintenance Parts Management Excellence, Don Barry, 2018
**How do I track parts needs throughout the asset life-cycle?**

![Diagram showing parts usage over time](Image)

**Example: Corporate Policy Statements supporting Inventory Management Life-cycle**

<table>
<thead>
<tr>
<th>Corporate Policy Statement</th>
<th>Organizational Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Inventory transactions will be conducted through the EAM system</td>
<td>Finance</td>
</tr>
<tr>
<td>There will be one inventory warehouse on the production campus.</td>
<td>Finance</td>
</tr>
<tr>
<td>No parts squirreling will be tolerated</td>
<td>Finance</td>
</tr>
<tr>
<td>• Current squirreled parts will be identified and returned to the central warehouse inventory for credit in Finance.</td>
<td>Finance</td>
</tr>
<tr>
<td>Surplus (unused) parts from workorders will be identified and returned to stock</td>
<td>Finance</td>
</tr>
<tr>
<td>All parts will be managed through the EAM System 'Item Master'</td>
<td>Inv. Planner</td>
</tr>
<tr>
<td>Surplus inventories will be reviewed regularly (at least quarterly) for potential redistribution, sale or scrap based on value, past activity and Recommended Spare Parts (RSP) settings.</td>
<td>Inv. Planner</td>
</tr>
<tr>
<td>Scrap recommendation against inventories will be reviewed at least semi-annually for potential sale or scrap based on value, past activity and RSP settings.</td>
<td>Inv. Planner</td>
</tr>
<tr>
<td><strong>Inventory Policy</strong> for ISP/RSP: High moving inventory, Medium moving inventory and Surplus inventory is to be forecast, facilitated and executed by the Inventory Planner, based on the mutually agreed to ISP/RSP levels provided by Capital Projects, Maintenance, Operations and Finance and established disciplines for active inventory.</td>
<td>Inv. Planner</td>
</tr>
<tr>
<td>All parts transactions will be in the EAM system with all parts in Item Master set up –</td>
<td>Maintenance</td>
</tr>
<tr>
<td>• CM, PM, PMc, Inspection, Equipment modifications</td>
<td></td>
</tr>
<tr>
<td>Capital Projects and Maintenance will generate the Recommended Spare Parts and Initial Spare Parts (RSP/ISP) lists and required part attribute data for Inventory Planning</td>
<td>Cap Projects &amp; Maintenance</td>
</tr>
<tr>
<td>Formally declare that Capital Projects (Engineering) and Maintenance own ISP/RSP item life-cycles across the asset life-cycle</td>
<td>Cap Projects &amp; Maintenance</td>
</tr>
<tr>
<td>All items – even not stocked items expected to be used in an asset lifecycle – to be identified by the Capital Project ISP process and listed in Maximo.</td>
<td>Cap Projects &amp; Maintenance</td>
</tr>
<tr>
<td>• They will populate all the defined elements and attributes that need to be set up in the EAM System Item Master for a new part (stocked or not stocked)</td>
<td></td>
</tr>
<tr>
<td>Have all suppliers registered in the organisation's EAM System</td>
<td>Procurement</td>
</tr>
</tbody>
</table>
Striking a balance between Inventory levels and costs

Total Operating Costs

Resource vs Inventory Costs vs Service Level Commitments

Inventory Optimization
Driving Optimal Inventory Policy

• What is Inventory Policy?
  • Setting inventory stocking guidance, by part number, for each stockroom for the specific assets and maintenance strategies they have been charged to support

• What variables can be included in an Inventory policy for a SKU?
  • Functional criticality of the asset supported
  • Understanding of the functional failure dynamics
  • Understanding of planned maintenance and frequency of scheduled activity
  • Recent unplanned activity
  • Understanding of the asset life-cycle
  • Surplus management
  • Scrap management
  • Parts repair infrastructure and policy
  • Warranty management

Why Parts are stocked

Maintenance parts should be stocked locally to support immediate needs
  • All other parts can be acquired and brought in (perhaps 'Just in Time') to align with specific work order requests. The rule of thumb should be that:

  • Planned Inventory requirements can be effectively passed to suppliers or at least higher in the inventory support network;

  • Unplanned requirements require significant planning to effectively predict so: ISP/RSP, active and annual parts usage tracking can help here for immediate need activities; and

  • New assets require asset lifecycle data to effectively assess initial support (ISP/RSP).
Which should be my stocking level? -> Inventory Policy Netting

<table>
<thead>
<tr>
<th>Stocking Strategies</th>
<th>ABC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td></td>
</tr>
<tr>
<td>• Top 80% used items by $ value</td>
<td></td>
</tr>
<tr>
<td>• Less than 10% of stocked items</td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td></td>
</tr>
<tr>
<td>• Next 15% used items by $ value</td>
<td></td>
</tr>
<tr>
<td>• Less than 20% of stocked items</td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td></td>
</tr>
<tr>
<td>• Bottom 5% used items by $ value</td>
<td></td>
</tr>
<tr>
<td>• Can be than 70% of stocked items</td>
<td></td>
</tr>
<tr>
<td>Surplus</td>
<td></td>
</tr>
<tr>
<td>• Surplus to policy supported by ABC above as well as down level parts</td>
<td></td>
</tr>
</tbody>
</table>

Example:

• Active Inventory = 5
  - Leveraging Safety Stock, Order Point, Max Stock, EOQ, Average Demand algorithms

• Annual Activity (by location) = 1
  - Leveraging Date Last Used, Date Stocked

• Initial Spare Parts Recommendations = 1
  - Leveraging input from Manufacturer, Design Engineer, Maintenance Tech, Inventory Manager, or RCM Team

• Netted ‘Max Stock’ Stocking = 5
  - Is set to the highest level of the three stocking strategies if our goal is a high service level
  - Surplus is deemed to be Available Quantity minus Netted Max Stock

**Typical Spare Parts Distribution Network**

Leading Practice Echelon Support

Example of Leading Practice Echelon Hierarchy

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote Location / Maintenance Site</td>
<td>Local Stock Room</td>
<td>Central Warehouse</td>
</tr>
<tr>
<td>Level 1 Target Service Level</td>
<td>Level 2 Target Service Level</td>
<td>Level 3 Target Service Level</td>
</tr>
<tr>
<td>55%</td>
<td>85%</td>
<td>95%</td>
</tr>
</tbody>
</table>

Target Service Level
- 100%
- 95%
- 85%
- 55%

Note – Services levels are accumulative
Example – Combine support of level 1 and 2 targets 85%

Managing surplus in the Parts Network Support?

Weekly Inventory Policy Calibration
- Order levels are recalibrated weekly by location
  - New Order points and Max Stock levels created and compared to Available Qty in each location
  - Orders are identified where Available Qty is below Order Point
  - Surplus by location is identified
  - Systems searches and places orders on surplus locations before generating PR/POs to outside vendors ‘Excess Redistribution’
    - When financially justified to procure internally from surplus
    - Inventory transfers from one local stock room to another
Stocking elements of an Inventory Policy

Each policy element is expected to be a compliment to the enterprise inventory management policy. Each asset will be supported by multiple sets of dynamic influences including:

- Local parts disbursement volumes (highly active or activity in the past year);
- The ISP/RSP settings;
- Or Inventory Optimized program overrides;
- Local history date related parameters; and
- Surplus management policies and activities
- Replenishment cycles
- Parts Returns policy

Understanding the applied maintenance concepts will help leverage the utilization of asset configuration and component data, failure histories and install base into the setting of effective inventory policies.

Adapted from Asset Management Excellence, by John D Campbell & Andrew K S Jardine, Joel McGlynn
Utilizing technology for inventory placement.

Data Considerations for Optimizer

- Service level desired
- Network structure
- Product volumes installed
- Service strategy
- Part function
- National failure rates
- Distribution costs
- Inventory costs
- Lead times

<table>
<thead>
<tr>
<th>Standard Inventory Policy Programs</th>
<th>Optimizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service levels by part number and location</td>
<td>Service levels by part number, asset, location or echelon</td>
</tr>
<tr>
<td>Mean Time between Failure estimates</td>
<td>Actual national failure rate data base to calculate</td>
</tr>
<tr>
<td>Local stock room demand</td>
<td>Local asset installation base by location</td>
</tr>
<tr>
<td>One location system</td>
<td>True multi-echelon system</td>
</tr>
<tr>
<td>Features: Manual Churn control Manual forces and blocks</td>
<td>Features: System calculated Churn control Service part type (how used) System driven inventory forces and blocks</td>
</tr>
<tr>
<td>Sub optimal total cost</td>
<td>Least total cost / higher network service levels</td>
</tr>
</tbody>
</table>

* Optimizer is a state-of-the-art inventory control system developed by IBM and the Wharton School of Business.

How an Optimizer capability can compliment the Inventory Policy

- An Optimizer system solution would be expected to:
  - Be a forecasting system that estimates the failure rates of individual part numbers in each asset type, and combines these known failure rates with the ‘asset location’ to estimate the part failure probability distributions to the closest stocking location;
  - Be a decision system to manage the multi-echelon stock-control dynamics as described earlier;
  - Interface with the existing Maintenance Parts Inventory policy management system to align and provide a platform for the Inventory Planner to manage Optimizer with the other asset support inventory policies

Inventory Stocking Inputs
- Initial Spare Parts / Recommended Spare Parts
- Highly Active Parts (Min/Max/EOQ)
- Date Activity (Birth, last used)
- Dynamic Inventory Optimizer
- Substitution Order Points
- Parts Replacement
- Found Parts, Commissioning surplus

Inventory Stocking Outputs
- Surplus Mgmt
- Scrap Mgmt
- Parts Usage / Returns
- Parts Network support
Benefits to an Optimizer system

- Reducing the inventory required across the network;
- Improving stock room availability levels and more often, higher combined service levels delivered from the supporting stock room network;
- Improved inventory planning and forecasting capability,
- Improved understanding of the impact of parts operations on the Maintenance Technician and Operations
- A dynamic flexibility capability in responding to changing business requirements; and
- Reducing the amount of touches required by the Material Handler in the stock room.
Optimizer system can be a complex endeavor to manage

- 10's of millions of part-location combinations;
- 10's of thousands asset-location combinations;
- Maintenance Parts system control parameters that must be updated frequently (weekly) in response to the dynamic changes in the installed base, enterprise metric demands and operational demands;
- Risk associated with the success of the transformation and supporting system as it is considered vital to an enterprise's daily operations and can have a major impact on its future reputation and revenues; and
- Change resisted by the affected employees within the enterprise given a perception that the existing inventory policy control system is functioning, and sophisticated and the overall parts logistics problem was complex.

Cost of missed Parts Availability
Two Inventory Optimization review case studies

Case Study 1:
• Multi-national working to drive inventory levels to a year end target without impacting services levels

Case Study 1: Example of a multi-national enterprise working to optimize maintenance parts inventories globally

• Complex Inventory challenges require multiple functional groups to work together to achieve the balanced inventory solution

• The challenge is to maintain or improve the service levels while reducing the combined inventory plan levels (on the Financial books) by 5% within the calendar year (10 months).
  • base inventory of hundreds of Millions of USD and
  • after a very well managed and well executed optimal inventory plan has been in place for over a decade.
  • Finding an additional 5% while improving service levels was a significant challenge to the enterprise.
Existing infrastructure supported an integrated and international parts network

- Inventory policy supported multiple countries and system support for:
  - Demand driven active inventory;
  - Date driven inventory;
  - Optimizer supported asset inventory;
  - System managed inventory overrides;
  - Inventory Network echelons and physical country borders;
  - Delivery logistics;
  - Supplier agreements and supplier service levels;
  - Dynamic supply issues;
  - Surplus management and scrap policy;
  - Inventory Financial provisions; and
  - Parts designated as available for repair.

An effective Parts optimization program requires support from multiple business units

Competitive Forces Model

- Suppliers
  - OEM / manufacturers
  - 3rd Party parts suppliers (OEM alternates)
  - Repair/re-utilization vendors
  - Internal
    - Repair/re-utilization
    - Surplus redistribution from stockrooms in surplus

- Maintenance Parts Network Inventory Policy
  - Demand driven active inventory
  - Date driven inventory
  - Optimizer inventory
  - System managed inventory overrides
  - Network and borders
  - Delivery logistics
  - Supplier agreements and service levels
  - Dynamic supply issues
  - Surplus management and scrap policy
  - Inventory Financial provisions
  - Parts designated as available for repair

- Process Support
  - IT Support
  - Finance Support
  - Operations/Maintenance / Engineering
  - Logistics Vendors Support

- Potential new entrants to Inventory
  - New ISP/RSP adds
  - Out of plan adds
  - New demand growth for active inventory
  - Customer service level issues

- Maintenance Parts Customers
  - Demand for higher availability
  - Demand for cost effective distribution
  - Expectation that parts delivery will be ‘best in class’ for immediate need orders/work orders
Mapping an Inventory Optimization Program

Example of a North American-wide Inventory Optimization mapping

Managing Maintenance Parts Inventory by Asset Type

Parts Availability % Levels

Inventory Turnover

167

168
Case Study 1: Example of a multi-national enterprise working to optimize maintenance parts inventories globally

- The Multi-functional and Multi-national team came up with inventory programs that were summarized to the following categories:
  1. Multi-country sharing opportunities
  2. Inventory Policy opportunities
  3. Parts Repair / Re-utilization opportunities
  4. Inventory Financial handling opportunities

<table>
<thead>
<tr>
<th>Potential Enterprise Multi-country sharing actions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenge the service levels vs inventory levels of an ISP vs Optimizer Inventory support policy</td>
<td>Look at country examples by equipment supported to confirm if Optimizer needs tuning or ISP policy could be better managed in Optimizer at a lower inventory cost and higher service level</td>
</tr>
<tr>
<td>All surplus re-distribution across countries</td>
<td>Re-distribute surplus—in country and across countries where financially practical</td>
</tr>
<tr>
<td>Work on improving customs cycle time between countries</td>
<td>Would allow lower safety and lead time stock in every stock room</td>
</tr>
<tr>
<td>Stock room parts order trafficking for non-immediate needs</td>
<td>Work to have planned work fulfilled from a more central site to balance work load in stock rooms and centralize the stocking inventory and handling costs</td>
</tr>
<tr>
<td>Review each business units inventory and parts usage spend</td>
<td>Compare like field service units, utilities and production plant inventory to business unit revenue to look for opportunities to improve technical training, and inventory placement by business unit</td>
</tr>
<tr>
<td>Look for Procurement to consolidate spend across multiple countries for basket of goods cost benefits and logistics efficiencies</td>
<td>Consolidate spend where it makes financial sense</td>
</tr>
<tr>
<td>Improve vendor warranty capture and execution</td>
<td>Consolidate data and spend leverage where it makes financial sense across multiple countries</td>
</tr>
<tr>
<td>Review ‘Available for Repair’ inventories to allow parts repair to take place in the most cost effective location</td>
<td>Consider availability issues on some parts and tax opportunities to ship lower valued defective parts to a country that may have their own repair operation and will use the parts as new.</td>
</tr>
</tbody>
</table>
Example of a multi-national enterprise working to optimize maintenance parts inventories globally

### Inventory Policy opportunities

<table>
<thead>
<tr>
<th>Potential Enterprise Inventory Policy actions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review the policy for stock room policy 'overrides'</td>
<td>Review the policy for local policy overrides and confirm how each stock room is performing within policy</td>
</tr>
<tr>
<td>Create visibility to Work Order staged or in-transit parts</td>
<td>See how this should complement the considered on-hand inventory balances in the replenishment algorithms</td>
</tr>
<tr>
<td>Look at lead times by vendor</td>
<td>See if a safety stock/lead time by vendor data set would create a more optimal set of active parts levels</td>
</tr>
<tr>
<td>Challenge Repair Vendors for JIT fulfillment</td>
<td>Track repair vendors and suppliers ability to support fulfillment aligned to our EOQ actual orders and not over ship quantities ordered</td>
</tr>
<tr>
<td>Close stock rooms with low volumes that can be supported else where</td>
<td>Where stock rooms are across a campus or city perhaps only one stock room can support all</td>
</tr>
<tr>
<td>Open high echelon stock room</td>
<td>Consider increasing the service level for a more centralized stock room as part of a strategy to close out remote inventory locations and low volume stock rooms</td>
</tr>
<tr>
<td>Parrado the inventory request ‘misses’</td>
<td>Do a root cause on why the service levels are not being addressed</td>
</tr>
</tbody>
</table>

Example of a multi-national enterprise working to optimize maintenance parts inventories globally

### Parts Repair / Re-utilization opportunities

<table>
<thead>
<tr>
<th>Potential Parts Repair / Re-utilization actions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirm sharing of parts vendors and processes where parts repair and re-utilization has been successful</td>
<td>Look at country examples by equipment type and model and confirm the quality and cost benefits would fit. Create an international database of parts that should be captured for potential re-utilization</td>
</tr>
<tr>
<td>List skills by country for parts repair and re-utilization</td>
<td>Look to understand if vendor or internal skills transfer opportunities could help with parts re-utilization growth</td>
</tr>
</tbody>
</table>
Example of a multi-national enterprise working to optimize maintenance parts inventories globally

**Inventory Financial handling opportunities**

<table>
<thead>
<tr>
<th>Potential Inventory Financial handling actions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review how parts warranty fulfillment is being treated in inventory</td>
<td>Consider repaired parts to be returned to inventory as new with the burden of the cost of repair (and associated logistics) plus a percentage of new (i.e. 20%) as credit for the used part carcass.</td>
</tr>
<tr>
<td>Review how parts warranty fulfillment is being treated in inventory</td>
<td>Consider warranty parts to be returned to inventory from the vendor as new with the burden of the cost of repair and associated logistics (equal to 50) plus a percentage of new (i.e. 20%) as credit for the used part carcass.</td>
</tr>
<tr>
<td>Create visibility to Work Order staged or in-transit to technician Work Order parts</td>
<td>Treat the parts in transit to a work order as expensed vs. inventory. Best to understand the dynamics and GAAPs.</td>
</tr>
<tr>
<td>Review how Available for Repair inventory is being treated in inventory</td>
<td>Typically would be below the new parts inventory line but still in the overall inventory number at perhaps 20% of new.</td>
</tr>
<tr>
<td>Challenge how inventory provisions (reserves) are being funded and released</td>
<td>Important when a inventory strategy change could generate a need for different inventory and identify unplanned surplus in a given time period.</td>
</tr>
<tr>
<td>Confirm what additional costs are burdened into the inventory number</td>
<td>Costs to ship a part to the first warehouse/stock room from the vendor is typically burdened into the inventory costs. Other costs such as shipping between stock rooms or to a technician and material handling and warehouse costs are treated as part of the inventory carrying costs.</td>
</tr>
<tr>
<td>Look to like companies for how they treat inventory financial accounting to see if other opportunities exist</td>
<td>Some may be depreciating their inventory rather than scrapping it. Best to understand the dynamics and GAAPs.</td>
</tr>
</tbody>
</table>

**Two Inventory Optimization review case studies**

**Case Study 2:**
- Single national leading maintenance parts management network being challenged to do more after decades of leading inventory optimization.
Managing Maintenance Parts Inventory by Asset Type

Parts Availability % Levels

Inventory Turnover

Year over year audits (5+ year look backs)

<table>
<thead>
<tr>
<th>Operating Metric</th>
<th>Baseline Metric</th>
<th>Delta after 5 years</th>
<th>Delta</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalent Asset Maintenance Revenue (EAMR)</td>
<td>$ XXX M</td>
<td>120%</td>
<td>➡️</td>
<td>Considers all sources of revenue the maintenance parts inventory supports</td>
</tr>
<tr>
<td>Inventory</td>
<td>$ XX M</td>
<td>83%</td>
<td>➳</td>
<td></td>
</tr>
<tr>
<td>Turnover</td>
<td>1.2</td>
<td>1.8</td>
<td>➳</td>
<td>Turnover based on average inventory and annual parts usage</td>
</tr>
<tr>
<td>Inventory : EAMR Ratio</td>
<td>1:5.7</td>
<td>1:8.3</td>
<td>➳</td>
<td></td>
</tr>
<tr>
<td>Country Availability Level Achieved</td>
<td>92%</td>
<td>87%</td>
<td>➳</td>
<td></td>
</tr>
<tr>
<td>Parts Procurement Time</td>
<td>2 Hours</td>
<td>2.9 Hours</td>
<td>➳</td>
<td></td>
</tr>
<tr>
<td>Stock Room Availability Level</td>
<td>85%</td>
<td>78%</td>
<td>➳</td>
<td></td>
</tr>
<tr>
<td>Maintenance Technician Satisfaction level</td>
<td>80%</td>
<td>75%</td>
<td>➳</td>
<td></td>
</tr>
</tbody>
</table>
The cost of the lost Maintenance Technician time versus Inventory costs

- The stakeholder perception comments were captured from interviews at the time. Some comments captured were:

  - "There seems to be a disconnect between the corporate challenges on inventory and what the maintenance Technician needs to perform the job efficiently;"
  - "The Maintenance Technician clearly does not have the parts base they had 5 years ago;"
  - "The Maintenance Technician has gone through a mourning process regarding the loss of parts support and are now more at the acceptance stage;"
  - "Maintenance revenue has been constant for the past 5 years, but inventory and parts service levels have been reduced;"
  - "With improved parts availability, a Maintenance Technician would improve their call backlog;" and
  - "The decline in maintenance parts service levels may simply not have hit their revenues yet."

2 types of cost of poor parts availability in a Maintenance organization

The cost of a Maintenance Technician leaving the site and returning and the related parts expediting costs due to a local parts availability miss.

- Maintenance Technician elements considered in the study included Maintenance Technician elements such as:
  - Escalation efforts assumed to happen - 50 to 80% of the time;
  - Leaving the asset site (tools down and packed up) - 100% of the time;
  - Returning to the asset site and setting up again from the repair - 100% of the time;
  - Initiating and closing a communication of the outage impact – 10 – 40% of the time; and
  - Related Maintenance Supervisor and Management time in support of the escalation and communication to operations and the Maintenance Parts Management team – 10 – 40% of the time

Note- Asset OEE losses not considered in a field service model

On average the cost of a parts down scenario ranged from $400 to $800 per incident for the studies viewed.
Observed position of example inventory assessment

Two Inventory Optimization review case studies

Case Study 2:
- Benchmarking a single national leading maintenance parts management network being
  - A different view to inventory baseline comparison
What is the net value /cost of our Materials Management Process?

Logistics Value Tree

• Logistics Costs:
  • Provisions
  • Warehouse & Inventory Management
  • Systems Management

• Parts Usage
• Parts Credits
• Sales Profit

Inventory $55.1 M
Turnover 1.8 X
Cost of Provisions $ 8.7M
Warehouse & Inventory Mgmt. $25.0M
Systems Mgmt. $ 3.7M
Total Costs $37.4M
Parts Usage Costs (includes parts sales) $99.0M
Reutilization Credits $(20.1M)
Parts Sales Profit (assumes 50% uplift on sales) $(1.7M)

Net Logistics Costs (all US$) $ 114.6M

In this example:
• the business focus evolved from doing field maintenance parts support to doing field maintenance parts support and
• supporting a new enterprise market offering of field maintenance outsourcing.
• In field maintenance outsourcing the old metrics did not recognize the ratio of inventory to this new revenue stream so a new metric called 'Equivalent Asset Maintenance Revenue' (EAMR) needed to be separated out to include all maintenance related streams the inventory was supporting.

<table>
<thead>
<tr>
<th>Maintenance Parts Cost Environment</th>
<th>Year X</th>
<th>Year Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory Level (S M)</td>
<td>$ XX</td>
<td>85%</td>
</tr>
<tr>
<td>Inventory Annual Turnover</td>
<td>1.2</td>
<td>1.8</td>
</tr>
<tr>
<td>EAMR Supported</td>
<td>$ XXX</td>
<td>120%</td>
</tr>
<tr>
<td>Inventory to EAMR Ratio (S M)</td>
<td>1: 5.7</td>
<td>1: 8.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maintenance Parts Cost Elements</th>
<th>Year X</th>
<th>Year Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Inventory Reserves (S M)</td>
<td>9</td>
<td>8.1</td>
</tr>
<tr>
<td>Provisions down due to lower average inventory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warehouse and Inventory Management Costs (S M)</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>Number of orders and transactions up to match the EAMR activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inventory Systems Support Costs</td>
<td>3.7</td>
<td>3.5</td>
</tr>
<tr>
<td>System costs relatively steady</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Managed Costs (S M)</td>
<td>37.7</td>
<td>39.6</td>
</tr>
<tr>
<td>Parts usage (and Parts Sales) (S M)</td>
<td>72</td>
<td>92</td>
</tr>
<tr>
<td>Up due to higher parts usage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Maintenance Parts Costs (S M)</td>
<td>109.7</td>
<td>131.6</td>
</tr>
<tr>
<td>Up to supported mix changes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parts Re-utilization Credits</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Parts Sales Credits (Profit)</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>Surplus Sales Recoveries</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total Maintenance Parts Inventory Credits</td>
<td>17</td>
<td>18.5</td>
</tr>
</tbody>
</table>

Net Maintenance Parts Costs 92.7 107.1
In this session we focused on key elements of Control and Continuous Improvement

Areas of Focus for this session:
- Inventory Planning
- Inventory Optimization
- Asset life-Cycle Integration
- Procure and Repair

What I hope to get from this course

- Review progress of Hope to get from Day 1
Questions?