Dollar Cost Banding

A New Algorithm for Computing Inventory Levels for Army Supply Support Activities

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Summary

When Army equipment fails, the speed with which maintenance technicians can restore it to mission-ready condition depends critically on the availability of needed spare parts. When parts are available at the maintainer's supporting supply support activity (SSA), maintainers receive their orders quickly; in contrast, parts that are unavailable at the supporting SSA might not arrive for a week or more. But despite the advantages of having parts available from the maintainer's supporting SSA, Army inventory managers determining what to stock in their deployable SSAs cannot simply base their decisions on the desire to achieve a high level of customer service by stocking as many items as possible. Instead, they must balance performance goals against the realities of limited funding and storage capacity constraints (the latter derived from the need for a highly mobile SSA). To manage this tradeoff, the Army uses an algorithm that tracks customer demands and computes which items to stock and how many of each.

However, the Army was not satisfied with the existing algorithm used to compute inventory levels for SSAs. Metrics developed under Velocity Management (VM) suggested that performance could be improved, and this was supported by evidence that Army maintainers too often found that critical parts were not on the Authorized Stockage List (ASL) of the supporting SSA, leading to long customer wait times, extended repair times, and reduced equipment availability. Part unavailability could also increase maintenance workload if maintenance technicians chose to work around a problem by remov-

ing needed parts from other pieces of inoperable equipment. When no workaround was possible, repairs could not be completed until all needed parts had arrived, thus reducing equipment readiness.

The Army's Deputy Chief of Staff, G-4 (Logistics) asked RAND Arroyo Center to develop a new algorithm for calculating inventory levels in SSAs. Arroyo logisticians applied the VM three-step methodology of Define, Measure, and Improve (D-M-I).[1] As part of this process, Arroyo developed a new stockage determination algorithm known as dollar cost banding (DCB). The idea behind the algorithm is simple: make it easier for small, inexpensive items with high-priority requisitions to be added to the ASL in sufficient depth so they are available when customer requests arrive—thus improving performance while holding down ASL storage requirements and inventory costs.

Defining the Process

To set the stage for improvement, RAND Arroyo Center researchers and other members of the VM Stockage Determination Process Improvement Team (SDPIT) walked the supply chain and inventory determination processes at several Army installations. A customer's order can be filled from one of several inventory points: (1) inventory held in the maintenance technician's shop and maintained by the parts clerk (unit-level inventory), (2) the customer's supporting SSA, (3) component repair, (4) referral from another SSA that supports other customers, (5) a regional distribution center, (6) direct vendor delivery (DVD), and (7) a backorder (when the part is not initially available from any of the SSAs or regional distribution centers, but is shipped when a replenishment from a repair source or vendor arrives). If the customer's request cannot be filled from unit-level inventory or the supporting SSA, the requirement must be passed to

[1] John Dumond et al., *Velocity Management: The Business Paradigm That Has Transformed U.S. Army Logistics.* Santa Monica, CA: RAND Corporation, MR-1108-A, 2001.

one of the other supply sources, which can be located outside the area of operations (AOR), leading to delays.

Measuring the Process

To gain a more detailed understanding of supply chain performance, the SD PIT developed a suite of metrics that address performance and resource consumption. Performance metrics, explained in the left-hand column of Table S.1, include customer service and process diagnostic metrics. Of these metrics, customer wait time (CWT) is particularly important for inventory managers because it focuses them on their customers' perspective and, implicitly, on equipment readiness. Resource metrics, also shown in the table, include several metrics associated with inventory investment, workload, and mobility.

Improving Performance

The DCB algorithm was designed specifically to address several problems associated with the Army's traditional way of calculating inventory.

More Flexible Criteria for Determining Inventory Breadth

First, DCB has made it possible to expand the breadth of deployable inventories. Traditionally, Army SSAs used a "one-size-fits-all" approach for determining whether or not to stock a particular item. While there are exceptions for low-density systems, an item not currently stocked would need nine requests over the prior review period (typically a year) to be added, while an item already stocked would need three demands to be retained.

The DCB algorithm provides greater flexibility by adjusting the criteria for determining whether an item should be added or retained according to the item's criticality, mobility impact, end item density, and dollar value. Under DCB, a small, inexpensive, but mission-

Table S.1
Performance and Resource Metrics for Inventory Management

Performance Metrics	Resource Metrics
• **Equipment readiness:** the percentage of weapon systems that are operational. • **Customer wait time (CWT):** the time from when an order is placed by the unit parts clerk until the item is issued. • **SSA fill rate:** the percentage of requests that are immediately filled from the supporting SSA—whether or not the item is on the ASL. • **Accommodation rate:** the percentage of requests for items that are on the ASL (have an RO > 0), whether or not the requested item is immediately available. • **Satisfaction rate:** the percentage of accommodated requests for which there is stock available at the time of the request.	INVENTORY INVESTMENT • **Dollar value of the requisition objective (RO):** the value of the maximum quantity of an item authorized to be on order or on hand at any time. • **Dollar value of the reorder point (ROP):** value of the point at which replenishment is initiated. • **Dollar value of inventory greater than the RO:** value of redistributable inventory (caused by unanticipated customer returns or when the RO is reduced when inventory levels are recomputed). TRANSITION COSTS/SAVINGS • **Transition costs:** the up-front investment needed to increase inventory levels of existing lines or to add new lines. • **Transition savings:** credits generated from turn-ins or draw down against future demands, resulting from a reduction in or deletion of inventory levels. WORKLOAD • **Workload:** the number of transactions by type required to fill customer orders and maintain inventory at proper levels. MOBILITY • **Number of lines:** number of unique items in the ASL with an RO > O. • **Number of cubic feet represented by the RO:** sum of the cubic feet of each item at the RO quantity. • **Number of trailers or containers:** Number of platforms used to hold inventory.

critical item might be added to inventory with only two demands per year and retained with just one per year. The algorithm also incorporates automated checks for identifying nonessential, bulky items that should not be stocked in deployable SSAs.

DCB Improves the Computation of Stock Depth

DCB also more effectively determines how many of a given item should be stocked. To do so, the new approach abandons the Army's traditional "days-of-supply" (DOS) algorithm for determining the quantity of each authorized item to stock. The main problem with the DOS method for calculating depth of inventory was the underlying assumption that demands are uniformly distributed throughout the year. Such a uniform distribution is almost never the case, due to the highly variable operational tempo (OPTEMPO) associated with Army training and deployments and the random patterns of equipment failure. The DOS approach frequently resulted in stock-outs, particularly during periods of high OPTEMPO; in other cases, capital might be tied up in a large order quantity for an expensive item. Additionally, increased workload might result because of frequent ordering of low-cost items.

The DCB approach is better able than the DOS approach to account for variations in demand and prevent stock-outs. It does this by first setting an order quantity that trades off inventory holding and ordering costs. Once the order quantity is set, an iterative simulation routine is used to arrive at the reorder point that achieves the desired CWT. Goals for CWT can be set based on unit price and criticality of the item.

In each simulation, the actual demands from the two-year review period are tracked against the daily inventory position. The simulation is initiated midway between the requisition objective (RO) and the reorder point (ROP); then each time the inventory position equals or falls below the ROP due to a demand, a replenishment order is initiated, and stocks are replenished after the replenishment lead time is computed from the data. After all the demands have been processed, the average CWT associated with the current value of the ROP is computed. A second routine adjusts the ROP, and the simulation is repeated until the CWT goal is achieved. To reach the CWT goal, the algorithm establishes a tradeoff between safety level, order quantity, and backorder time if the item is not available from the ASL (which affects CWT).

Automated Checks to Reduce Workload

The new DCB methodology also saves time by automating many of the decision rules typically used by local supply managers. The algorithm automatically identifies certain nomenclatures and federal supply classes (FSCs) that should not be stocked and automates the process for identifying low-density and other items (e.g., aviation and missile) that would normally not qualify for inventory under the "9 demands to add and 3 demands to retain" criterion (hereafter, 9/3) but for which policy exceptions to add with three demands and retain with just one demand have existed. This automation reduces the time and workload necessary to conduct ASL reviews while improving their effectiveness.

Improvements Under Dollar Cost Banding

DCB has been used successfully to conduct ASL reviews in divisional SSAs, nondivisional tactical SSAs, and nontactical SSAs. DCB was first used to conduct ASL reviews in the 101st Air Assault Division and led to a significant increase in the breadth of inventory, despite the tight mobility constraints under which the SSAs operate. For example, after the first ASL review with DCB in 1998, the number of unique parts stocked in the forward support battalions (FSBs) doubled or tripled, while those in the main support battalion (MSB) more than doubled. Much of the increase resulted from adding items that cost less than $100 and had experienced high-priority demands.

The use of DCB in the 3rd Infantry Division led to an expansion in the breadth and depth of certain items while reducing the overall inventory investment and ASL mobility requirements. The initial ASL review under DCB resulted in a 33 percent increase in the number of stocked items (i.e., unique items stocked, referred to as "lines"), with the largest increases occurring in the FSBs and the aviation support battalion (ASB). The RO value of the ASLs was reduced from \$58.2 million to \$53.5 million. The total cube of the parts in the ASL was reduced and the number of trailers in the MSB was reduced, thus improving mobility. A second ASL review using DCB, conducted in September 2000, resulted in further improvements. Fill, satisfaction, and accommodation rates all rose. As a result of improved ASL performance, CWT was reduced.

The use of DCB in ASL reviews has also led to improved inventory performance at the Army's Armor Center and School at Fort Knox. As home to the Army's tank training, Fort Knox supports a high OPTEMPO similar to that of deployed units. The DCB recommendations at Fort Knox resulted in a net decrease in inventory value of \$1.3 million, while the number of unique parts stocked in the warehouse almost doubled to 4,572. Unlike the deployable units such as those found in the 101st Air Assault Division and 3rd Infantry Division, Fort Knox operates its SSA out of a nondeployable fixed warehouse with considerably more storage space. With the application of DCB, the SSA fill rate at Fort Knox improved from 41 percent to 63 percent, mostly due to higher accommodation rates. As a result, the median CWT for high-priority demands collapsed from 2–3 days to the same or next day.

Improved local fill rates and reduced CWT led to an increase in the operational availability of the M1A1 tank fleet at Fort Knox. One of the reasons for this improvement was an increase in the percentage of repair jobs for which all the required parts were available from the ASL. When all parts required for a job are stocked in the ASL, repairs can be completed more quickly because no parts need to be requisitioned from off post. Overall, the average repair time for M1A1 tanks at Fort Knox decreased from 12.4 days to 8.8 days, a 29 percent decrease.

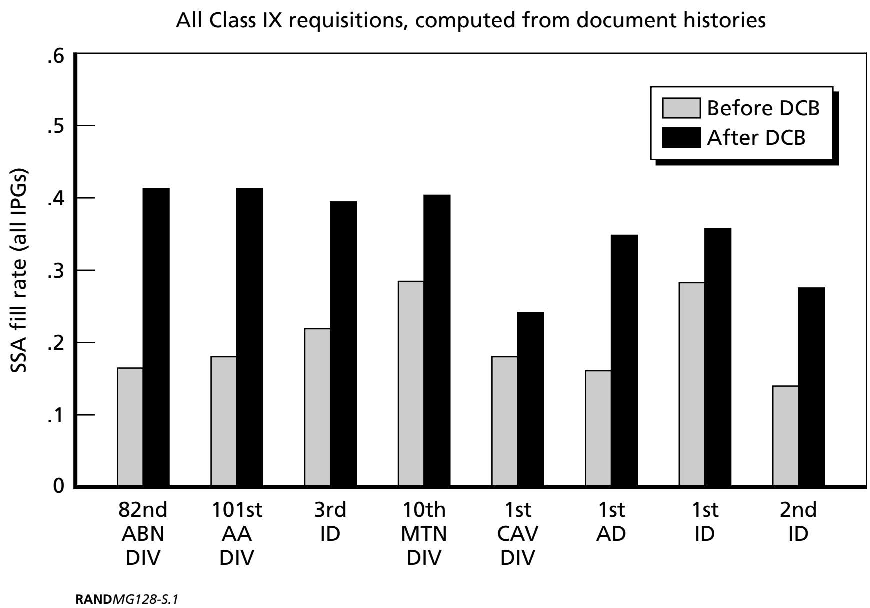
Inventory Performance Improvements for SSAs Across the Army

The DCB logic has been incorporated into the Integrated Logistics Analysis Program (ILAP). At the same time, RAND Arroyo Center has continued its research to improve the DCB algorithm. The use of DCB has also been made part of Army policy. In 2000, DCB was made an approved policy option for units conducting ASL reviews; while in 2002, the use of DCB was made mandatory for ASL reviews.

Figure S.1 shows the ASL fill rates for eight active Army divisions before and after the use of DCB for an ASL review.

The best performance is in the XVIII Corps divisions (the four leftmost divisions in the figure), which were the first to use DCB in ASL reviews. Units that have not shown as strong an improvement

Figure S.1
Fill Rates for Divisions Before and After ASL Reviews with DCB



have not been able to fully leverage the recommendations from DCB due to budget or other constraints or have conducted fewer ASL reviews with DCB.

Continuous Improvement

The final step of any process improvement, after propagating it across the organization, is always one of continuous improvement. The experience to date has suggested two major areas in which DCB can be improved:

- **First, the recommendations of DCB need to be better linked to weapon system readiness.** To better tailor the ASL to support readiness, RAND Arroyo Center is linking the DCB logic with data on requisitions for parts needed to complete maintenance jobs to return inoperable equipment to mission-ready status. Such data are available through the Equipment Downtime Analyzer (EDA),[2] which provides a systemwide view of how much each process and organization contributes to equipment downtime. Arroyo is seeking to improve upon the existing logic of how to identify a "critical" item, then better focus inventory investment and mobility resources on readiness drivers.
- **Second, inventory decisions for Army Materiel Command (AMC)-managed items need to be coordinated across echelons under SSF.** Under Single Stock Fund Milestone III (SSF MS III), the inventory in tactical SSAs converted to Army Working Capital Fund (AWCF) ownership. This shift will potentially reduce some of the financial barriers to improving ASLs. Arroyo is considering additions to the DCB logic to address resource allocation under the new funding environment.

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[2] Eric Peltz et al., *Diagnosing the Army's Equipment Readiness: The Equipment Downtime Analyzer*, Santa Monica, CA: RAND Corporation, MR-1481-A, 2002.