The light bulb is a good example of certain components that are more likely to fail when being turned on and off than operating continuously. This phenomenon is known as *failure on demand*.

contemporary issues

Analyzing Air Force Flying-Hour Costs
Improving Base Demand Levels Using COLT

Contemporary Issues presents two analytical articles in this edition—"Analyzing Air Force Flying-Hour Costs" and "Improving Base Demand Levels Using COLT."

In the first article Captains Kevin P. Dawson and Jeremy A. Howe, project managers at the Air Force Logistics Management Agency, examine the effect decreasing average sortie duration (ASD) would have on the cost per flying hour (CPFH) for the F-15C/D. Their research also included analyzing break rates and pilot-reported discrepancies in relation to ASD.

The research found little correlation between ASD and F-15C/D break rates, suggesting most aircraft failures are dependent on the number of sorties flown, not the sortie duration.

The analysis shows the impact changing ASD would have on five modes of failure, and demonstrated CPFH would increase as ASD was decreased.

The research suggests decreasing ASD to fly either more sorties totaling the same number of flying hours, or the same number of sorties totaling less flying hours was not cost effective.

The second article outlines COLT (customer-oriented leveling technique) implementation. COLT is a relatively new system that determines Air Force base stock levels for Defense Logistics Agency–managed consumable parts. It overrides the Standard Base Supply System (SBSS) demand level for most consumable and some low-cost equipment items. The goal is to improve supply support by reducing customer back orders and wait time.

When COLT was first implemented, it used fixed adjusted stock levels (ASL) to ensure the COLT level overrides the demand level. Although using fixed ASLs worked, it took more effort to load and did not allow COLT to consider items with minimum ASLs. In early 2006, COLT switched to readiness-based leveling-type levels. This will allow COLT to eventually push levels through the Defense Automated Addressing System and include items with minimum ASLs. COLT, in theory, is superior to the SBSS demand level and has shown, in practice, to provide better results.

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Improving Base Demand Levels Using COLT

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COLT (customer-oriented leveling technique) is coming to a base near you! Starting in 2006, the Air Force began formally implementing COLT levels, causing many people to ask, "What is COLT, and what will it do for me?"

COLT is a relatively new system that determines Air Force base stock levels for Defense Logistics Agency (DLA)–managed consumable parts. It overrides the Standard Base Supply System (SBSS) demand level for most consumable and some low-cost equipment items.[1] The goal is to improve supply support by reducing customer back orders and wait time.

As shown in Figure 1, the Air Force began using COLT in fiscal year (FY) 2001 at the air logistics centers. There were several events over the next 4 years culminating in the Air Force Materiel Management Board approving COLT for Air Force-wide implementation at the end of FY 2005.

Level Setting

The basic concept for consumable items is the same under COLT as it is under the SBSS demand level (DL). Both employ a reorder point (ROP) which is the point to order stock to replenish the demand levels, and an economic order quantity (EOQ), or the minimum amount ordered. The total demand level is the combination of the two (Level = ROP + EOQ). When the number of assets on hand and due-in drops to the ROP, an order is placed for enough assets to bring the number on hand and due-in up to ROP + EOQ (see Figure 2).

The ROP should be large enough to cover demands for an item during the replenishment period, sometimes referred to as the order and ship time (OST), as well as cover variability in demands. A back order occurs when users demand more during the replenishment cycle than is on hand when the order is placed—theoretically that is the computed ROP.

COLT currently uses the same EOQ as the SBSS, but a different ROP. So, how should the Air Force set their ROPs? Why doesn't the Air Force just buy more stock? The fiscal reality is that there are never enough funds to prevent all back orders, and funds spent on one item cannot be spent on another item. Therefore, we need to determine the *right* mix of levels. COLT has proven to be both more efficient and more effective than the SBSS in determining what items to stock and the amount to stock.

The COLT ROP is different from the SBSS ROP for three reasons: its logic minimizes back orders, it considers DLA support levels, and its method considers demand variability. These differences can cause levels to be either higher or lower than the SBSS demand level (see Figure 4 later).

Cost of a Back Order/Back Order Minimization

Back orders will occur, but having a back order for a low-cost item is disconcerting. Why ground an aircraft for the lack of a 5-cent item? In fact, for the same cost of saving a single big-ticket item from back order, we can save hundreds of back orders on cheaper items. This concept of considering both back orders and cost underlies the COLT back order minimization logic.

The SBSS sets a ROP to achieve a given *fixed* level of support. For example, in Figure 3, the SBSS sets the ROP to satisfy all demands during the reorder cycle 84 percent of the time. Stated another way, the SBSS expects back orders 16 percent of the time. COLT, on the other hand, minimizes the amount of back orders for a given level of investment. So by performing this optimization, COLT is finding the levels to provide the best possible performance; SBSS does not optimize anything.

COLT asks the question, "If I have one more dollar to spend on safety levels, which item will provide the largest reduction in back orders for that dollar?" COLT increases levels incrementally in this order. This results in the fewest back orders for any given total cost.

For low-cost, high-demand items, COLT tends to stock more than the SBSS would stock (see Figure 4, left). For high-cost, low-demand items, it tends to stock less than the SBSS (see Figure 4, right). COLT is constrained to spend the same amount as the SBSS, so COLT stocks less for a few high-cost items and is then able to stock more for many low-cost items. COLT increases levels for about 89 percent of the demand, compared to the SBSS demand level, stocks the same for about 2 percent of demand, and stocks less for 8 percent of the demand.

The Replenishment Period Considering DLA Support

SBSS only considers OST for the replenishment period, as shown in Figure 3. Because OST measures the time to obtain the item from the depot—assuming the depot has the item—it ignores the instances when the depot does not have the item on hand and must obtain it from a vendor.

COLT considers expected DLA support levels (DLA issue effectiveness, DLA delay times, and DLA delay variability) as well as OST. The SBSS does not. This makes for a more accurate measure of the replenishment period, and allows COLT to select levels that are more effective.

Suppose we have two national stock numbers (NSN) with exactly the same characteristics (same demand rate, OST, and so forth), except one has good DLA support and the other does not. SBSS would give both NSNs the same level. COLT would perceive the item with poorer support (low DLA stock availability or long lead times) and realize the base requires a higher safety level (higher ROP) to cover the variability in DLA's support. Figure 5 illustrates the difference in the distribution of back orders if only the OST is used to determine levels versus when the replenishment period also considers DLA delay time. SBSS computes the ROP to satisfy 84 percent of the demand. However, because it fails to consider DLA delay time, it only satisfies 60 percent of the demand during the actual replenishment period, which includes expected DLA delay time.

Demand Variability

COLT considers the expected DLA stock availability (and delay time if there is no stock), order and ship time, average order size, and demand rate in determining demand variability. When the variability is high, the frequency of orders and the quantity requested is harder to predict. Therefore, bases must keep more on the shelf to reduce the chance of a back order. Inaccuracy with demand variability can drastically affect the number of back orders. Improperly estimating the demand variability can lead to a level that is too low, producing too many back orders (see Figure 6, right). Figure 6 shows demand is more variable (the distribution is more spread out) than the SBSS computes, so the level assuming 84 percent actually satisfies demands less than 84 percent of the time. Similarly, it can lead to a level that is too high (Figure 6, left), where funds that could better be spent elsewhere are wasted on unnecessary stock levels.

Level Setting Summary

Based on the factors discussed previously, COLT determines an item's ROP. This can result in COLT providing levels higher or lower than the SBSS demand level (see Figure 4). Although COLT does not directly compare itself to SBSS DL when assigning levels, we found at the 15 bases testing COLT, the COLT level is greater than or equal to the SBSS level for 71 percent of items and 91 percent of the demand. That is, COLT is computing more levels where they are needed most.

COLT Leveling

Optimization

COLT minimizes the base-wide customer wait time (CWT) for a given investment. It does so by minimizing the time-weighted expected back orders (EBO) for that investment. The SBSS DL system does not perform any optimization. Its formulas are designed to provide a percentage of back orders on every item, regardless of cost or demand variability. Although there are other common performance measures, such as issue effectiveness (IE) and back order days, also known as delay or conditional wait time, conditional wait time is a more complete measure.

COLT starts every item with a zero level. Even if there are demands in the system, there is no guarantee that an item will

Article Acronyms

ASL - Adjusted Stock Level
COLT - Customer-Oriented Leveling Technique
CWT - Customer Wait Time
DAAS - Defense Automated Addressing System
DL - Demand Level
DLA - Defense Logistics Agency
EBO - Expected Back Order
EOQ - Economic Order Quantity
FY - Fiscal Year
HAZMAT - Hazardous Material
IE - Issue Effectiveness
IEU - Individual Equipment
LI - Line Items
LSC - Logistics Support Center
MIC - Mission Impact Code
MICAP - Mission Capable
NSN - National Stock Number
OST - Order and Ship Time
ROP - Reorder Point
SBSS - Standard Base Supply System

receive a level. Although the criteria for receiving a positive level is different than that for SBSS, the concept that some items do not receive levels is the same. COLT finds the item that produces the largest reduction in back orders per dollar spent, called the sort value. It assigns a level to that item, then repeats this process until some preestablished target is reached. Once the overall target is reached, COLT has found the collection of levels that produce the minimum EBO for a given level of investment.

Selecting a Target

We can assign levels all day long, but we have to stop at some point. COLT uses three possible targets: obligation, sort value, and CWT.

The obligation target considers the amount of money to be spent. COLT is cost neutral, compared to the SBSS. That is, COLT uses the obligation dollars that would be spent for the remainder of the fiscal year using the SBSS levels. As COLT provides levels, it keeps track of the estimated obligations based on the COLT levels. When the COLT obligations reach the SBSS obligations, COLT stops leveling. COLT uses this method during the first run for each base to establish a baseline, thus providing *cost-neutral* COLT levels. Subsequent runs normally use the sort value obtained from the initial run.

A sort value is the reduction in back orders per dollar—the primary goal of COLT. As described earlier, COLT assigns the next level to the item with the highest sort value. As COLT proceeds, the highest sort value becomes smaller and smaller. Using a sort value target causes COLT to stop leveling when the highest sort value is less than the target. Essentially, this means we reached a point of diminishing returns—the reduction in back orders per dollar is so small it is no longer worth spending that dollar.

A CWT target works much like the sort value. As more levels are assigned, the overall CWT decreases. Once it reaches a targeted CWT value, the model stops.

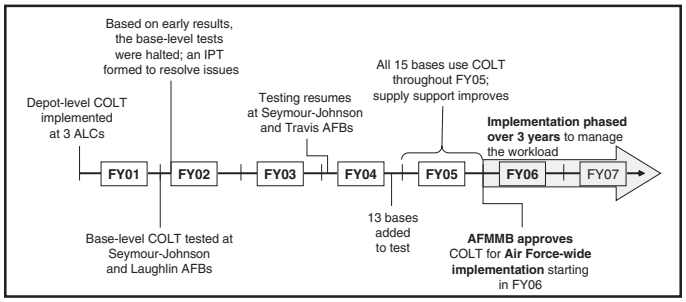


Figure 1. Timeline of COLT Development

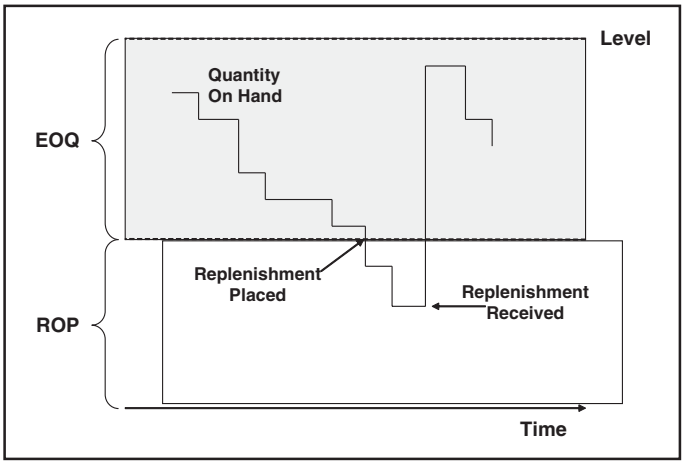


Figure 2. SBSS and COLT Leveling

Additional COLT Business Rules

To more correctly model the real world, COLT includes some additional business rules. These are the *tweaks* that make the system more accurate and useful to the end user.

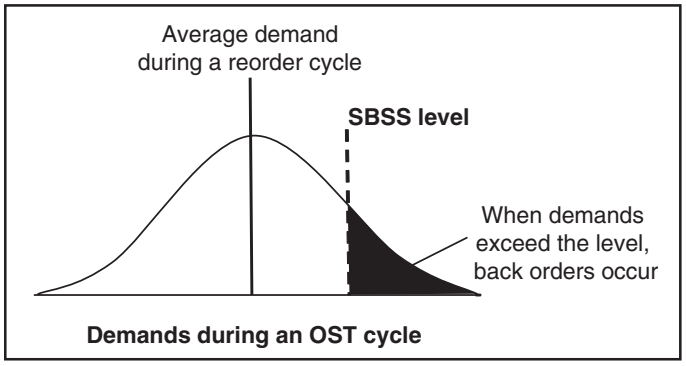


Figure 3. SBSS Leveling

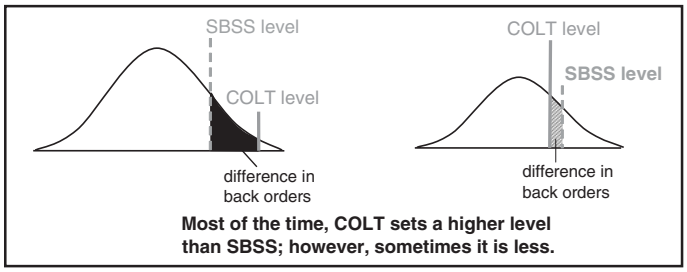


Figure 4. COLT versus SBSS Leveling

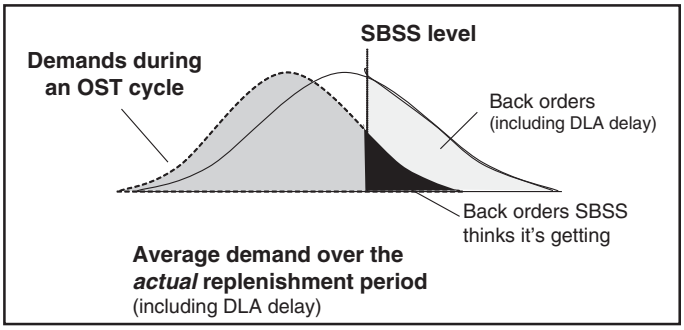


Figure 5. Difference in Back Order Distribution (OST versus Replenishment Period)

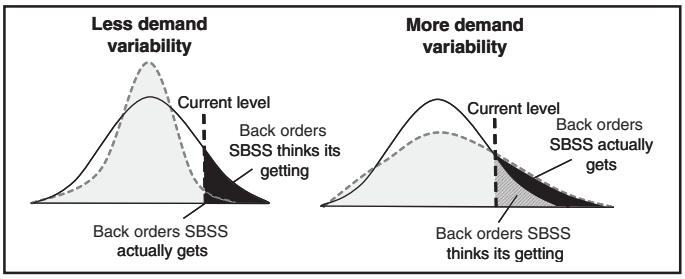
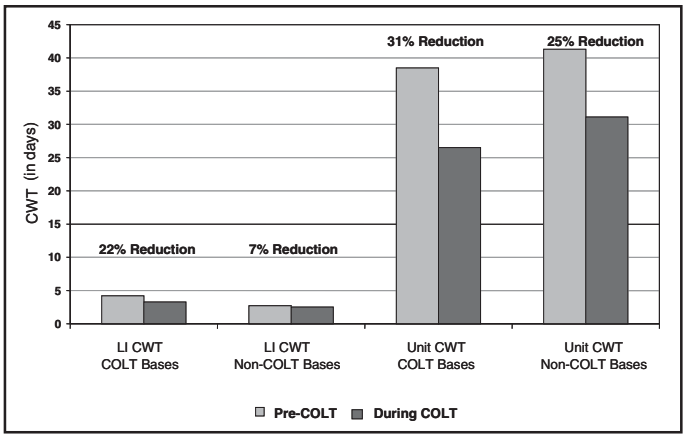
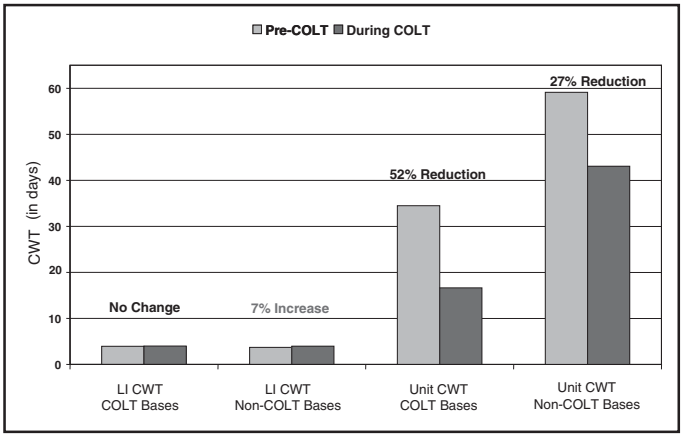


Figure 6. Inaccuracy Due to Demand Variability

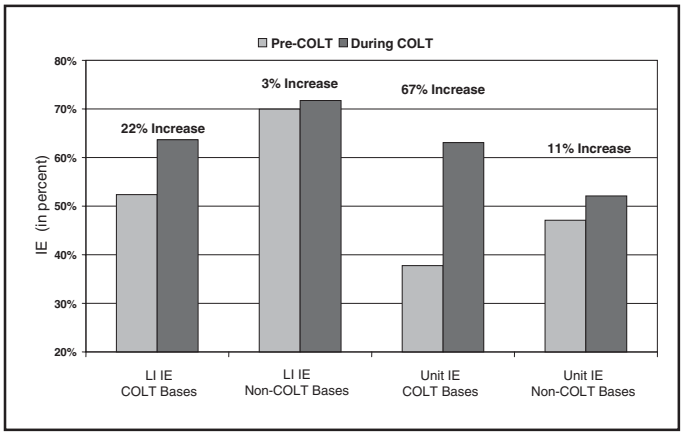


Customer Wait Time for FY04 Bases

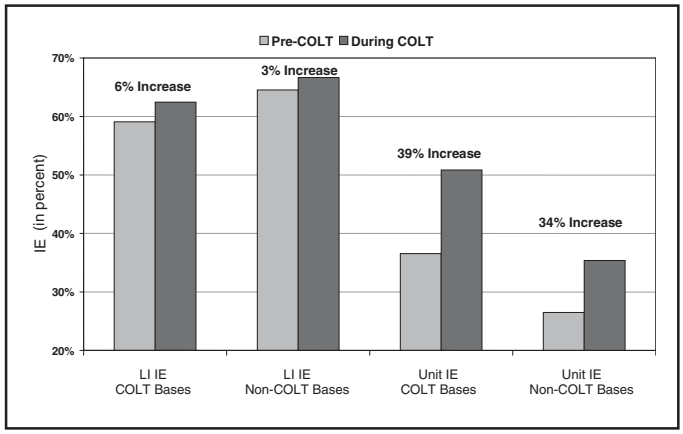


Customer Wait Time for FY05 Bases

Figure 7. Comparison of Customer Wait Time

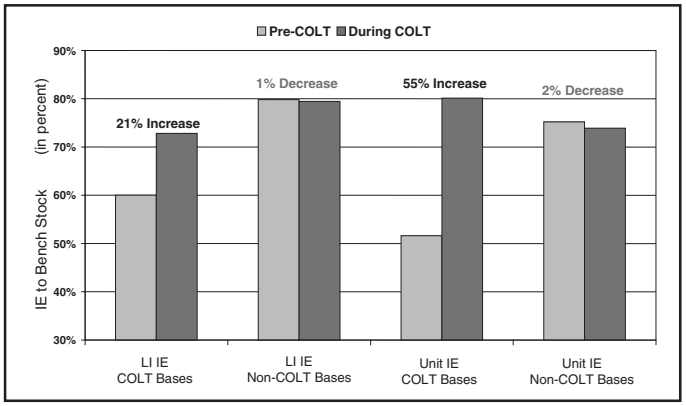


Issue Effectiveness for FY04 Bases

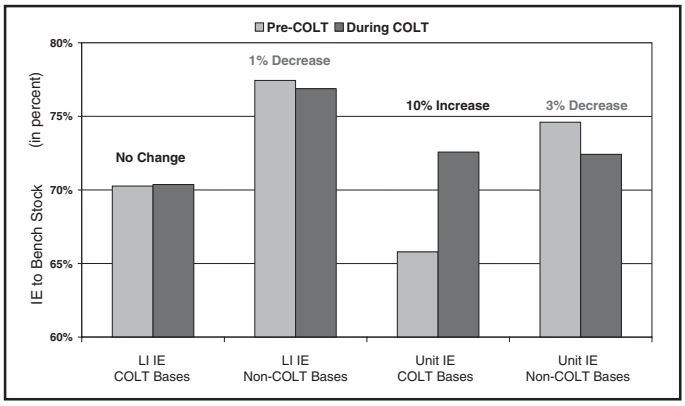


Issue Effectiveness for FY05 Bases

Figure 8. Comparison of Issue Effectiveness



Bench Stock Issue Effectiveness for FY04 Bases



Bench Stock Issue Effectiveness for FY05 Bases

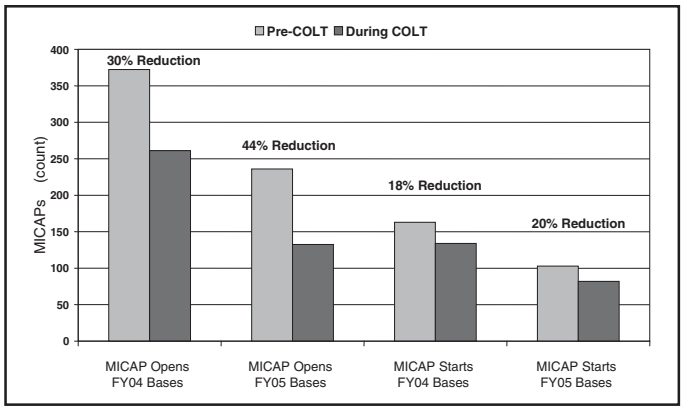
Figure 9. Comparison of Bench Stock Issue Effectiveness

Frequency of COLT Runs

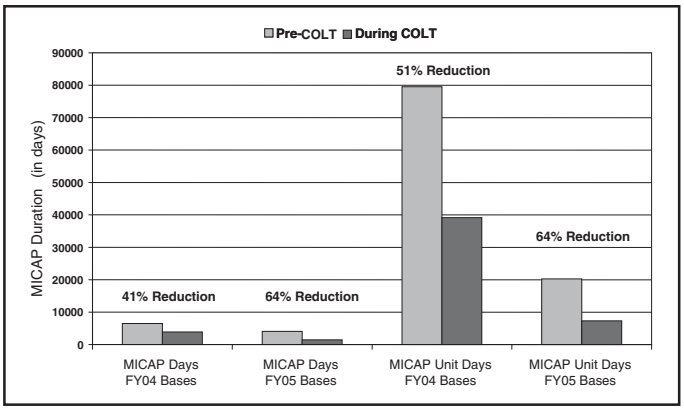
Although COLT could be run as often as desired, quarterly base runs were selected. This is sufficiently frequent to keep up to date with the base's data, but not overreact to every minor blip in demand. To spread the workload and reduce requisition spikes, about one-third of the bases are run monthly, so all are run at some point within the quarter.

Level volatility reduction

COLT is trying to find the best levels, period. Sometimes that means changing the level based on a trivially small decrease in EBOs. Although this is mathematically correct, a change of any size may require workload, requisitions, excess, and so forth. So a rule was established: the level must change by at least the square-root of the old level before COLT will provide an updated



MICAP Open and Starts for COLT Bases



MICAP Days for COLT Bases

Figure 10. MICAP Results

value. For example, if the old level is 9, COLT will only change the level if COLT computes a level either more than 12 or less than 6. The SBSS uses the same rule.

Other Inventory

Base supply (retail levels) is not the only stock available on base to satisfy user demands. Bench stock is regularly available for particular users and available to all users for back orders and for all mission capable (MICAP) parts. COLT considers some portion of the bench stock as available to reduce expected back orders. In essence, COLT *retail* levels do not duplicate the bench stock levels.

COLT Caps

The COLT ROP and EOQ are both capped at 1 year.[2] These caps forestall having too much stock. Stockage priority code 5 (SPC 5) items are capped at the existing on-hand balance. This allows COLT to maintain a level on these items, and prevents back orders, but keeps the system from buying more unless there are subsequent demands. If there are subsequent demands, the SPC code will decrease and full leveling can once again take place. The final cap calls for the total COLT level to be capped at $4,000, if DL = 0, or $5,000 more than the SBSS DL, if DL > 0. COLT will sometimes provide significantly more levels than the current DL. Although mathematically it is the proper thing to do, these caps can produce problems with shelf space, funds, and requisition rejections.

COLT Restrictions

There are particular issues with individual equipment (IEU) items (FSG 84 and FSC 4240) and hazardous material (HAZMAT) items (issue exception codes 8, 9, or M). Despite MAJCOM policies that severely restrict the stocking of these items, there are still recurring demands and SBSS demand levels for them. Reacting to demands for these restricted items, COLT will develop levels for items that some bases and major commands do not want. COLT only provides levels on IEU and HAZMAT items if the SBSS DL is greater than zero. That way, if the items did not have a level before COLT, they will not have a level with COLT.

Mission Impact Code 1

Mission impact code (MIC) 1 items are very important because they have previously caused a weapon system grounding incident (MICAP). Therefore, COLT guarantees a positive level for all MIC 1 items.

Does COLT Work?

COLT includes more information than the current system and has an optimization scheme to minimize customer wait time. Therefore, in theory, it should be better than SBSS. But does it provide better results in practice?

Figures 7 to 9 compare supply performance for FY04 and FY05 COLT to non-COLT bases, and Figure 10 provides MICAP data for the COLT bases. FY04 COLT bases were Travis and Seymour-Johnson. The non-COLT bases (chosen for like missions or aircraft) were Dover and Lakenheath. The FY05 bases included the remaining 13 COLT bases and 7 non-COLT bases. Pre-COLT data was taken from December 2002 to November 2003 or 2004 as appropriate, and COLT data was taken from December 2003 or 2004 until October 2005.

Figure 7 compares customer wait time for line items (LI) and units.[3] Although it is interesting that both COLT and non-COLT bases improved, the bases running COLT longer (FY04 bases) show a distinctly larger improvement than the non-COLT bases (22 percent versus 7 percent LI CWT reduction, and 31 percent versus 25 percent unit CWT reduction). The newer COLT bases also showed improvement over the non-COLT bases (no change versus 7 percent LI CWT increase, and 52 percent versus 27 percent unit CWT reduction).

Figure 8 compares issue effectiveness (IE) for line items (LI) and units. Although CWT is a more complete measure, IE is commonly used. Once again, both COLT and non-COLT bases improved; but the COLT bases improved by significantly more. This is especially seen in the unit measures.

Figure 9 compares bench stock IE for LI and units. Earlier, we stated that COLT considers part of bench stock as available to reduce back orders. That raises the concern that COLT might provide poorer support for bench stock items than prior to COLT. However, we see that the COLT IE to bench stock improved significantly for both LI and unit measures for FY04 bases and for unit measures for FY05 bases; non-COLT bases decreased slightly for all categories.

Figure 10 shows MICAP results for the FY04 and FY05 bases. The average number of MICAPs open reduced 30 percent for FY04 bases and 44 percent for the FY05 bases, while the average number of new starts reduced about the same (18 and 20 percent). The right-hand chart shows the MICAP days reduced even more (41-64 percent). These charts demonstrate that even though COLT is designed to minimize customer wait time, it also does a good job at reducing MICAP incidents and duration.