GRA

Supply Chain Strategy,
Planning & Execution

Asset Maintenance in Resources (Perth)
Pre Conference – Workshop D

Accurately forecasting your demand for Maintenance, Repair & Operations/Overhaul (MRO) spares to maximise uptime performance

7 November 2011

Real People. Real World. Real Results.

Agenda

1. Introduction
2. MRO Spares Planning
   i. Initial Provisioning
   ii. Demand Planning

short break (10 min)

   iii. Inventory Optimisation
   iv. Replenishment Planning
   v. Performance Management
3. Opportunities Assessment

Supply Chain Strategy, Planning & Execution

MRO Spares Inventory Management

- Introduction – why have inventory

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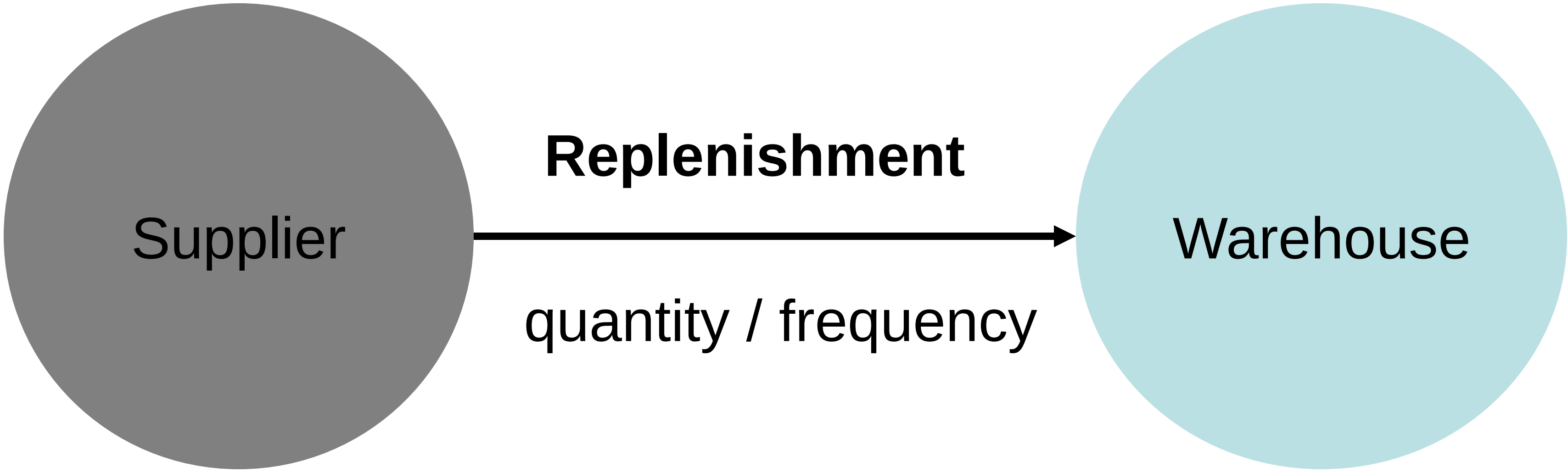
Agenda

1. Introduction (15min)
   i. Why Have Inventory
   ii. Inventory Segmentation
   iii. Inventory Management Approaches

Why have inventory?

- economics
- service level
- time
- variability/error
- constraints
- business environment

Why have Inventory Optimisation – a tradeoff problem



Why have Inventory
Is this too much, too little or just enough inventory?

Inventory Segmentation

- What is an inventory segment?
- What parameters should be considered when defining an inventory segment/deciding which segment a stock code should be in?

Inventory Segmentation
Why is managing inventory difficult (to name a few)?

- number of SKUs
- number of Locations
- different lead times
- different supply channels & supplier constraints
- different demand sources
- different demand patterns
- different service level expectations
- different costs
- supersession
- phase in / phase out
- engineering changes
- network changes
- dynamic environment
- and more…

Inventory Segmentation
So what do we (usually) do?

- aggregation or 'top down' planning
- averaging
- 'one size fits all'
- simplistic approaches
  - rules like 'weeks cover'
- dis-integrated
- non-dynamic

Inventory Segment Examples

- Repairable/Consumable
- Item Value
- Service Impact
- Criticality
- Demand Frequency
- Usage Pattern
- Availability
- Lead Time
- Seasonality
- Departmental
- Family / Group

Inventory Segment Examples
Rotable / Repairable Inventory

- Most inventory management practices have evolved to manage consumables.
- Rotables - can be repaired infinitely to support the life of the equipment, usually through the replacement of piece parts. Modular rotables can be often be replaced in the field and the faulty unit returned for shop repair
- Repairables – can be refurbished a limited number of time before they must be scrapped (and replaced through purchasing) e.g. tyres, turbine blades
- Inventory approach developed by US Air Force in response to the huge spares inventories demanded by the Vietnam War

Inventory Segment Examples
Rotable /Repairable Inventory

- Rotable / Repairable are important:
  - Large dollar value
  - Dominate end-item availability
  - Long Procurement lead-times
- Simple – one decision to make: stock level
- Complicated – multi-echelon support networks and multi-level indentured parts lists (do you hold piece parts or sub-assemblies – chips or circuit boards?)

ABC Analysis

- A items (most critical)
  - Require tight inventory controls, frequent review of demand and usage
  - Typically 5-10% of total item count
  - Typically 70-85% of total annual inventory usage
- B items (lesser criticality)
  - Normal inventory controls, occasional review of demand and usage
  - Typically 15-20% of total item count
  - Typically 10-20% of total annual inventory usage
- C items (least impact in terms of warehouse activity or financials)
  - Minimal inventory controls, review of demand and usage is sometimes waived in favour of placing large infrequent orders to maintain plenty of stock on hand
  - Typically 65-80% of total item count
  - Typically 5-10% of total annual inventory usage

Inventory Segmentation

- Consider demand profiles, risk, criticality, service and cost to create inventory segments
- Assign appropriate management policies, methodologies and techniques to each segment
- Define review frequencies for each inventory segment
- Develop an inventory management matrix based on the above

Inventory Segmentation

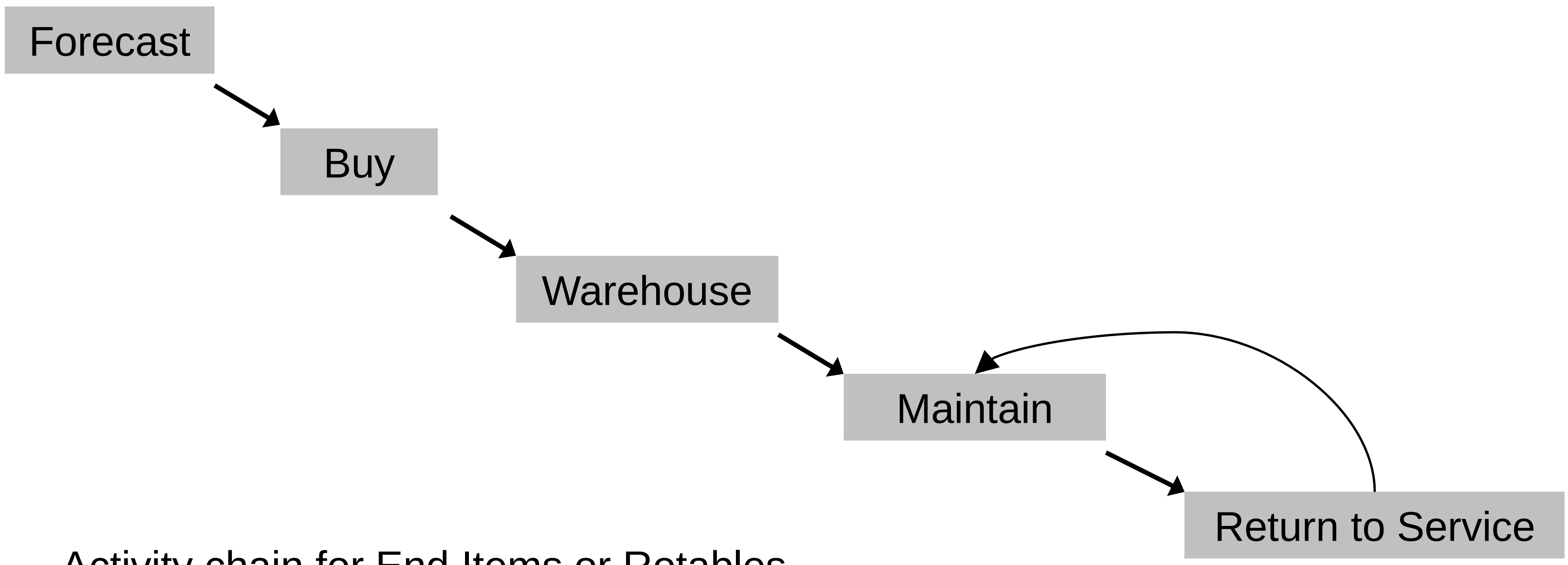
- *To describe common characteristics and assign the right management approach, for example:*

	High Moving 3 or more hits in 6 mths 28,500 SKULs / $5.3m Inv	Slow Moving < 3 hits in 6 mths 9,500 SKULs / $0.99m Inv	Non Stock < 4 hits in 12 mths
Demand Planning	•Forecast: average last 3months Sales, Usage,	•Forecast: average last 3months Sales, Usage,	•No forecasting
Safety Stock and Order Quantity	•Target Service Level (TSL) set by ABC code. •Forecast Error (FE) calculated with MAD Method 2 •Safety Stock calculated with Method 3 using TSL and FE	•Target Service Level (TSL) set by ABC code. •Forecast Error (FE) calculated with MAD Method 2 •Safety Stock calculated with Method 3 using TSL and FE	•Procure to order only •Safety stock set to zero
Replenishment Planning	•MRP Planned (Planning Method 1) •ABC Code sets dynamic Lot Sizing, in Order Multiples	•MRP Planned (Planning Method 1) •ABC Code sets dynamic Lot Sizing, in Order Multiples	•Lot sizing controlled by Order Multiple

Inventory Management Approaches

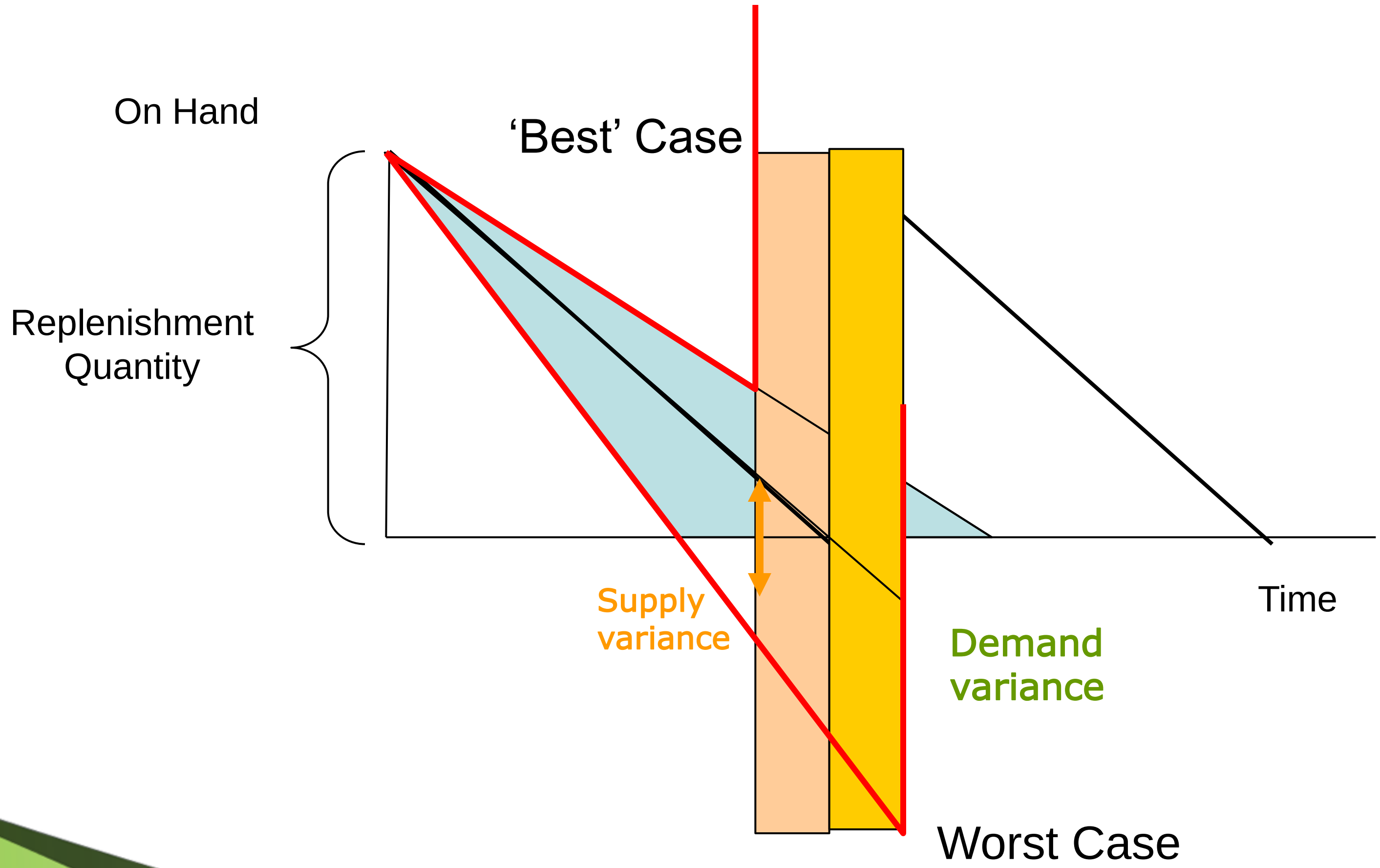
- Techniques for deciding how many repairable/rotable items to buy initially (i.e. Initial Provisioning)
- Techniques for deciding what to stock, where to stock it and at what service level promise
- Techniques for anticipating future demand (Demand Planning)
- Techniques for holding just the right amount of inventory (Inventory Optimisation)
- Techniques for replenishing inventory at least annual cost (Replenishment Planning)

Inventory Management Approaches
MRO Activity Chain



Activity chain for End Items or Rotables

Inventory Management Approaches
The Saw-Tooth Graph and The Real World



Supply Chain Strategy, Planning & Execution

MRO Spares Inventory Management

- MRO Spares Planning

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Initial Provisioning

- Consumables
  - OEM initial spares package advice
- Repairables
  - Maintenance Requirements Determination
    - what's a repairable, what's a consumable
    - What is an appropriate maintenance plan
  - Service level, repair pipeline and stocking locations
  - Repairable Item (RI) modelling to determine initial RI buy
    - Technique 1 – OEM advice
    - Technique 2 – Item based sparing
    - Technique 3 – System based sparing

Initial Provisioning
RI determination techniques

- Two techniques include:
  - Item Based Sparing
  - System Based Sparing
- Both techniques require the following:
  - Mean Time Between Failure (MTBF) data
  - Turn Around Time (TAT) data; and
  - assume that the failure rate follows a poison distribution (not a normal distribution)

Initial provisioning
Item based sparing - how many spares?

- Palm's Theorem*
  - *"If the demand for an item is a Poisson process with annual mean **m** and if the repair time for each failed unit is independently and identically distributed according to any distribution with mean **T** years, then the steady-state probability distribution for the number of units in repair has a Poisson distribution with mean **mT**."*

* Sherbrooke, Craig C., "Optimal inventory modeling of systems: multi-echelon techniques" ISBN 0-471-55838-9, 1992, John Wiley & Sons, Inc.

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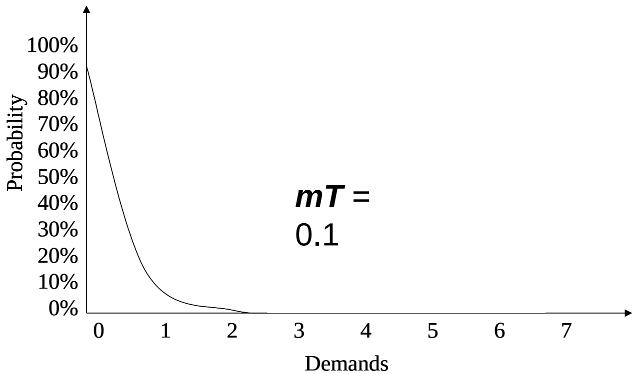
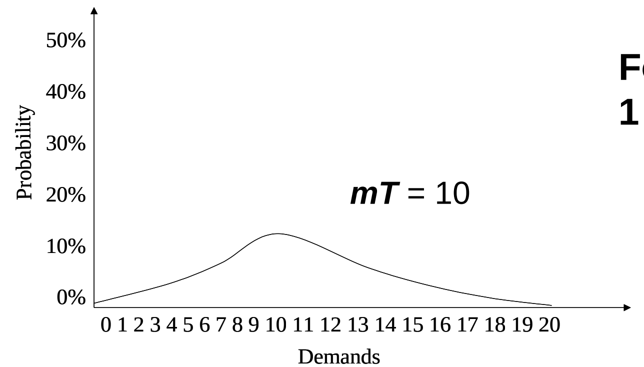
Initial provisioning
Item based sparing - how many spares?

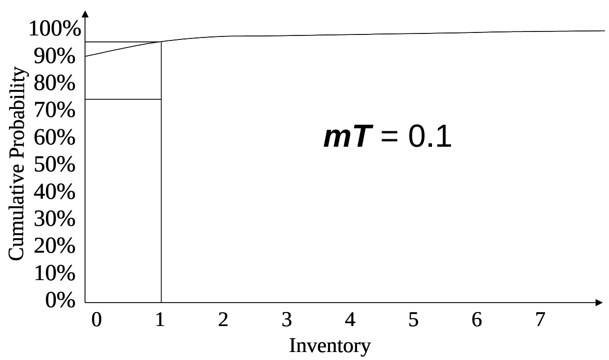
- Palm's Theorem
  - For example, if an Essentiality 1 component fails on average twice a month (m=24/year) and the TAT is 1 month (T= 1/12 year) then the average number in repair at any time is mT= 2.0 . Applying the protection factor of 1.7 for a 95% Service Level, gives the theoretical stock level to deliver this fill rate of 3.4 units, but since we must buy either 3 or 4 units, one would round up to 4.
  - Current Initial Provisioning Protection Levels
    - Ess 1= 95%, Ess 2 = 92% and Ess 3= 90 %

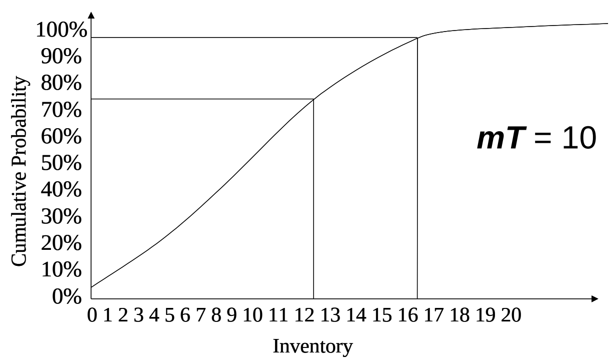
Initial provisioning
Item based sparing





Probability of x Demands in time *T*





Cumulative Probability or Fill Rate curves

For the first component, *mT* =0.1 1 spare provides 95% Fill Rate.

For the second component 15 spares are required.

If the spares budget must be cut, which item will suffer?

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Problems with Item based sparing

- There is no explicit consideration of cost in the equations and the outcomes, such as the spares budget or average fill rate are not known until all items have been analysed and added up. Few airlines have even simple simulation models to assess the operational performance of a spares recommendation.
- If the first analysis does not meet the Chief Financial Officer's approval then the list is cut again, based on the gut feel and experience of the analysts – an inherently biased and unrepeatable process with no pretensions to optimality.
- The method typically only recognises one level of indenture in the Hardware breakdown structure (line replaceable units - LRUs, as opposed to shop replaceable units, SRUs).
- Most airlines assume a single "Main base" model which gives no guidance on the geographic distribution of components. Rules of thumb are used to allocate millions of dollars of spares around a network.
- The method favours low turn over items and prejudices high turn over items – most analysts will buy at least one of everything, but will cut back on items with higher calculated requirements.
- If an item is common to two aircraft types in a fleet but experiences different failure rates on each type, simply summing the demands will not give the correct answer.

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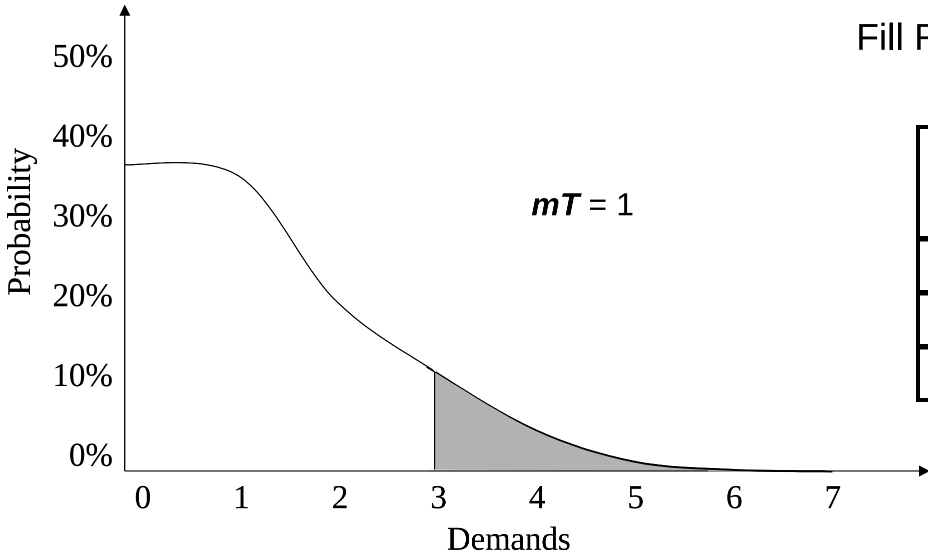
Initial provisioning
System based sparing



Risk of a Back Order for Stock Level = 3

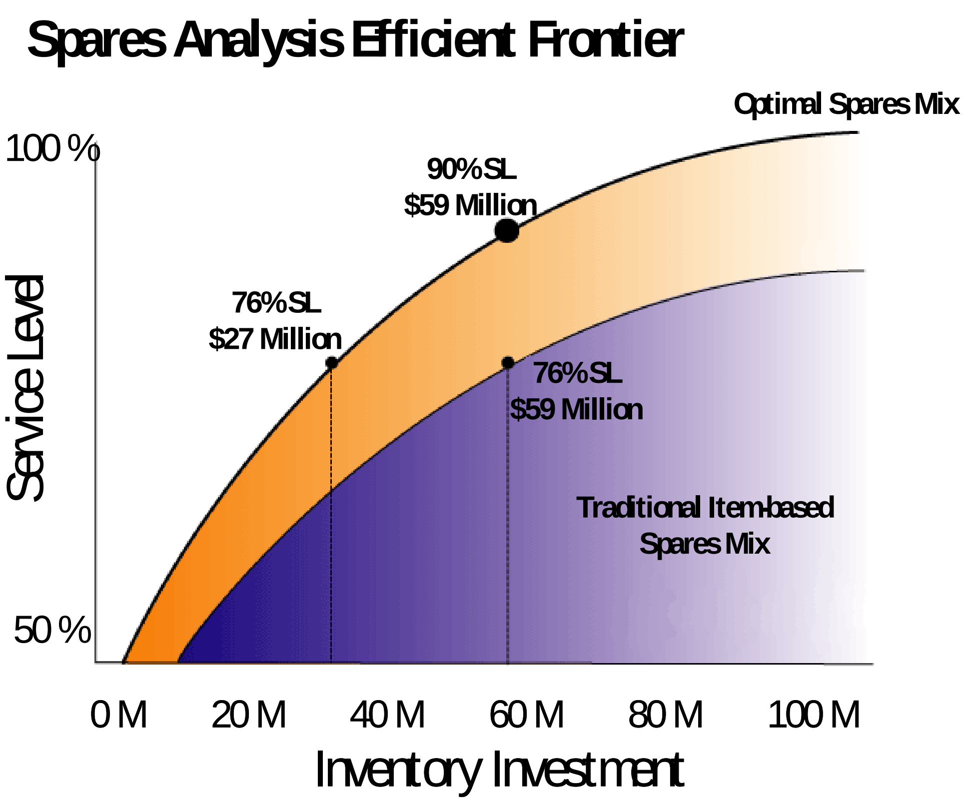
Fill Rate and Back Order Risk for Different Components

Fill Rate	*mT*	Stock Level	Expected Back Orders
0.95	0.1	1	0.005
0.95	1	3	0.0227
0.95	10	15	0.11

For a discrete distribution the long term average or Expected Number of Back Orders (EBO) can be determined from the sum of each possible demand multiplied by the probability of such a demand**.**

Initial Provisioning
Optimal Spares Mix

- Marginal Analysis to determine the reduction in EBOs/$ for each incremental spare at each location in the network.
- The cumulative investment curve is the optimal spares/location mix for any given budget
- The optimal curve is an efficient frontier



Initial Provisioning
Optimal Spares Mix

- Such a spares mix is usually of the order of *20% cheaper* than a traditionally derived mix, yet delivers about half the Aircraft on Ground (No Go) and other part shortages events.

- This is achieved by having the right parts in the right location in the network and achieving very high fill rates for a range of cheaper components (greater EBO reduction/$) at the expense of a slightly lower fill rate on a few very expensive components.

Initial Provisioning
Advantages of system based sparing

- Large savings in Inventory investment for a given service level, coupled with the ability to predict the operational impact of budget changes.
- Complex multi-echelon support networks (supply chains) can be modelled explicitly.
- Models are unlimited in the number of levels of indenture in the hardware breakdown structure and can trade-off holding SRUs against additional LRUs if SRU data is available.
- Part demand is modelled correctly across airframe types and does not assume a perfect Poisson failure rate distribution. (Variance / Mean ratios ≠ 1 can be accommodated explicitly).
- Can use a lower used market or book price for items currently owned and catalogue prices for proposed new purchases. This tends to bias the solution to keeping existing stock, reducing inventory churn required to reach an optimal solution.
- Equations explicitly consider Cost, Essentiality, Flight Schedule, maintenance infrastructure, resupply times and RCT for each item and deliver optimal quantity and location(s).
- A fast, repeatable and reliable methodology able to calculate Availability, Waiting times, EBOs and Fill Rates.
- Able to determine incremental spares purchases/sales and timing for each incremental aircraft entering/leaving the fleet

Initial Provisioning
Advantages of system based sparing

Commercially available off the shelf software

For Example GE Commercial Aviation Services offers performance guarantees if they can acquire your inventory :-

Net Inventory	↓	20 – 40%
Flight Delays	↓	20 – 30%
Service Level	↑	10 – 15%
Costs	↓	5 – 10%

Initial Provisioning
System based sparing = "establishment"

- The output of a system based spares analysis will tell you what spares to buy and where to put them (float and establishment)

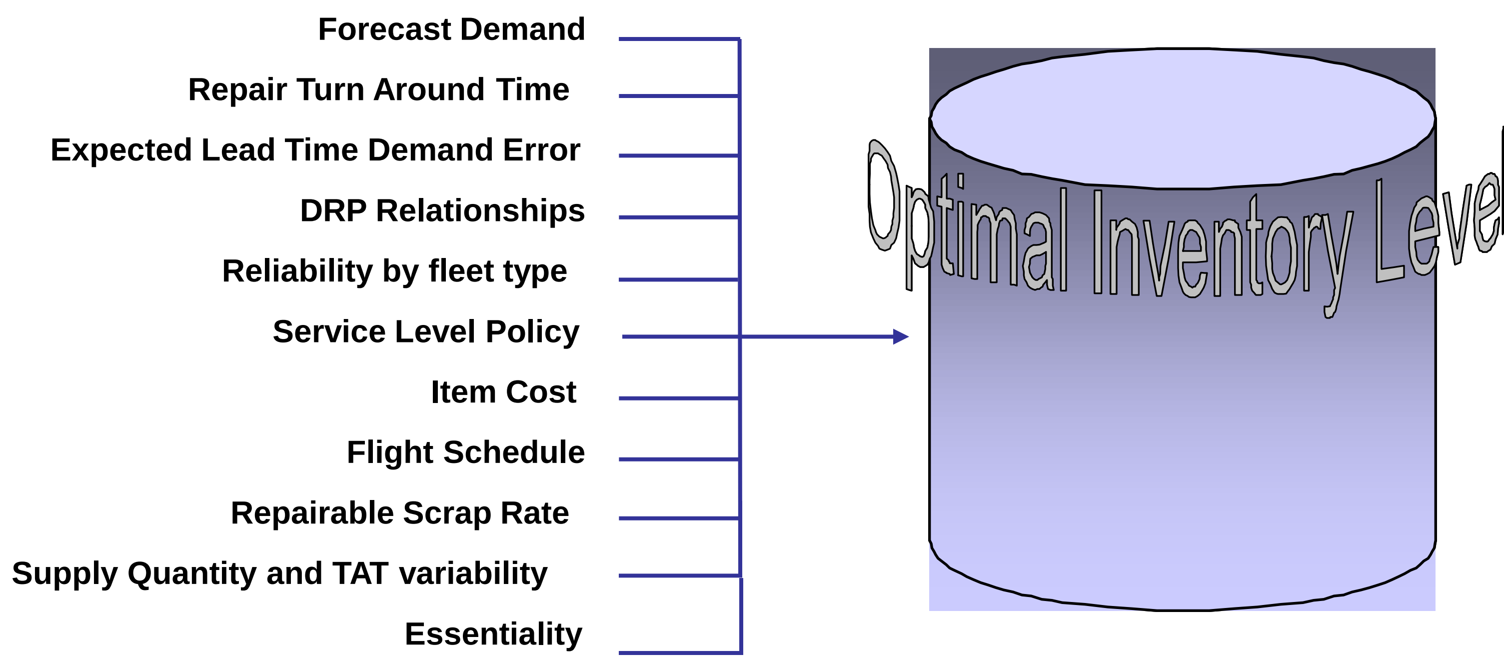
- Based on Cost, Essentiality, Protection factor, equipment schedule, point estimates of Reliability and TAT
  - Additional spares (safety stock) is required to manage variability in TAT
  - For repairables the scrap rate is also a variable (n sent for repair, x% get scrapped and require procurement)
  - Establishment is not static: Reliability (MTBF), TAT, rate of effort or number of equipments in service can change over the service life

Initial Provisioning
System based sparing is not demand planning

Cannot answer the question:

- "How many component failures will occur in the next 3 months?"
- Where will the failures occur?

Initial Provisioning
Rotable inventory management

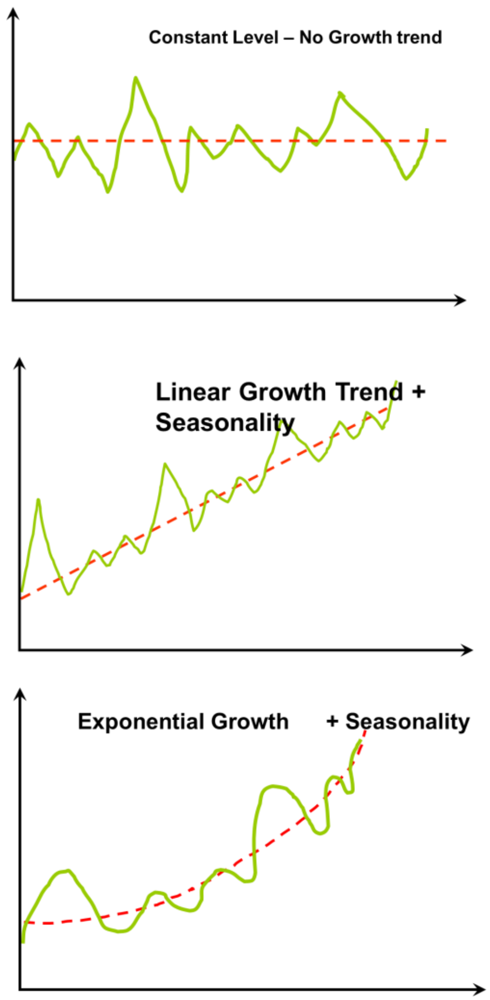


- Therefore the management of rotable and repairable inventory requires systems or procedures that measure delivery performance and yields, an incorporates these factors into the Safety Stock calculation

Demand Planning

- Demand Planning is the discipline of determining what the customer will demand in the future

- The Demand Planning discipline is impacted by considerations such as:
  - Stocking policy – do I stock?
  - Deterministic - BOM
  - Stochastic – statistical
  - Other?



Demand Planning in MTS, ATO, MTO & ETO environments

- The Make to Stock environment (MTS)
  - The Demand management focus is on the maintenance of finished goods inventories as customers purchase directly from available inventory holdings. Customer service is determined by whether the item is in stock or not.

- The Assemble to Order environment (ATO)
  - Demand management involves defining the customer's order regarding options and alternates and ensuring the configuration of inventory components is viable. i.e. 2 door versus 4 door car and a convertible cannot have 4 doors.

Demand Planning in MTS, ATO, MTO & ETO environments

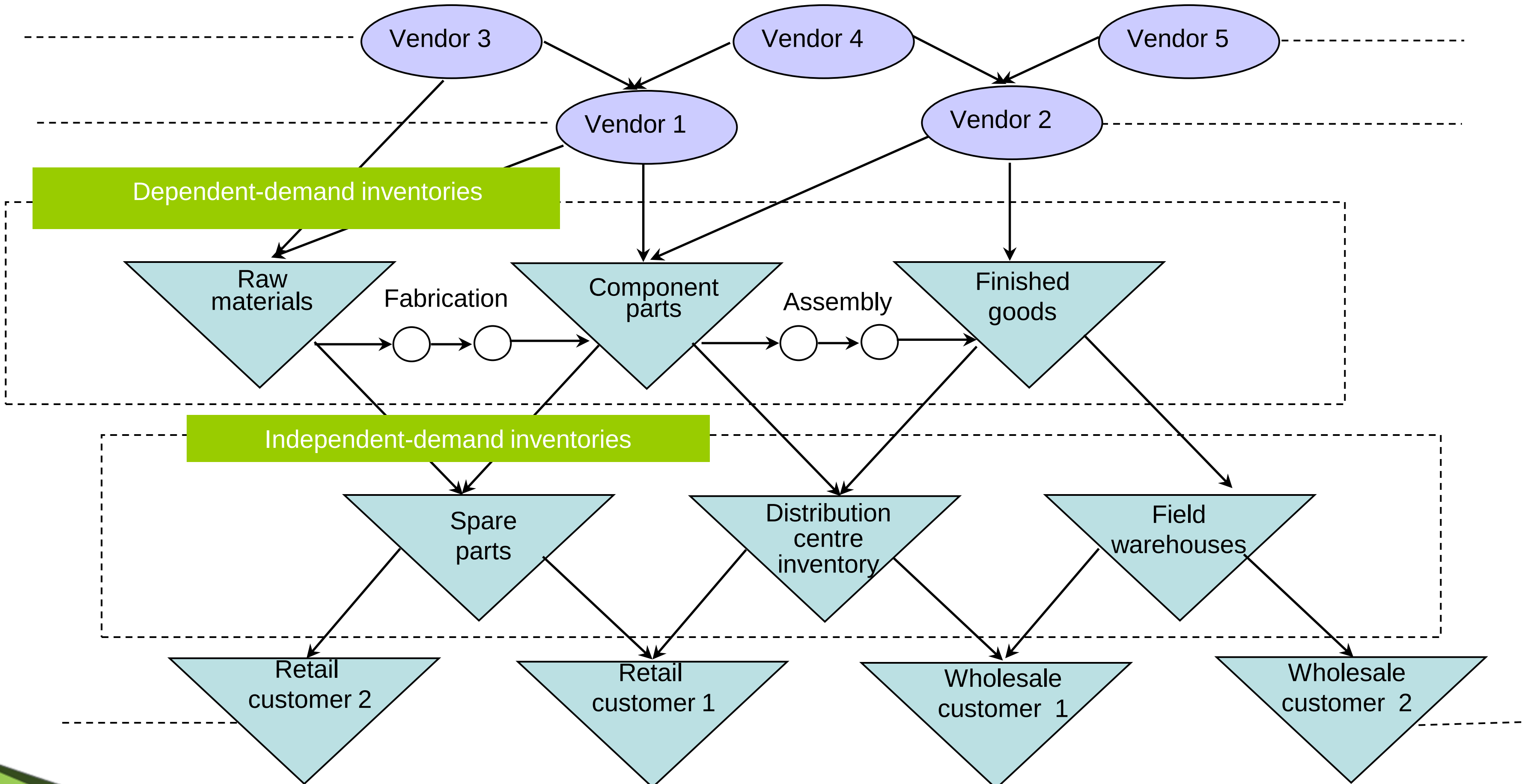
- The Make to Order environment (MTO)
  - The Demand Management focus, unlike MTS is not on satisfying customer orders from inventory (finished goods or components), but rather forecasting how much engineering capacity is required to meet future customer needs, based on the product specifications of the customers.
  - In this environment ,the customer order decoupling point moves the independent demand information to the company and reduces the scope of dependent demand information

- Engineer to Order environment (ETO)
  - allows the product specification and suppliers to be bespoke e.g. a chemical plant or power station, high rise buildings, etc…

- **Step 1: Create an objective baseline forecast**
  - Definition: an automated and regenerative approach that statistically incorporates all structured, objective data including history and available leading indicators
  - Why do it?
    - measure the value & effectiveness of different adjustments & methods
    - creates a good default forecast in case some forecasts are not reviewed (exception management)
    - Reduces subjectivity & “passionate” discussions

- **Step 2: Develop an approval process**
  - Pros
    - Quality of contributions when sign-off required
    - Reviews completed before execution
    - Creates ownership
  - Cons
    - Potentially high cost of time involvement
    - Process bottlenecks may cause delays in execution
    - Cost of developing process and system
    - Value / benefit of input?
  - determining the owners
    - Determine who has the most stake
    - Link incentives to outcomes related to the quality of the forecast
      - e.g. service levels *and* inventory turns

Dependent & Independent Demand Inventories



Source: Vollmann T., et al Manufacturing Planning & Control for Supply Chain Management, Figure 5.1

Some Practical Functionality

- Automatic selection of best formula
- 2 History records: Original & Adjusted
- Notes to document assumptions, adjustments
- Supercession – New product introductions, copy history, notes
- Historical costs & prices, Future (forecast) costs & prices
- Ability to express data in Cost $, Sell $,Margin $, and 'equivalent" units of measure, cartons, kgs, etc
- Graphical representation, trend & seasonal forms
- Import & export data as desired; Access, Excel etc
- Categorize by product class, planner, vendor, ABC code
- Tools to manage by exception…Ranges, Filters, Queries
- Store & evaluate prior forecasts versus actual
- Aggregate & Prorate forecasts to implement management changes
- Curves

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Inventory Optimisation
Why bother?

- For capital intensive businesses, effective demand planning and inventory **optimisation** represents a unique opportunity to generate windfall ROI by rapidly:
  - minimising inventory investment,
  - generating cash,
  - improving service level performance, and
  - increasing profits by reducing supply chain operating costs as a percentage of sales.

- "Inventory affects costs in more ways than you realise. Understanding and managing inventory-driven costs can have a significant impact on margins."
  - Harvard Business Review, *"Inventory-Driven Costs"*

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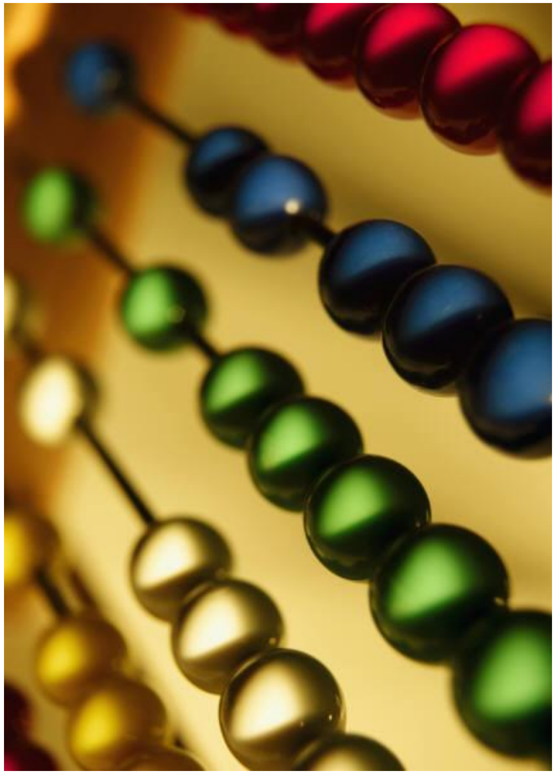
optimisation is…

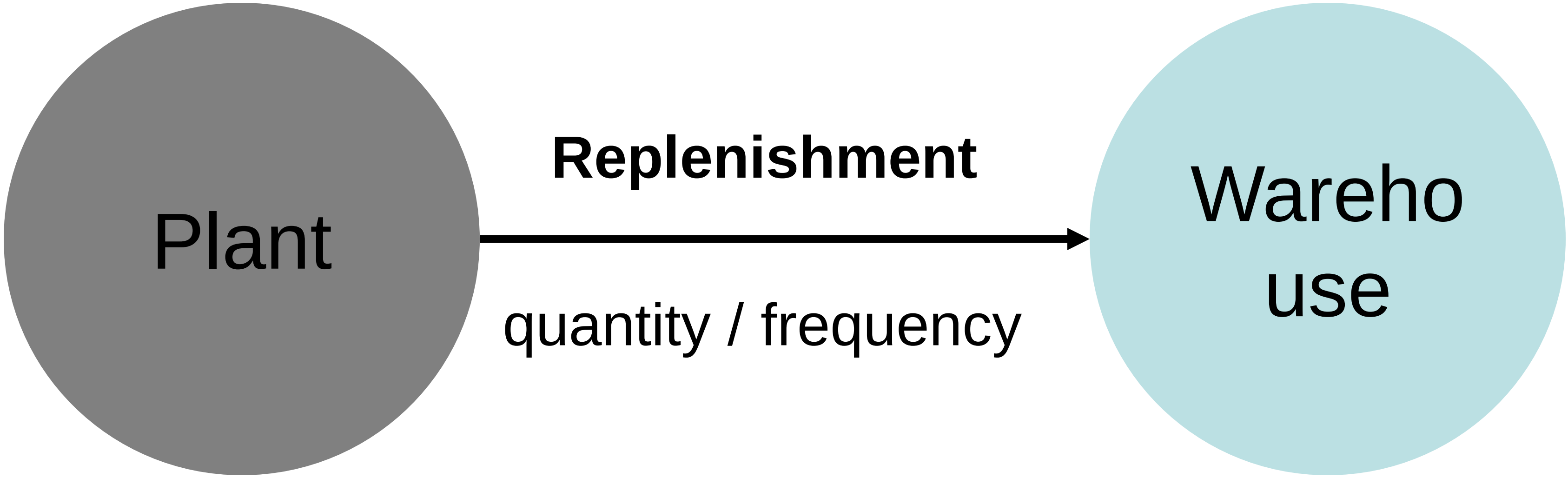
- not “improvement” (but it is an outcome)
- the minimisation or maximisation of something
- a tool set and not a rule set

focus for today – inventory optimisation

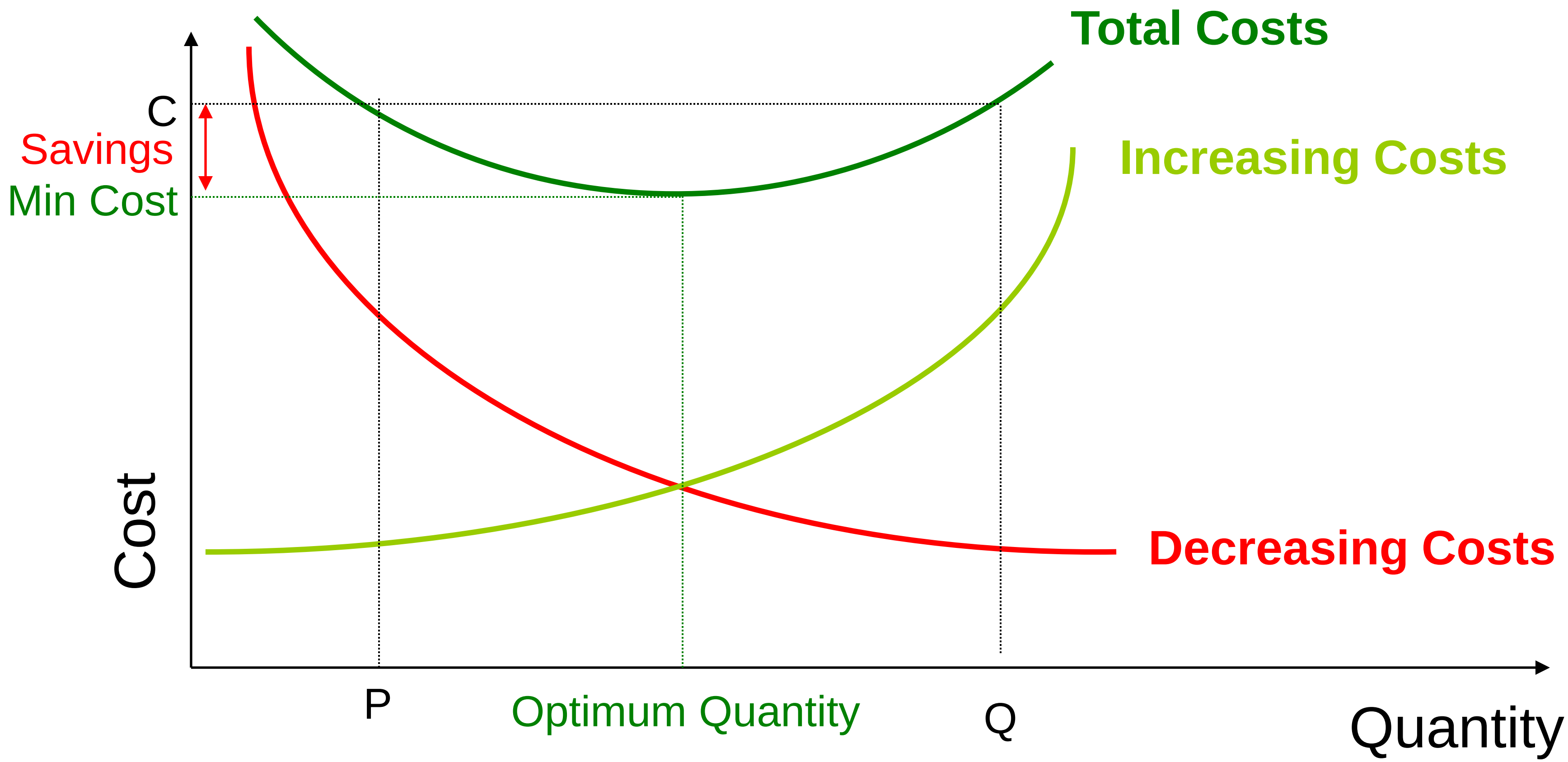
- optimisation can be used for strategic simulation & modelling
  - What is the minimum inventory investment needed to achieve target service levels?
  - What service level (i.e. stock availability) policy maximises profit?
  - Given a financial/budget constraint, what inventory policy maximises service level?
- optimisation can be used for operational management and planning
  - as above, but dynamic and adaptive to on-going changes in your business environment
  - within the context of a forecasting and inventory planning process



A Tradeoff Problem



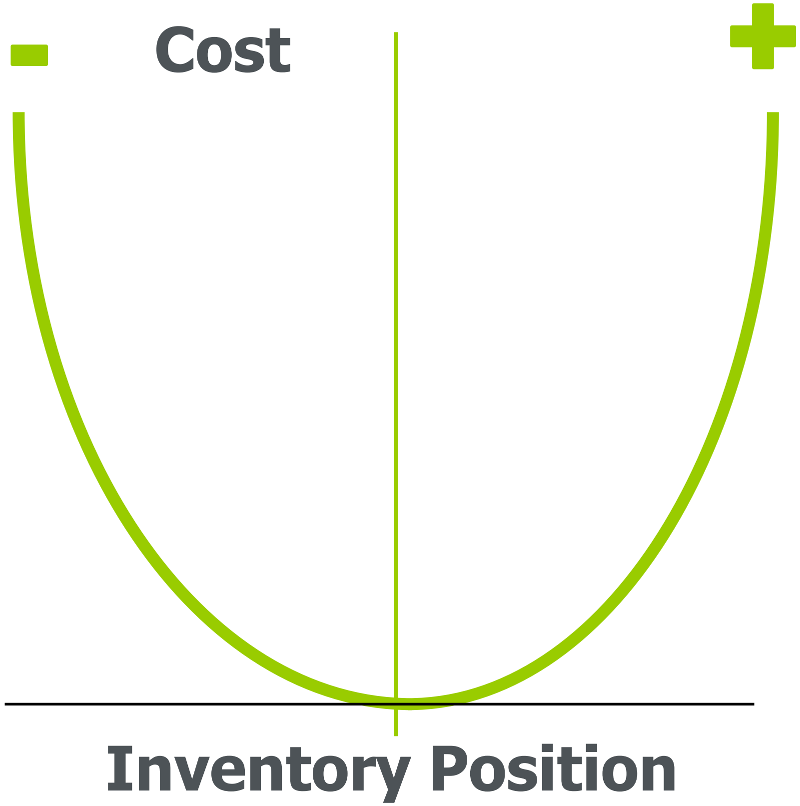
Cost Trade-off Example



Inventory Optimisation (IO)

UNDERSTOCKED

- Asset Downtime
- Rescheduling
- Unnecessary Overtime
- Poor Service Levels
- Expedite Costs
- Premium Price
- Unnecessary Ordering Costs



OVERSTOCKED

- High Cost/Low Return
- Diminished Margins
- Excess Ordering Costs
- Poor Capacity Utilisation
- Poor Storage Utilisation
- Obsolescence Costs
- Opportunity Cost

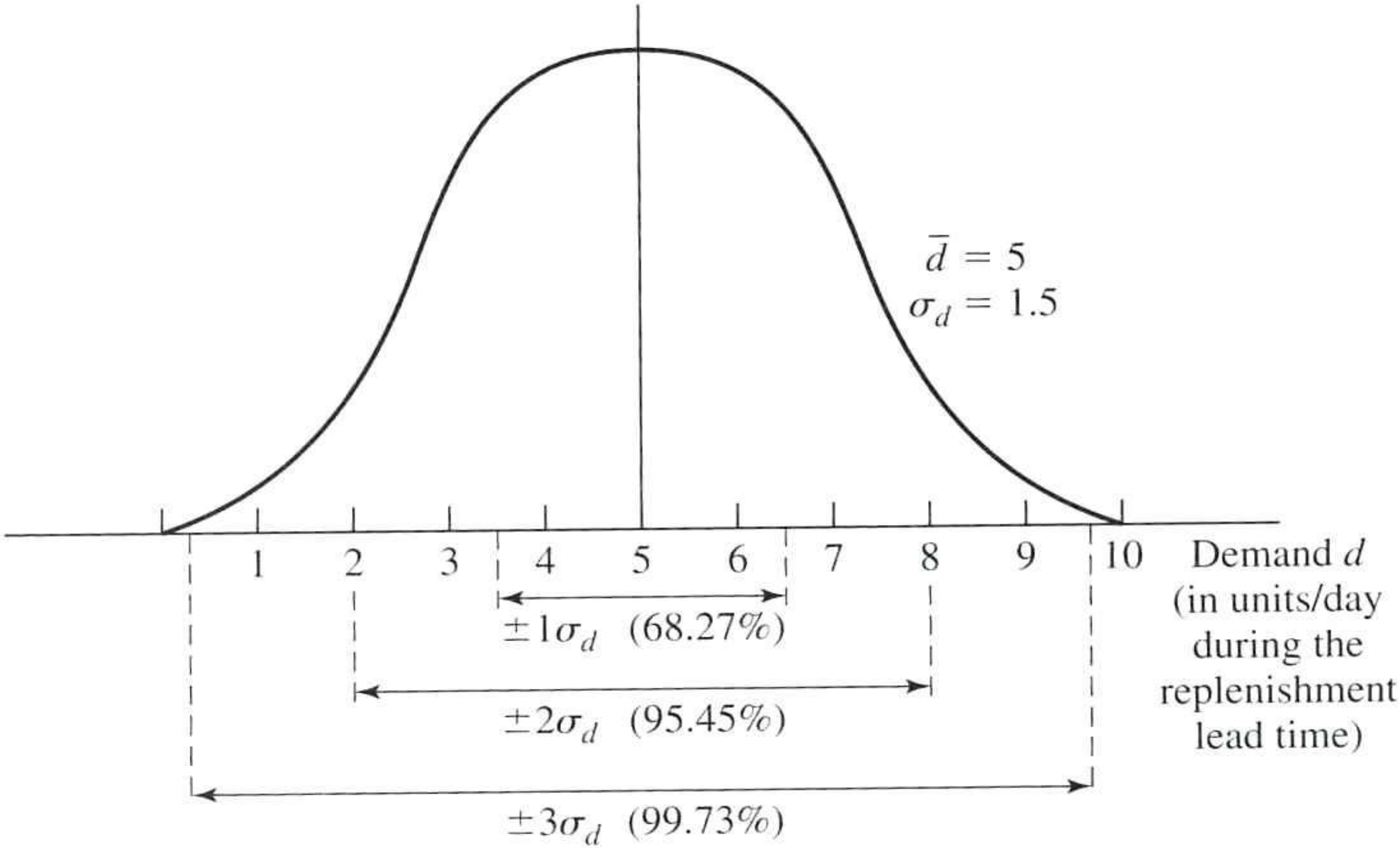
- Examples of Safety Stock and Order Quantity impacts on Service Levels and Inventory Costs
  - raises questions regarding the current inventory settings and business objectives

Item #	Description	XYZ Safety Stock	XYZ EOQ	Resulting Service Level
EABF22053C	KEY DR/IGN LOCK	66	200	48.9%
030515105	TUBE WATER	38	91	99.9%
EAB9A837B	POTENTIOMETER	72	120	92.6%
87DA8A616BA	VISCOUS DRIVE	0	350	65.0%
BC6H50080A	BRACKET FRT BMPR RH	21	24	36.0%
BVAM50031B	BUMPER BAR FRONT	15	13	52.7%

Optimised Safety Stock	Optimised Order Quantity	Managed Service Level
110	1300	95.0%
0	490	95.0%
4	330	95.0%
24	350	95.0%
30	130	95.0%
9	40	95.0%

Preventable Costs	Cause
* Lost Sales * Expedite Costs * Order Costs (650%)	* Insufficient Safety Stock * Low Order Quantity
* Order Costs (538%)	* Low Order Quantity
* Order Costs (275%) *Expedite Costs * Lost Sales	* Low Order Quantity
* Lost Sales * Expedite Costs	* Insufficient Safety Stock
* Lost Sales * Expedite Costs * Order Costs (542%)	* Insufficient Safety Stock * Low Order Quantity
* Lost Sales * Expedite Costs * Order Costs (307%)	* Low Order Quantity

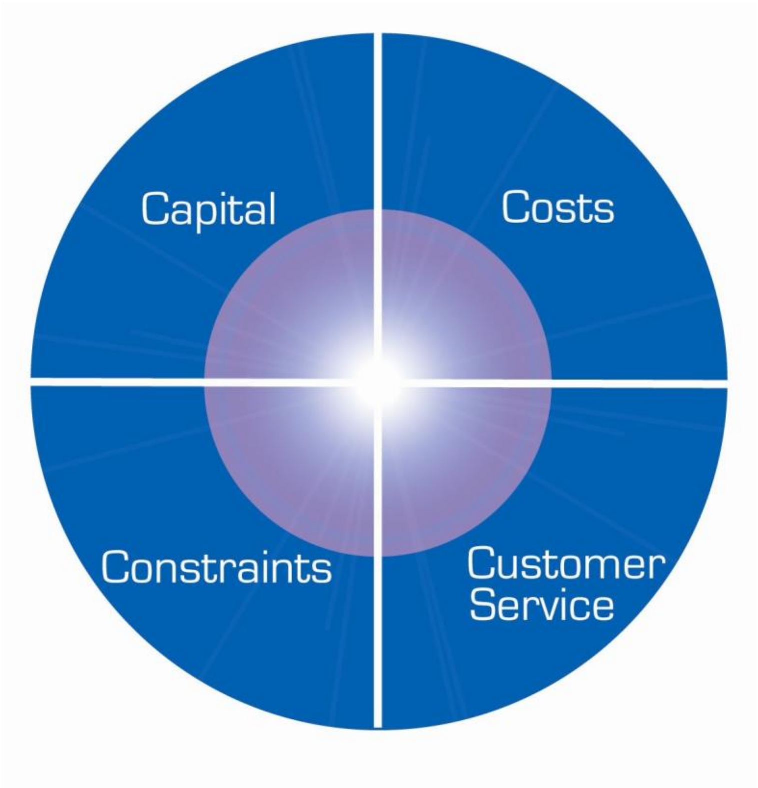
Daily Demand Distribution



Source: Vollmann T., et al Manufacturing Planning & Control for Supply Chain Management, Figure 5.9

Inventory Optimisation: Generation

- Inventory parameters (OQ/SS) should be driven by:
  - Service Level
  - Costs
  - Constraints
  - Demand Variability/error
  - Supply Variability/error



What drives Order Quantity?

- **Order Quantity**
  - demand plan
  - supply chain costs
    - procurement cost
    - carrying cost
    - receiving / order cost
  - constraints
    - capacity
    - order minimums / increments
    - financial

$$EOQ = \sqrt{\frac{2(\text{Annual usage in units})(\text{Order cost})}{(\text{Annual carrying cost per unit})}}$$

Note that the EOQ calculation and its inputs may require modification or fine tuning in some instances. For example, if multiple items are ordered against a single supplier, then the receiving cost should be adjusted accordingly.

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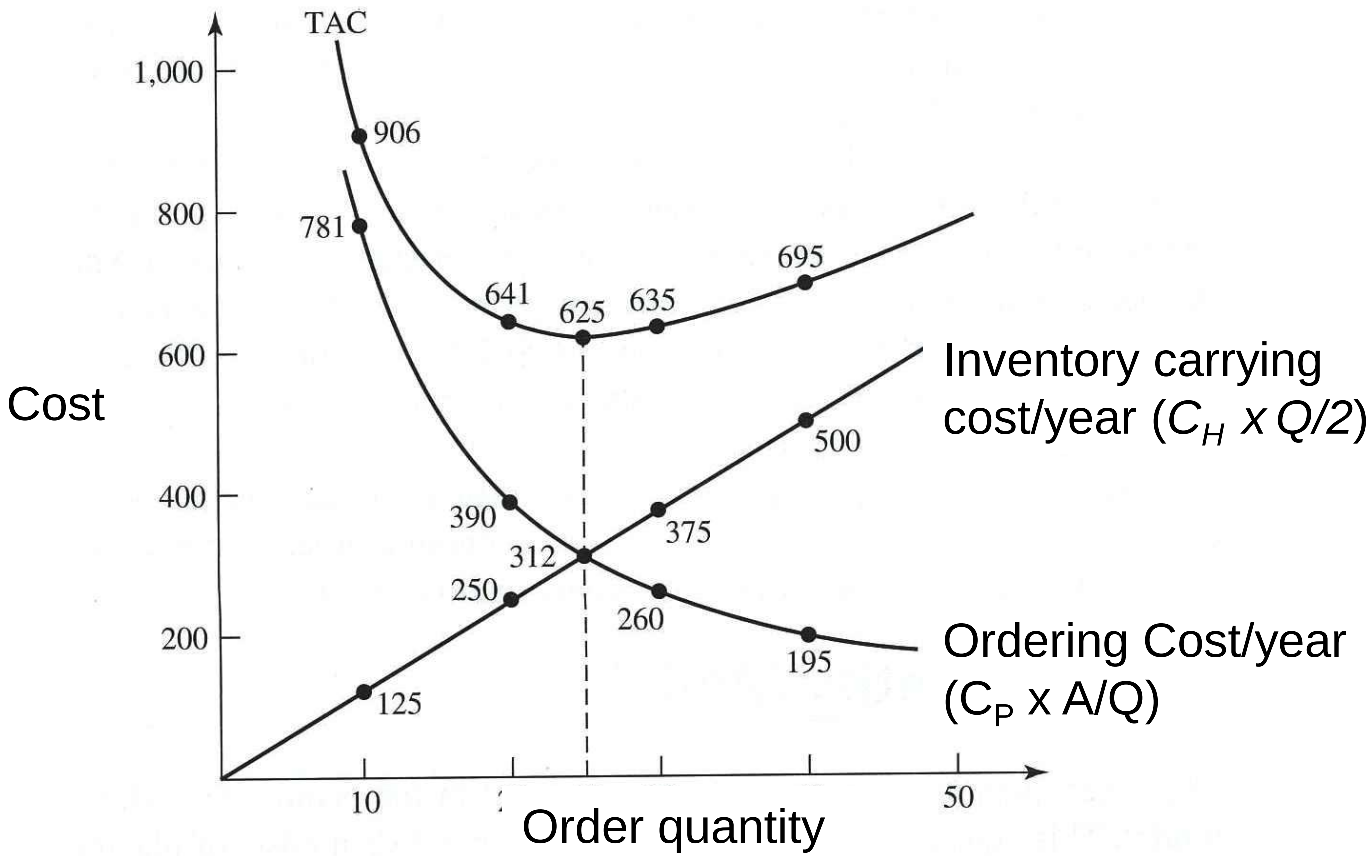
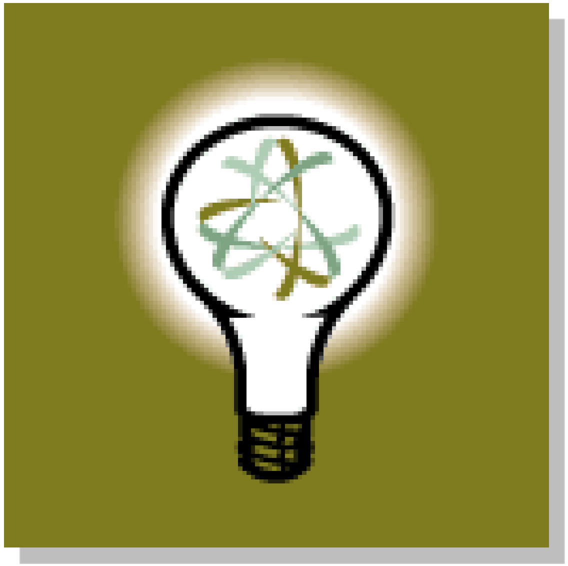
Cost V. Order Quantity for Television Set



Source: Vollmann T., et al Manufacturing Planning & Control for Supply Chain Management, Figure 5.4

- **Safety Stock**
  - Service Level goal
    - Stock availability
  - Demand Plan Error
    - Error over lead time
  - Supply Variability / error
  - Additional risk factors



Safety Stock = LT DMD STD DEV x Service Factor

Safety Stock calculation Inputs

- You can also use Excel function STDDEVPA to calculate standard deviation
- Service Level is your stock availability goal
- Multiply your standard deviation by the service factor associated with your service level

Service Level	Service Factor	Service Level	Service Factor
50.00%	0.00	90.00%	1.28
55.00%	0.13	91.00%	1.34
60.00%	0.25	92.00%	1.41
65.00%	0.39	93.00%	1.48
70.00%	0.52	94.00%	1.55
75.00%	0.67	95.00%	1.64
80.00%	0.84	96.00%	1.75
81.00%	0.88	97.00%	1.88
82.00%	0.92	98.00%	2.05
83.00%	0.95	99.00%	2.33
84.00%	0.99	99.50%	2.58
85.00%	1.04	99.60%	2.65
86.00%	1.08	99.70%	2.75
87.00%	1.13	99.80%	2.88
88.00%	1.17	99.90%	3.09
89.00%	1.23	99.99%	3.72

Safety Stock = LT DMD STD DEV x Service Factor

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Safety Stock - Hidden Truth

- Safety Stock management is actually more important than maximising Demand Plan accuracy for service level & cost management

what is replenishment planning

- Replenishment planning (often called Supply planning) is the process of determining future supply requirements. It encompasses :
  - Demand Planning,
  - Capacity Planning, and
  - Replenishment Planning.
- The planning horizon ranges from
  - long term, say 1 to 5 years, typically for planning new facilities, expanding capacity, and deciding make/buy/import strategies.
  - medium term, the next 12 months , typically for labour and raw material planning .
  - short term, the next few months, levels of over time required shorter lead time materials

replenishment planning methodologies

- There are seven (7) planning major supply planning methodologies
  - Fixed Order cycle/ Fixed Order Qty / Hybrids
  - Time Phased Order Point (TPOP)
  - Material Requirements Planning (MRP)
  - Manufacturing Resources Planning II (MRPII)
  - Distribution Requirements Planning (DRP)
  - Distribution Resources Planning II (DRPII)
  - JIT "Pull" systems, Lean Manufacturing

replenishment planning
two basic inventory control systems

There are two basic inventory control systems:

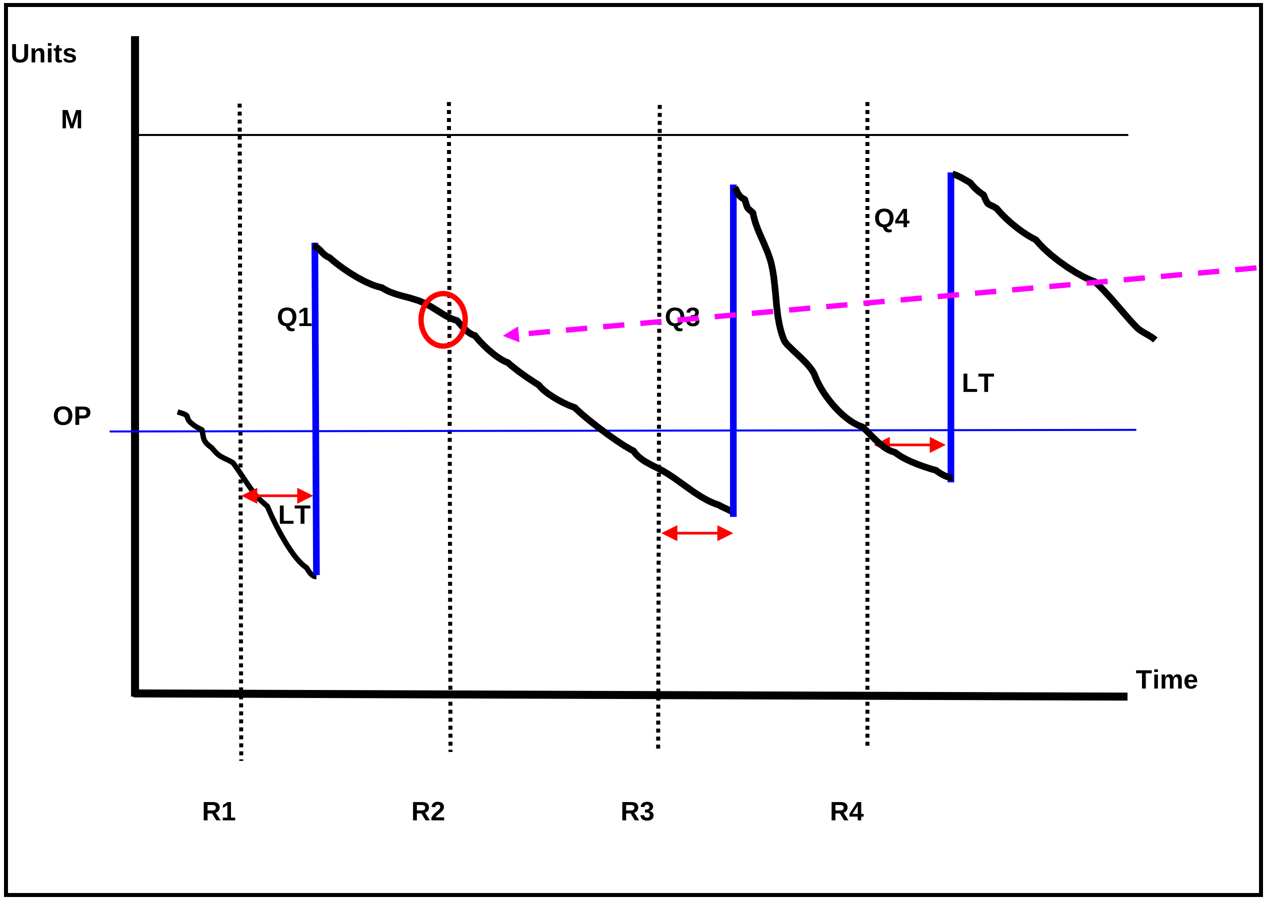
- Fixed Order Quantity System
- Fixed Order Cycle System

	Quantity	Interval
Order Quantity	Fixed	Variable
Order Interval	Variable	Fixed

	How much to order	When to order
Fixed Quantity	EOQ	When Inv = ROP
Fixed Interval	(Max Inv – Inv)	R review period

Source: Toyota Production System
Yasuhiro Monden

replenishment planning
Hybrid Model - Periodic Review/Order Point Combination Optional Replenishment System



In this method, order quantities are only evaluated at the regular review times R1, R2 etc, and an order is not placed if the quantity on hand is above OP, as is the case at Review time R2.

The objective of this method is to prevent placing orders for relatively small quantities.

Clearly the gap between M and OP influences order frequency. This raises issues with shelf life and ordering costs versus carry costs.

replenishment planning
Time Phased Order Point (TPOP) - what is it ?

Time Phased Order Point (or Time Phased Replenishment Planning (TPRP) is:

- Proactive
- Dynamic
- Predictive

TPOP is *proactive* because it enables the inventory planner to preposition inventory in anticipation of future requirements. It does not just simply seek to replace what has been used.

TPOP is *dynamic* because its estimate of lead time demand is not static. TPOP handles variable demand over time such as occurs with seasonal products, and catalogue promotions.

TPOP is *predictive* because it provides forecasts of future replenishment requirements which are valuable for suppliers, as well as being valuable for planning future warehousing and transportation requirements. TPOP provides superior replenishment planning capabilities for dependent demand items.

Manufacturing Requirements Planning (MRP) - what is it

- Material Requirements Planning (MRP) is a methodology that attempts to:
  - Ensure the availability of materials, components, and products for planned production and for customer delivery
  - Maintain the lowest possible inventory
  - Plan manufacturing activities, delivery schedules and purchasing activities
- MRP systems differ from traditional inventory systems in one fundamental way
  - the Master Production Schedule (MPS) is the force that directly initiates and drives subsequent activities of purchasing and manufacturing functions

Distribution Requirements Planning (DRP) – what is it

- Distribution Requirement Planning (DRP) is a system of determining demands for inventory at the lowest levels in the distribution network, consolidating that demand information backwards, and acting as input to the production and materials systems
- DRP ties production and distribution requirements together by determining aggregate time-phased net requirements at the same point in the material flow as the Master Production Schedule (MPS)

replenishment planning summary

- Replenishment planning is a key step in managing and operating the supply chain
- There are a number of different replenishment planning methodologies – each with their own strengths an weaknesses
- The choice of replenishment planning methodology will go a long way to defining your logistics costs

performance management strategy comes first

- “Would you please tell me which way I ought to go from here?” asked Alice
- “That depends a good deal on where you want to get to.”
- “I really don’t know,“ replied Alice.
- “Then it doesn’t matter which way you go,” said the cat.

Lewis Carroll
Alice’s Adventures in Wonderland

What KPIs to start with?

- Customer facing
  - DIFOT
  - Customer Wait Time (CWT)
- Internally facing
  - Cost to Deliver to Service – total and functional % of sales, throughput cost
  - Demand Forecast Accuracy
  - Inventory Turnover
  - Inventory Balance (excess & under stock)
- Supplier DIFOT

Develop KPIs to :
1. Measure Performance
2. Diagnose under performance

KPI Examples

Performance measures		AAA	BBB	CCC	DDD	EEE
1. Customer service						
1.a. Delivery in full and on time						
(i) By order	**99/00**	45%	45%	83%	91%	58%
(ii) By case/unit	**99/00**	97%	93%	94%	94%	92%
2. Logistics Costs						
2.a. Total logistics costs / total no. of orders ($ / order)	**99/00**	$220	$408	$79	$109	$463
2.b. Total logistics costs / no. of cartons ($ / unit)	**99/00**	$2.39	$3.68	$0.71	$1.03	$7.67
2.c. Total logistics cost as a % of sales	**99/00**	9.0%	4.1%	7.0%	5.1%	4.0%

Reference: Presentation by Stephen Hanman Director, Benchmarking Success.

- Performance management – critical to maintaining focus and improving performance
- Causal analysis – understanding what is limiting/affecting performance
- Data analysis – enabling investigations of supply chain performance

Performance Management

- Requirement – performance measurement/management has proven to be crucial to sustained improvements in inventory management
  - What you can't measure, you can't manage
- Need to remember 'rules' for performance measures – especially – don't measure unless you intend to act
- Should be able to look at a report and know in several seconds whether the news is good or bad

Supply Chain Strategy, Planning & Execution

MRO Spares Inventory Management

- Opportunities Assessment

7 November 2011

Real People. Real World. Real Results.

Opportunity Assessment

	Key MRO Planning Elements					Potential Improvement Opportunity (Advanced)	
	Initial Provisioning	Demand Planning	Inventory Optimisation	Replenishment planning	Performance Management	Service Level	On Hand Inventory ($)
Basic	❑ OEM Recommended Spares List	❑ nil	❑ nil, or ❑ manually set SS and order quantity (ORQ) size /freq	❑ reactive - triggered by a customer demand	❑ Nil	10 - 20%	20 - 40%
Intermediate	❑ RIs - item based sparing (e.g. Palms theorem)	❑ deterministic only (e.g. scheduled maintentance) ❑ simple statistical ❑ rudimentary business process	❑ SS and ORQ based on Service level target only ❑ automated SS and ORQ calcs. ❑ rudimentary business process	❑ ROP /ROQ – updated regularly ❑ rudimentary business process	❑ service level ❑ stock on hand ❑ stock turns	5 - 10%	10 - 20%
Advanced	❑ RIs - system based sparing techniques (e.g. Vmetric) ❑ sensitivity analysis ❑ robust business process	❑ sophisticated SKUL level stat. forecasting ❑ both stochastic and deterministic demand ❑ Predict future serviceable RI demands ❑ robust business process	❑ SS & ORQ adjusted monthly based on Service level target, forecast error and supply variability ❑ inventory carrying and receiving costs included in ORQ ❑ robust business process	❑ Time Phased Replenishment Planning ❑ DRP ❑ proactive inventory sharing ❑ priority-based replenishment plan ❑ robust business process	❑ DIFOT ❑ Customer Wait Time ❑ Forecast acc. ❑ Inv. balance ❑ Understocks ❑ Excess inventory ❑ robust PM framework		

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Summary
what have we covered?

- Inventory segmentation is critical to effective and efficient supply chain management (one size doesn't fit all)
- Demand Planning is a combination of **both** technology and robust business process
- It is the combination of forecast and safety stock that deliver service level – not forecast accuracy alone
- Least cost supply chain strategies require inventory optimisation techniques (for both RIs and consumables)
- Performance management is not just performance reporting – it must facilitate causal analysis

References

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