White Paper

A Global Inventory Planning Foundation

Fundamentals of Finished Goods Inventory Management

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Overview

How much finished goods inventory does your business need to be competitive? Do inventory levels need to change over time? How do you ensure inventory levels are properly synchronized to customer demand in each global region over time? The answers depend on a variety of factors such as competitor's service levels, customer demand patterns, and capital investment constraints. They also require regular review and adjustment, applying a sound set of inventory management fundamentals. Whether your business uses traditional MRP planning techniques, multi-site DRP processes, kanban pull signals, or custom solutions, many of the fundamentals are the same. And for global businesses, with inventory spread across multiple continents in distribution centers servicing discreet regional locations, the fundamentals are even more important. Inventory management practices must be standardized and managed with a view to optimizing regional and global business results such as inventory turns, line fill (or product availability) performance and profitability.

This paper outlines a key set of inventory management fundamentals which, in aggregate, provide a roadmap for answering the questions posed above, and achieving the desired business results. The top-level objectives are simple and address the fundamental questions:

(1) How much inventory do we need?
(2) How do we consistently maintain those levels over time in every global distribution location?

A number of key elements to attaining these objectives are outlined, then discussed in detail. Along the way, a project management perspective is provided, outlining potential projects and initiatives which may be required to fully deploy the processes discussed.

Definitions

To ensure full understanding of the concepts discussed here, a few definitions are in order.

- ✓ ABC – An inventory classification code usually based on pareto analysis (the 80/20 rule) of the cost-of-sales. A-items represent the "vital few", C-items the "trivial many" and B-items those parts in the middle. Some companies choose to further segregate into A, B, C and D classes with the top 10% being A's, the next 20% B's, 30% B's and the bottom 40% D's.

- ✓ COS – Cost of sales, typically the annual sales of a product (part number) valued at standard cost
- ✓ DRP – Distribution Requirements Planning. A replenishment planning technique, similar to MRP, used to manage the replenishment of inventory through a network of two or more distribution centers.
- ✓ MRP – Material Requirements Planning. A set of techniques that uses bill of material data, inventory data, and the master production schedule to calculate requirements for materials. (APICS Dictionary, 12th Edition)
- ✓ Safety stock – A quantity of inventory planned to be on-hand to protect against fluctuations in demand or supply.

Objectives

The top level objectives are deceptively simple, addressing the fundamental questions of "how much" and "how to".

1. Calculate statistically-valid safety stock and inventory targets able to achieve specified product availability levels by ABC class. (Conversely, to reliably determine expected service levels resulting from a pre-determined level of inventory investment.)
2. Maintain a sustainable, consistent, global-standard set of processes to maintain finished goods inventory levels in-synch with current and projected sales.

Achieving these objectives requires a set of underlying demand planning and inventory management processes. These key elements are outlined below, then discussed in detail.

Key Elements

- ✓ A centralized Inventory Model for each country or region
- ✓ A common global source of customer order demand history
- ✓ A common ABC methodology based on global best-practices
- ✓ A common statistical safety stock methodology based on global best-practices
- ✓ Demand outlier detection and smoothing
- ✓ Unusually large customer order management process
- ✓ Inventory Dashboards
- ✓ Replenishment lead time management
- ✓ Replenishment lot size management

Centralized Inventory Model

Maintaining a central model is the key to driving consistent execution of an inventory planning strategy. The model must incorporate the parameters identified above (ABC coding, safety stock calculations, etc.) and allow for iterative planning, beginning with senior management defining the desired service and inventory objectives. A properly constructed model allows multiple alternatives to be developed for management's consideration. For example, service objectives by ABC code may be modeled at 99% for A-Items, 98% for B-items, and lower levels for C & D items. The resulting inventory level may or may not be acceptable, or within available budget. Alternate scenarios may be tested to arrive at the right inventory/service balance. Additionally, what-if scenarios may be run to test the impact of shorter lead times, smaller lot sizes, etc. Once a particular plan is agreed upon, the model then becomes the vehicle for consistent application across planning systems, and subsequent execution of the plan.

This approach is in contrast to a decentralized planning environment, where each location or inventory planning manager considers only their subset of part numbers, and therefore sub-optimizes the planning process, eroding the company's inventory, financial and service results. For example, one planner may manage replenishment of product from one or more suppliers. Modeling such as that described above is difficult, and can be done only on a subset of parts sourced from the specified site(s). In some cases, multiple planning systems may exist, as in the case where a company has not standardized on a single ERP platform. In this event, each system may have its own unique internal processes for ABC coding, safety stock modeling, etc. Maintaining process consistency in this distributed environment is challenging, if not impossible, without a centralized model. This was the situation at an aftermarket company in the US, where service levels were well below competitive levels and inventory well above budget. By standardizing on a central model, and distributing a consistent set of ABC and Safety Stock values back out to the various planning systems, this company was able to achieve double digit improvements in line-fill and on-time delivery with significantly less inventory.

The Inventory Model's design depends on the size of the company, available budget and technical capabilities, and can be constructed using a small-scale spreadsheet application, desktop database tool, or in the case of a global company on a data warehousing or similar platform. Regardless of the technology used, it is wise to fully engage the IT organization in its development and maintenance, thereby ensuring consistency of the application, and revision control, across the organization.

Common Global Source of Customer Demand

To further drive consistency, a common source of customer demand data is needed. Ideally, this data will be by product (part number) by day for each site. The source of this data is the company's customer order system; however, detailed order line data is not needed. Rather, all orders for a product with a given due date should be summarized into a single record, then stored in a database such as a data mart repository. At a minimum, one year of data is needed for valid statistical safety stock calculations. Care must be taken to ensure this data is properly updated, with appropriate adjustments for cancelled orders and order modifications such as quantity or due date adjustments.

Once populated, this database becomes the primary data source for the safety stock calculations discussed later in this paper. A variety of SS methodologies exist, some of which use weekly or even monthly summaries of demand data by part. It is this author's contention that the daily usage approach discussed below is superior in terms of statistical correlation to line-fill (customer service) results. However, the superiority of this method lies in the ability to "scrub" the daily history for statistical outliers; i.e., demand days which are far outside normal demand patterns, and should therefore not be included in subsequent safety stock calculations. More on this point later.

Global Standard ABC Methodology

The case for global-standard ABC coding is compelling. ABC codes drive many inventory management decisions including line-fill expectations, inventory investments, lead time and lot size targets, manufacturing and purchase order prioritization, and others. As supply chains, both internal and external, become more global, a consistent ABC coding methodology will drive consistency of decision making across the entire enterprise. The alternative is inconsistency, leading to confusion over investment decisions, replenishment priorities, and unnecessary conflict between business sites and regions.

A roadmap to achieve this consistency relies on two major elements: (1) the common inventory model, discussed above, on which ABC codes are determined, and (2) a commitment to identify and standardize global ABC best-practices.

The best-practice discussion is illustrated by way of example using the experience of a global aftermarket manufacturing company in the US, with manufacturing and distribution centers on every continent. This company made two major improvements in ABC methodology. The first, limited to one region, was an "ABC by Market Segment" approach, which elevated to A or B status those products deemed most important in key growth segments. Previously, these smaller segments had been overshadowed by the company's primary high-volume products, resulting in a preponderance of C and D-class items in the growth segments. Since C and D-class items are given lower replenishment priority, and carried safety stocks targeted to achieve somewhat lower service levels, these market segments experienced lower product availability and on-time customer delivery, working against the company's growth objectives. The new approach determined ABC codes for each segment independently, then compared ABC codes across all segments, assigning the highest code as the final ABC code for the part number. For example, if a product is sold in three market segments, is an A-item in one, a B in another and a C or D in the third, the final ABC assignment would be A for that part. Figure 1 below illustrates several examples.

PN	Seg1	Seg2	Seg3	Final ABC
AAA	A	B	D	A
BBB	D	C	B	B
CCC	B	C	D	B
DDD	A	A	C	A
EEE	A	B	D	A
FFF	B	C	B	B
GGG	C	D	A	A
HHH	D	D	D	D
JJJ	C	C	D	C

Figure 1 – ABC by Segment Example

The second change was made in a different global region. A blended ABC approach was adopted, supplementing the standard cost-of-sales (COS) pareto model with a sales-frequency pareto, based on number of order-lines received for each product. Each pareto analysis resulted in a rank score. In the first ranking (COS), the product with the highest cost-of-sales is ranked 1, the second highest is ranked 2, and so forth. In the second ranking (order frequency), the product with the highest number of order-lines is ranked 1, followed by the second highest, etc. The two ranks are then added together for the final ABC assignment as illustrated in Figure 2 below. The top 10% of products were coded A-class, the next 20% B-class, followed by 30% and 40% for C- and D-class products. The net result was to elevate ABC class for frequently ordered products, regardless of cost or volume. This company's primary customer service measure is based on line-fill, in which any order-line, regardless of size or value, which cannot be filled by the due date, counts as a service hit. By elevating high-frequency products to higher ABC classes, and carrying higher safety stock levels on these less expensive products, the company was able to improve service levels with lower inventory investment.

PN	No. Lines	Annual Sales	Std Cost	COS	COS Rank	No. Lines Rank	Total Rank
AAA	6981	4,678	$ 3.15	$ 14,729.82	2	1	3
EEE	3838	6,025	$ 4.03	$ 24,310.23	1	5	6
FFF	5861	751	$ 9.21	$ 6,917.61	4	3	7
DDD	4732	3,600	$ 2.66	$ 9,568.68	3	4	7
GGG	6431	903	$ 4.85	$ 4,379.96	6	2	8
CCC	1623	80	$ 58.10	$ 4,648.00	5	6	11
HHH	281	99	$ 4.59	$ 454.79	9	7	16
BBB	241	654	$ 4.21	$ 2,751.20	8	8	16
JJJ	78	23	$ 125.00	$ 2,875.00	7	9	16

Figure 2 – Blended ABC Rank example

In this company's case, these changes were considered global best practices, and drove positive benefits to both inventory and service in the two regions. The remaining challenge for this company is to determine how best to blend these approaches into a global ABC standard practice. Once defined, the new standard ABC methodology will be incorporated into the standard Inventory Model, where it can be deployed consistently across all global regions. Employing this type of project management mentality, with clear deliverables, is key to attaining and sustaining the benefits described. Senior management must provide the leadership to ensure this happens.

Global Standard Safety Stock Methodology

A simple statistical formula for calculating safety stock (SS) is:

SS = SF x SD x Sqrt(LT)

Where:

SS = Safety Stock

SF = Service Factor (refer to the appendix)

SD = Standard Deviation of daily demand for a part number

Sqrt(LT) = Square Root of Lead Time (in days) for a part number

To illustrate:

Product XYZ has a service expectation of 99%.

The service factor associated with 99% availability is 2.33 (see appendix)

SD = 150 pieces

LT = 20 days

SS = 2.33 x 150 x Sqrt(20) = 1563 pieces.

The Achilles heel in a statistical safety stock model is the existence of highly erratic demand points. Demand "outliers" can significantly impact the safety stock calculation, unnecessarily raising safety stock. Sound safety stock policy is to identify and "smooth" these data points prior to calculating product-specific safety stock levels. The business rationale is to **not** rely on safety stock to protect against these spikes. Rather, the business should understand the sources of demand spikes, and manage each appropriately. Safety stock, then, is needed only to cover "normal" demand variability. For many aftermarket companies, there are three primary sources of demand spikes:

1. Sales specials – These drive predictable, but very high, levels of demand in a compressed time frame, often limited to a few A-class items. Since this demand can be predicted in advance, producing to a forecast is the preferred approach, rather than carrying inflated SS levels year-round.
2. Unusually large order quantities (LOQs) – These can occur at random, unrelated to sales specials and often create unexpected stock-outs. Since LOQs are not predictable, they tend to create sudden "shocks" to the supply chain. Typical MRP planning processes cannot recover rapidly. As a result, each LOQ can cause many additional customer back orders, and therefore service hits. In one particular company, this problem was so great that LOQs, by themselves, accounted for more than 2 percentage points of disservice. In other words, even if this company's supply chains (including manufacturing plants) did *everything else perfectly*, their objective of 98% line-fill could not be achieved! LOQ orders can be a major cause of disservice and must be managed. The key to doing so is a detection process which allows LOQ orders to be immediately, but temporarily, suspended allowing designated customer service or inventory planning personnel to validate the order with the customer and to work out a mutually agreeable delivery plan which balances the company's supply-side capabilities with the needs of *all customers*, not just the one customer placing the large order.
3. Random statistical spikes – The Inventory Model must include statistical processes to identify "demand outliers". Many of these may result from sales specials and LOQs. However, others are truly random, and unpredictable. The model should apply a smoothing algorithm to all outliers, resulting in lower safety stock levels. (Note that the safety stock formula which began this section uses the final "smoothed" standard deviation value.) A simple step-by-step method follows:
    a. Collect daily-demand data for each part number
    b. For each part, calculate the average and standard deviation of daily demand.
    c. For each part, define an outlier as any day with demand exceeding the average plus N standard deviations. (A typical N value is 4 or 5, indicating that an outlier represents a data point above the 4 or 5 sigma level.)
    d. Replace each outlier with the average daily demand value.
    e. Recalculate average and standard deviation, then repeat steps (c) and (d) two or more times until no outliers remain. (Alternately, limit the process to 3 iterations, achieving the majority of smoothing, with less complexity.)

Combined with the LOQ process described above, the net result is better service year-round, with less inventory, and a management-by-exception process whereby the company can resolve order spikes on a case-by-case basis.

All of the above are considered best-practices, and should be incorporated into the standard Inventory Model.

Inventory Dashboards

The above elements form the foundation for determining target inventory levels by product and source in a particular distribution location. These targets can be accumulated then compared to actual inventory levels, providing management a window into the effectiveness of operational execution of the inventory plan. Key elements of the dashboard are (a) variance to targets, (b) overstock and (c) product short. This blended view informs management, and inventory planners, of inventory performance over time, as well as the ability to drill down to underlying details. For example, Figure 3 below shows an inventory dashboard for a Distribution Center being supplied by 3 manufacturing plants, one or more external suppliers (perhaps purchased branded products) and one or more international sources. Using Plant 2 to illustrate, we see this plant is in good position overall to target, as evidenced by the variance being within acceptable range of target (Variance is color-coded green). However, even though inventory, overall, is slightly below target, some products from this source plant are overstocked; i.e., above the maximum level normal MRP processes should allow. The combined overstock value for the parts in question totals $29K (the yellow coding indicates this value is between 2% and 5% of target). Again, the dashboard should provide the ability to drill-down to the underlying part number details. In addition, this plant has some products which are stocked-out, or on backorder, as evidenced by the Product Short value. In total then, Plant 2 is in good overall financial position, but with some inventory imbalances: too many of some products and out of stock on some others.

Inventory Dashboard ($000)					
Source	**Target Inventory**	**Actual On Hand + Intransit**	**Variance**	**Overstock**	**Product Short**
Plant 1	$1,348	$1,568	$220	$37	$159
Plant 2	$984	$937	($47)	$29	$81
Plant 3	$1,274	$1,402	$128	$94	$87
Purchased	$569	$490	($79)	$0	$0
International	$826	$853	$27	$37	$12
Total	**$5,001**	**$5,250**	**$249**	**$197**	**$339**

Variance Legend:	**Overstock & Product Short Legend:**
Green within 10% of Target	**Green < 2% of Target**
Yellow within 15% of Target	**Yellow within 2 - 5% of Target**
Red greater than 15% of Target	**Red > 5% of Target**

Figure 3 – Inventory Dashboard Example

Now that inventory position is understood, action plans can be developed such as canceling production orders for overstocked products, or accelerating replenishment of product-short items. While MRP and other planning tools provide this micro-level view to planners, they do nothing to inform management. Inventory Dashboards bridge the gap by providing management the opportunity to review the big picture, and to "pull the right levers" when directional correction is needed.

To be most effective, operations and logistics leadership must accept the challenge to leverage the power of this tool. Doing so means taking ownership of a monthly review, providing top-down direction to the source plants and supply chain planning team. This is a necessary step towards a Sales & Operations Planning (S&OP) process.

Lead Time and Lot Size Management

The above elements are foundational to sound inventory management. However, their impact is limited by current-state lead time and lot size constraints. The primary drivers of inventory are:

- ✓ Demand variability – customers drive this; suppliers have minimal ability to alter these patterns. Exceptions include LOQ management and careful planning of sales specials, as discussed above.
- ✓ Lead Times – the replenishment delay between detecting the need for more product, and its availability in stock.
- ✓ Lot Sizes – the standard, or minimum, production or purchase quantity which can be economically obtained.
- ✓ Service expectations – set by management, typically by ABC code
- ✓ Safety Stock – ideally this is calculated statistically to achieve a desired level of service.

Since demand patterns are generally beyond the control of the supplier, the amount of inventory needed to obtain a certain level of service is **fixed**. It is a mathematical reality. To significantly improve service with less inventory, lead times and lot sizes must be reduced. There is no other choice. Joint cooperation between logistics and operations, with laser-like focus on lead time and lot size reduction is needed to move the needle on inventory, while maintaining or improving service levels. Companies who are serious about improving customer service with less inventory must create structured plans to focus on lead time and lot size reduction, and monitor the progress carefully.

The best piece of advice I can offer here is to focus Lean Teams on setup (change-over) reduction. Properly defined, this means that each instance of change-over is done in less time than before. Running larger lot sizes, and claiming "we've reduced weekly changeover time" is antithetical to this approach. Start with a target of 50% reduction. Use a pit crew approach, or any technique these teams believe will give that result. Then in 3-6 months do it again. And again.

By cutting setup time, smaller lots can be run economically, in less time, leading to shorter wait times for products further down the production plan. This approach has been demonstrated over time to be highly successful by many organizations. Major inventory reduction can be achieved from this combination of lead time and lot size reduction with no adverse impact on service. Or, improvements can be leveraged into a combination of inventory reduction and service improvement, moving each in the desired direction in parallel.

A word of caution is in order. Some companies who successfully reduce setup times direct these improvements towards productivity measures rather than inventory reduction. Senior management, guided by Finance, is in the best position to determine if this is the best approach for the business. However, as stated earlier, unless some portion of lead time and lot size improvements are directed towards inventory reduction, inventory levels and resulting line-fill service levels will remain stagnant. Forced inventory reductions in this environment will almost certainly create customer service issues in the areas of product availability, line-fill and on-time delivery.

Conclusion

The strategies described above builds upon processes which are already in place in many companies, but not always with the consistency needed to fully leverage their inherent benefits. Identify the best practices in your own company, or adopt those described here. Formalize an Inventory Model to provide a platform on which to implement globally across your organization. Institutionalize these as your new best practices, then turn the focus towards lead time and lot size reductions. These steps represent a path forward towards a leaner, more efficient inventory replenishment process. Your customers will benefit from improved service, as your business grows and enjoys increased profitability.

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Appendix – Service Factor Table

SF	%	SF	%	SF	%	SF	%
0.00	50.00%	1.00	84.13%	2.00	97.72%	3.00	99.865%
0.05	51.99%	1.05	85.31%	2.05	97.98%	3.05	99.886%
0.10	53.98%	1.10	86.43%	2.10	98.21%	3.10	99.903%
0.15	55.96%	1.15	87.49%	2.15	98.42%	3.15	99.918%
0.20	57.93%	1.20	88.49%	2.20	98.61%	3.20	99.931%
0.25	59.87%	1.25	89.44%	2.25	98.78%	3.25	99.942%
0.30	61.79%	1.30	90.32%	2.30	98.93%	3.30	99.952%
0.35	63.68%	1.35	91.15%	2.35	99.06%	3.35	99.960%
0.40	65.54%	1.40	91.92%	2.40	99.18%	3.40	99.966%
0.45	67.36%	1.45	92.65%	2.45	99.29%	3.45	99.972%
0.50	69.15%	1.50	93.32%	2.50	99.38%	3.50	99.977%
0.55	70.88%	1.55	93.94%	2.55	99.46%	3.55	99.981%
0.60	72.57%	1.60	94.52%	2.60	99.53%	3.60	99.984%
0.65	74.22%	1.65	95.05%	2.65	99.60%	3.65	99.987%
0.70	75.80%	1.70	95.54%	2.70	99.65%	3.70	99.989%
0.75	77.34%	1.75	95.99%	2.75	99.70%	3.75	99.991%
0.80	78.81%	1.80	96.41%	2.80	99.74%	3.80	99.993%
0.85	80.23%	1.85	96.78%	2.85	99.78%	3.85	99.994%
0.90	81.59%	1.90	97.13%	2.90	99.81%	3.90	99.995%
0.95	82.89%	1.95	97.44%	2.95	99.84%	3.95	99.996%