Safety Stock: Finished Goods, Intermediates, or Raw Materials? *That is the Question.*

by Nathan A. Boyd

Introduction

With the advent of lean manufacturing and build-to-order final assembly, many managers no longer believe that safety stock is needed to meet their customer's delivery and service requirements. In some cases they are correct. However, they are wrong if:

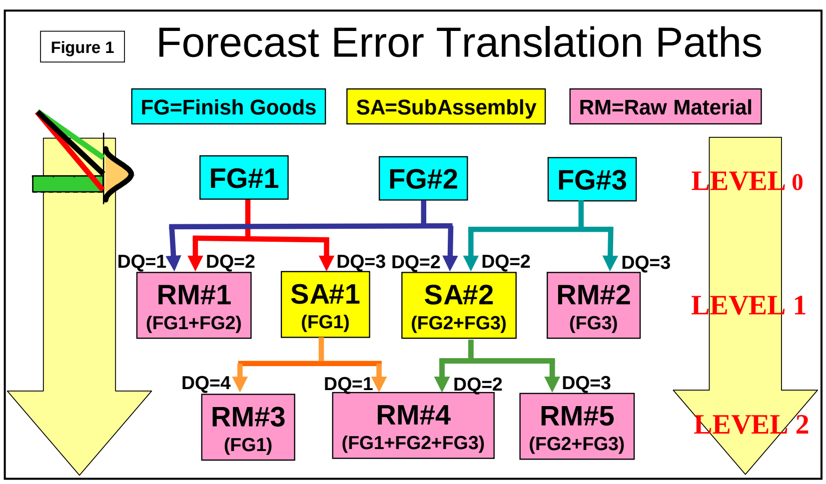
1. the forecast error is greater than zero, and
2. the total supply lead time is greater than the customer lead time, and
3. service from working stock is less than the customer's service target, and
4. customers require stated lead time and service level policies to be honored.

Under these circumstances (i.e., a competitive market) safety stock must be employed to meet a customer's lead time and service requirements! So if safety stock is required, where should the safety stock be placed: finished goods, intermediates, or raw materials?

What Is The Answer?

The best solution is to apply finished goods safety stock techniques selectively to intermediates and raw materials, yielding a *component safety stock* (CSS). Using the service target, forecast error, error distribution, lead time, and replenishment frequency; one can calculate safety stock for any product at any stage of the manufacturing process and all of these factors are known, or can be calculated. The benefits of doing so are: significantly reduced total inventory investment, improved service and manufacturing/packaging flexibility, shorter lead times, and reduced expediting.

So why isn't this CSS technique more widely used? In the past, the forecast error and error distribution at the intermediate and raw material levels were unknown. But now these values can be calculated (see Figure 1). The process translates the forecast error of the finished goods (level 0) products down through the bill-of-material structure to the next level. Then this process is repeated to move the forecast error down each level until it reaches the raw material level. Simply stated, the process is similar to a typical bill-of-material explosion, except that forecast error rather than the forecast itself is exploded through the bill-of-material. See Reference 1 for more information on this technique.



Implementing CSS reduces inventory by keeping safety stock in cheaper sub-assemblies or raw materials. Reinvesting some of the savings in products that need higher service raises customer service. Production schedule interruptions or vendor expedites can be reduced by setting CSS targets that manage the annual projected level of interruptions or expedites. Finally, cumulative lead time can be reduced by implementing a CSS that essentially provides 100 percent service. Since a component with CSS will always be available, there is no need to include this component's lead time in the calculation of cumulative finished good lead time.

Applications

Inventory Reduction

Here, a heavy-duty automotive distributor reduced its inventory in a kitting operation by applying component safety stock against a long lead time component. When producing a product from seven components—six with lead times of 35 days or less and one with a lead time of 130 days (see Figure 2); what is the lead time of the finished product?

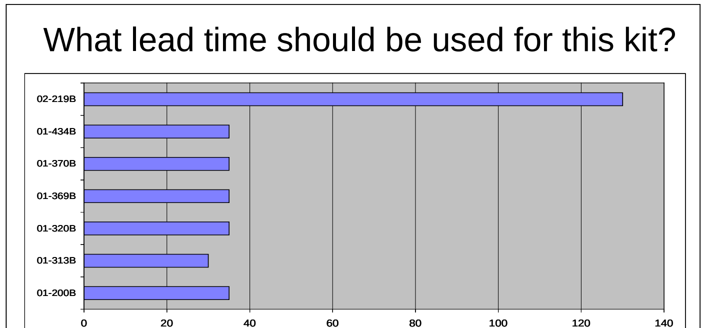


Figure 2

If you answer 130 days, you get excellent service, but very poor inventory turns. If you say 35 days, you get excellent turns, but very poor service. So how does one obtain *both* excellent turns and service? The answer for this company is to use CSS just for the long-lead-time component.

To provide 99.99% service at the finished goods level for this parent and 60 other parents that all require this long-lead-time raw material, requires $168,308 in safety stock—if it is maintained only at level 0 (see Figure 3).

	Finished Goods Safety Stock Dollars	Finished Goods Service	Annual Projected Finished Goods Stockouts	Component Safety Stock Dollars	Component Safety Stock Service	Annual Projected Component Expedites	Total Safety Stock Dollars
No CSS	$168,308	99.99	0.24	$0	0	0	$168,308
CSS on 1 part	$113,277	99.99	0.24	$9,064	99.46	0.28	$122,341
Savings	$55,031			($9,064)			$45,967

Figure 3: Compare No Component Safety Stock with Component Safety Stock on One Part

However, adding $9,064 of CSS for just the long-lead-time material removes its 130 days from the cumulative lead time calculation. As a result, only $113,277 of finished goods safety stock is required to provide the target service. This means that $9,064 of safety stock at the component level eliminates the need for $55,031 at the top level—a net savings of $45,967 or 27%.

Managing Production Interruptions or Vendor Expedites

In another example, a supplier of machined castings regained control of its production schedule by applying component safety stock.

"Our customer places orders for castings at lead time, but then calls to change the quantity two or three times before the order is shipped. We just don't have the capacity to respond to this level of change" was the lament of the foundry manager. He had the capacity to allow some production interruptions; what he needed was a means to control how many production interruptions occurred. The solution was to implement component safety stock, calculated to minimize production schedule interruptions.

Figure 4 Expediting Options Versus Inventory and Service Levels

Expedites			Inventory		Service	
One Expedite Per	Number of Annual Expedites To Achieve 100% Service	% of Annual Lots	Safety Stock Weeks	Safety Stock Days	Annual Line Items Short	% Line Item Fill
Day	252	29.1	0.5	2	151,920	91
Week	52	6	2.1	10	32,014	98.1
Month	12	1.4	3.2	16	4,563	99.7
Quarter	4	0.5	3.8	19	1,301	99.9
Year	1	0.1	4.4	22	274	100
Decade	0.1	0	10.8	28	21	100

Each molding line was evaluated to determine how many annual expedites could be tolerated without compromising the foundry's efficiency. Then we calculated a CSS that results in no more than that number of expedites for each molding line (see Figure 4).

This data allows the foundry management team to evaluate the tradeoff between inventory investment and service (percent line item fill rate), as well as the additional expediting labor and process interruptions required to approach a 100 percent service level.

For example, if the foundry is capable of expediting an item only once per year, 22 days' worth of safety stock is required to achieve 100 percent service (see "Expedites" and "Days" columns in Figure 4). However, if the foundry could tolerate one expedite per week, they would need only 10 days' supply of safety stock—a savings of 12 days' supply or 54.5% over the one-expedite–per-year option. That means each expedite saves them 0.23 days' supply of inventory. At one expedite per day, they need just 2 days' supply in safety stock, a savings of 20 days supply or 90.9% over the one per year option. However, since this means expediting 29% of their replenishment lots, it is not a realistic option. This example underscores the need to understand the cost of expediting.

If the customer does not require a 100 percent service level from the foundry, the foundry should still consider its expediting capability in determining the level of safety stock. For example, looking at the "Service" column in Figure 4, if the customer requires 99.9% service, the foundry could place 19 days' supply into inventory and would not have to incur any expedites. Or the foundry could stock 10 days' supply and incur 48 annual expedites (52 expedites minus 4 expedites) to reach the 99.9% service level.

Effective Lead Time Reduction

An HVAC manufacturer's market share is threatened when a competitor reduced its customer lead time to three weeks. Customer lead time is the amount of time the supplier requires its customers to wait to receive their material. For the HVAC manufacturer to remain competitive, it too must reduce its customer lead time from 8 weeks to 3 weeks. What options does it have?

For one product line with an 8 week customer lead time, $311,668 (see Figure 5) is required to cover the supply-side lead time less an 8 week customer lead time (which in this case is 46 days) and provide a unit service of 98.94% with only 1 projected annual stock out. However, if the finished goods lead time is increased from 46 to 81 days, to account for the 5 week change in customer lead time, $412,957 of finished goods safety stock is now required to cover the 81 days of net finished goods lead time and still provide the same unit service and projected annual stock out levels. This represents an increase of $101,289 or 32% in finished goods safety stock (see Figure 5), but it allows the HVAC manufacturer to ship product in 3 weeks while maintaining its unit service target.

Figure 5 Scenario	FG Lead Time	FG Safety Stock Dollars	FG Service	FG Projected Annual Stock Outs	CSS Dollar	CSS Service	CSS Projected Annual Stock Outs	Total SS Dollars
FG SS @ All with 8wk Cust LT	46	311,668	98.94	1.00	0	0	0	311,668
FG SS @ All with 3wk Cust LT	81	412,957	98.59	1.00	0	0	0	412,957
CSS @ Lead Time GE 21	0	0	100.00	1.00	90,177	99.99	0.24	90,177

Another approach is to implement CSS. Since the finished goods lead time needs to be reduced to 21 days to match the new customer lead time, an initial step would be to implement CSS against all component part numbers with lead times greater than or equal to 21 days. When $90,177 of CSS is applied against these part numbers, component service approaches 100% (see CSS service in Figure 5) and the lead time of these component part numbers can be excluded from the calculation of the finished goods lead time. When the cumulative lead time is recalculated, it is 21 days. When the cumulative lead time is netted against the 3 week customer lead time, the finished goods lead time is zero. With a zero lead time the HVAC manufacturer can wait until it receives an order from its customer to start its manufacturing process, hence no finished goods safety stock is required (see the FG Lead Time and FG Safety Stock Dollars columns in Figure 5). As a result of using CSS, the company was able to reduce customer lead time to 3 weeks, cut total inventory by $221,491 (71%), decrease the effective lead time by 46 days, and provide service approaching 100 percent to their customers and the final assembly process.

Summary

Inventory dollars become far more powerful as they are pushed down to the intermediate or raw material levels. Component safety stock provides yet another opportunity to reduce inventory while raising service and reducing expediting. In addition, cumulative lead times can be shortened radically, giving manufacturing far more flexibility when responding to customer orders. CSS is particularly applicable to manufacturing, assembly, or packaging operations where component lead times vary widely.

References

[1] Mazel, Joseph L., "New Tool for Inventory Management: Component Safety Stock Reduction," *Inventory Reduction Report*, July 2001, IOMA Inc., New York. This article is available online at http://www.estepsoftware.com/images/irr01071.pdf.

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