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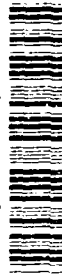


Improving System Safety Levels at the Defense Logistics Agency

DLA Project 20290
Briefing Book DL206R1

Christopher H. Hanks
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INTRODUCTION

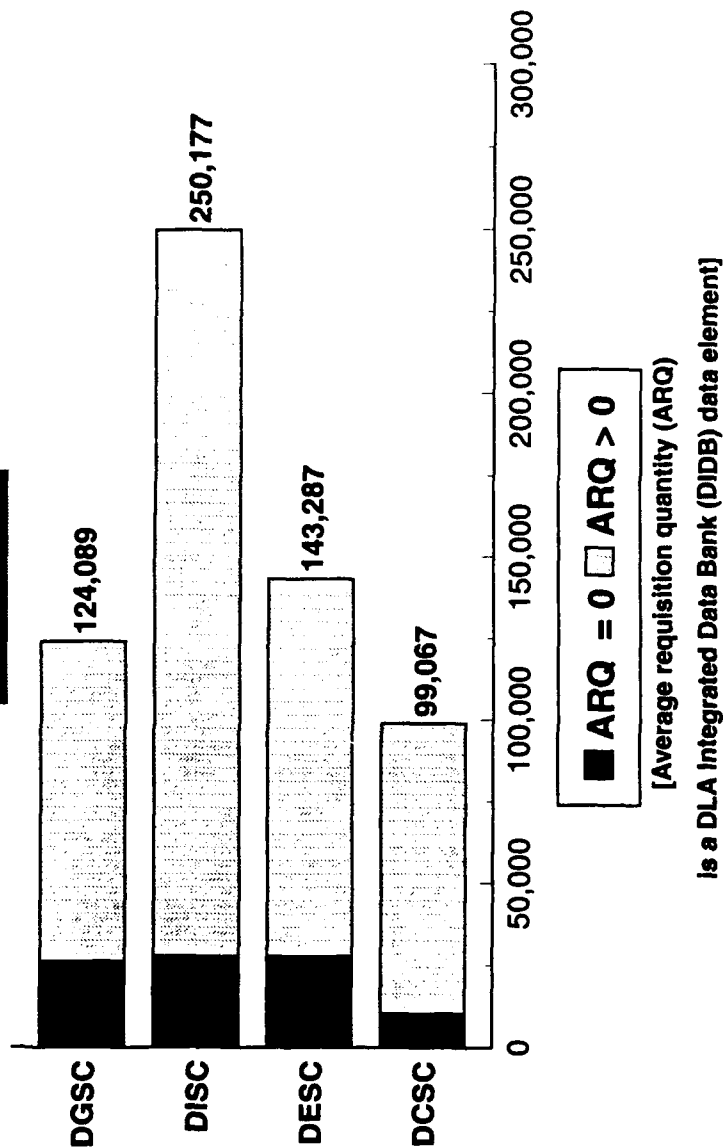
In a deterministic inventory system charged with providing spares and repair parts, the right number of spares to carry would be exactly equal to the number of spares the customer would demand during the time it takes to obtain replacements from the relevant resupply process (i.e., procurement, repair, or the order-and-shipping process). Unfortunately, customer demands and resupply process times are not precisely predictable, and thus we need "*safety levels*." The safety level for an item is the extra stock carried above the average number of demands expected over a resupply time for the item. (We occasionally use the term *pipeline* to refer to the average number of demands over a resupply time — so safety levels represent the extra stock carried above the pipeline. *Negative* safety levels occur when the number of spares carried is less than the pipeline.) Safety levels protect us against the statistical fluctuations that occur in most demand-and-resupply processes.

System safety levels are those computed for systems (groups of items). Under the system approach, each item is assigned a safety level, but the actual value varies from item to item depending on the price of the item and its demand characteristics

in relation to other items in the group. By making tradeoffs across items — a greater safety level for some items and less for others — system calculations are designed to optimize *system* supply performance rather than individual *item* performance. If the items in the group all have roughly the same importance (i.e., a backorder for any item in the group has roughly the same effect on customer operations as a backorder for any other item in the group), the system approach makes sense.

This report describes ways for the Defense Logistics Agency (DLA) to reduce system safety level requirements at its four hardware supply centers while maintaining or improving supply support to customers. The report is presented as a briefing: each chart is accompanied by explanatory text. By adopting the approaches suggested in this report, DLA can save money on wholesale stock replenishment at its four hardware supply centers without compromising supply performance.

NUMBER OF DEMAND-BASED ITEMS AT DLA'S FOUR HARDWARE CENTERS (December 1992 DIB/SAMMS data)



[Defense General Supply Center (DGSC); Defense Industrial Supply Center (DISC); Defense Electronics Supply Center (DESC); Defense Construction Supply Center (DCSC); Standard Automated Materiel Management System (SAMMS)]

NUMBER OF DEMAND-BASED ITEMS AT DLA'S FOUR HARDWARE CENTERS

This chart shows the number of "demand-based" items included in the analysis.¹ Demand-based items are those with enough recent demand to support the inventory calculations needed to compute system safety levels.

In its role as a wholesale supply manager, DLA evaluates its supply performance in terms of requisitions. A key measure DLA managers use, for example, is the requisition (i.e., line) supply availability rate: What percentage of incoming requisitions over the past month or quarter did we fill? Another important measure is the number of outstanding requisition backorders in place at the end of the most recent reporting period.

If each requisition were for one unit of a given item, unit and line supply availability would be the same, and unit and line backorders would also be the same. Requisitions for consumables, however, tend to be for more than one unit of the item involved. Replenishment requisitions from Service-operated retail supply sites are almost always for more than one unit, for example. In such cases, if DLA is out of stock and the requisition (say for 100 units) is backordered, DLA would have established a single line backorder, but that single line

backorder would correspond to 100 outstanding unit backorders.

In this report, we evaluate supply performance in terms of both lines and units. To do that, we translated back and forth between line-oriented and unit-oriented supply measures, using, as DLA does, the average number of units per requisition (i.e., the ARQ) for each item. Because the ARQ is used as a divisor when converting unit measures into line measures, it cannot be zero. This chart shows the number of items at each hardware center that had a nonzero ARQ value in DLA records as of the end of December 1992. (The items with ARQ values equal to zero tend to be items that have not experienced any demand over the past year, causing the ARQ value to revert to zero in the file.)

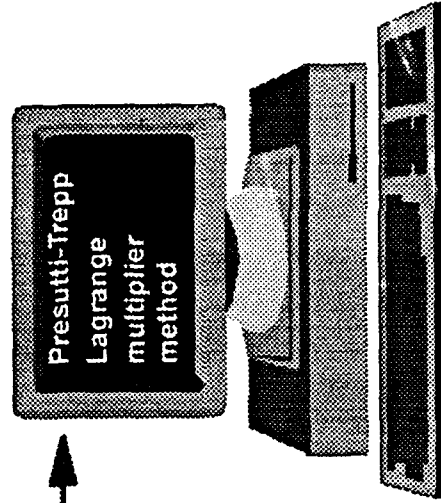
The DIB is maintained at DLA's Operations Research Office (DORO) in Richmond, Va. We used DIB data current as of the end of December 1992 for our analysis. The DIB contains item data extracted quarterly from DLA's Standard Automated Materiel Management System (SAMMS).

¹ In the chart, SAMMS = Standard Automated Materiel Management System; DGSC = Defense General Supply Center; DISC = Defense Industrial Supply Center; DESC = Defense Electronics Supply Center; and DCSC = Defense Construction Supply Center.

SYSTEM SAFETY LEVELS

- A "system" of items is simply a group of more than one item.
- "System" safety level calculations are calculations done for a group of items rather than one item at a time.
- The goal is "system" supply performance - not individual item performance.
- DLA policy is to compute **system** safety levels.

DLA **practice**, however, is producing safety levels that cost **more** than necessary while delivering **less** in supply performance.



SYSTEM SAFETY LEVELS

Supply policy in DoD calls for the use of the system approach when computing safety levels. As discussed earlier, the system approach gives managers a way to make trade-offs — less safety level for some items, greater safety level for others — with the idea of maximizing supply performance for the system rather than for each item individually. The standard DoD method for calculating system safety levels for consumable secondary items is based on a *Naval Research Logistics Quarterly* article in July 1970 by Victor Presutti and Richard Trepp of the Air Force Logistics Command.²

In their article, Presutti and Trepp show how to minimize ordering and holding costs for a system of items subject to a constraint on the average number of outstanding unit backorders the system is willing to tolerate over time. The fewer

the number of outstanding backorders the system can accept, the greater the safety level requirements will be, and vice versa. The Presutti-Trepp algorithm uses the Lagrange multiplier method of calculus to solve this constrained optimization problem.

The observations motivating this study are that while DoD and DLA policy is (and has been) to use the system approach (and the Presutti-Trepp algorithm is, in fact, programmed in SAMMS), actual DLA practice appears to be producing safety levels that cost more than they need to while delivering less in expected supply performance than might otherwise be achieved. The next chart provides an example.

² Presutti, Victor J., Jr., and Richard C. Trepp, "More Ado About Economic Order Quantity," *Naval Research Logistics Quarterly*, Vol. 17, No. 2, June 1970, pp. 243-251.

FOR EXAMPLE,

DESC safety levels in		But LMI-computed safety	
December 1992 yield		levels for DESC yield	
59,911	line EBOs	53,784	
486,764	unit EBOs	291,325	
0.964	line SA	0.966	
0.968	unit SA	0.983	
\$128.1 million	cost	\$120.0 million	

HOW CAN THAT BE POSSIBLE?

Note: expected backorder (EBO); supply availability (SA).

FOR EXAMPLE

Based on the item safety levels the DESC had on its books as of the end of December 1992, standard inventory calculations show it should expect to have 59,911 line backorders in place on average over time. (We use the term "line EBOs" when talking about the average number of outstanding line backorders for a system of items.) After multiplying by the ARQ for each item, the 59,911 line EBOs translate to 486,764 unit EBOs for the roughly 115,000 DESC items we examined. The expected line and unit supply availability rates are 96.4 percent and 96.8 percent, respectively. The total value of the DESC safety level requirement is \$128.1 million.

Against those DESC values, we were able to find a mix of safety levels (using a unit-based approach) that costs \$8.1 million less than the DESC requirement and at the same time improves DESC's expected supply performance. That improvement occurs in all categories — no matter whether we look at line or unit measures, are interested in supply availability rates, or consider EBOs.

We deliberately chose DESC as our first example because we wanted to show that it is possible for the unit approach to improve line measures as well as unit measures. That is not the case at every center, but it is the case at DESC. The central point, though, is not that DLA should move to unit-based methods (it should, but for other reasons that we will discuss later). The point here is that, at least at one hardware center, it appears

possible to reduce overall safety level requirements while improving expected supply performance.

We have included supply availability rate results in this chart because they are widely used performance indicators at DLA. One of the disadvantages of supply availability rates as performance indicators is that they tend not to change very much in response to changes in stockage levels (the changes shown here are an example). With high service levels (i.e., supply availability rates over 90 percent), even large relative changes in the nonavailability rate look small when expressed in terms of the corresponding availability rate. (The change from 3.2 percent to 1.7 percent in the unit nonavailability rate at DESC represents almost a 50 percent change in the nonavailability rate, but only a 1.5 percent change in the availability rate from 96.8 percent to 98.3 percent.) For that reason and others (for example, supply availability rates are much more difficult to relate to weapon system readiness than outstanding backorders), supply availability rates are much less valuable or useful measures of supply performance than outstanding backorders.

The obvious question raised by this chart is: How did LMI manage to do better at DESC for a lower investment in safety level? The next chart addresses that question.

HOW DID LMI DO BETTER THAN DLA AT DESC?
BY FOLLOWING DoD/DLA **POLICY** FOR SYSTEM
SAFETY LEVEL CALCULATIONS (almost)

★ MINIMIZE INVENTORY COSTS

★ SUBJECT TO A BACKORDER CONSTRAINT
(either LINE backorders or UNIT backorders)

PLUS

★ NEVER LET SAFETY LEVELS BE SMALLER THAN
ZERO NOR LARGER THAN LEAD-TIME DEMAND

- DLA SAMMS
- DoDI 4140.39
- DoD 4140.1-R

Note: DoDI = DoD Instruction.

HOW DID LMI DO BETTER THAN DLA AT DESC?

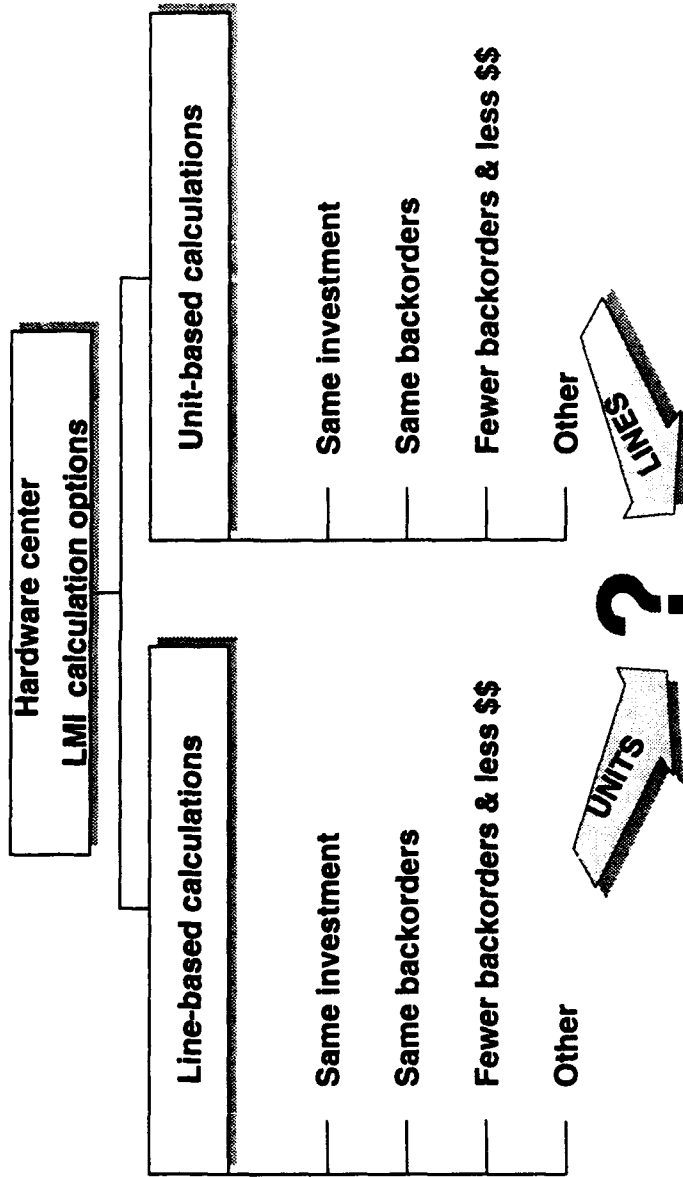
The LMI results for DESC were obtained, surprisingly enough, by simply following existing DLA (and DoD) policy for computing system safety levels. That policy, as summarized in this chart, is to minimize inventory costs subject to an acceptable level of outstanding backorders and to do so while making sure that safety levels are at least zero (i.e., never stock less than the pipeline) but no greater than lead-time demand (i.e., never let safety levels get too large). We implemented that policy in our calculations in the same way that DLA implements the policy in SAMMS: We performed a Presutti-Trepp system calculation to obtain an initial set of safety levels, and then we constrained those safety levels on the bottom (negative safety levels are reset to zero) and the top (safety levels greater than lead-time demand are reset to equal lead-time demand). The one new wrinkle in our calculation for DESC (and the reason for the qualifying "almost" in the title) is that all the arithmetic was done in terms of unit backorders rather than line backorders.

In particular, for the DESC results we used a unit backorder target [the "beta" system backorder constraint in the Presutti-Trepp and SAMMS formulas] of 486,764 unit EBOs.

Traditionally, DLA uses line rather than unit backorder targets because DoD's wholesale supply policy for the past 23 years has been to "minimize time-weighted *requisitions* short" (italics ours). (Conversations with "old hands" who were

around at the time the DoD policy was formulated indicate that while most analysts recognized that the unit-based approach was preferable, gaining acceptance from supply managers for the *system* method was itself a struggle and, thus, the decision was made to sidestep the units-versus-requisitions issue.) Standard inventory theory, however (including the Presutti-Trepp method), is done in terms of units, not lines. To use line backorder constraints, SAMMS has to divide Presutti-Trepp unit backorder quantities for each item by the item's ARQ to obtain estimated line backorders for the item. That changes the resulting mix of safety levels because not every item has the same average requisition size. Indeed, the line approach biases requirements in favor of items with small average requisition size. That may be good for wholesale line supply availability rates, but it is not always in the best interests of readiness or customer support. (More on that point in a moment.) Except for the use of item ARQs, however, the system arithmetic we used to obtain the DESC results is identical to the system arithmetic programmed in SAMMS. Also, although we deliberately employed the unit approach for the DESC example, our methodology for improving system safety levels at DLA does not require the use of the unit approach. As the next chart shows, we have several options for making improvements — some of which employ the traditional line-based approach.

OPTIONS



OPTIONS

Whether calculating line-based or unit-based levels, improving system safety levels entails one of the following options: matching current investment in safety levels at each center (and improving expected performance); matching current expected backorders at each center (and saving on safety levels); finding a way to reduce expected backorders and reduce safety level investment (as in the DESC example); or some other option, such as iterating the system calculation to find a stable system backorder target that still saves money. The results presented later for the other DLA hardware centers all fall into one of these categories.

As the chart suggests, no matter whether a line- or unit-based calculation is used, it is important to specify the effects in terms of *both* line- and unit-based performance. In particular, if

DLA decides to adopt the unit-based approach, it should still plan to track line supply availability and line backorders. Similarly, if it stays with the line-oriented approach, it should start paying more attention to unit supply availability rates and unit backorders. Both kinds of measures are important. That is why both sets of measures are deliberately included in all the results presented in this report.

We will get to more results shortly. First, on the next chart, we review some of the positive reasons for adopting the unit approach.

THE ADVANTAGES OF UNIT-BASED CALCULATIONS

- Unit backorders - not line backorders - drive readiness in the field.
- The line approach can distort the safety level mix.
- The line approach presents a data problem.

THE ADVANTAGES OF UNIT-BASED CALCULATIONS

The DLA should switch to a unit-based approach for at least three good reasons.

First and most important, unit backorders drive readiness effects in the field and wholesale-level line backorders do not. As noted earlier, the line approach reflects the traditional, requisition-oriented mindset in wholesale supply. Fielded weapon systems, however, do not experience downtime because a requisition is backordered by DLA; they do so because one of their units has failed and needs to be replaced with a spare unit issued by the local retail supply point. For the ultimate using customers of spares and repair parts - the maintenance personnel who fix weapon systems and other military equipment - individual units are what matters, not requisitions.

In this vein, DLA is interested in pursuing multi-echelon requirements methods. The basic multi-echelon idea is that the best way for DoD to determine total spares requirements is to look at both wholesale and retail requirements at the same time, rather than doing independent calculations for wholesale and retail supply echelons separately. In multi-echelon calculations, the goal is to minimize retail due-outs (i.e., the average number of outstanding, retail-level unit backorders) to maintenance customers. That is quite different from trying to minimize wholesale line backorders at depot supply windows. Indeed, simultaneous optimization for lines at wholesale and units at retail is mathematically impossible. *If DLA is serious about pursuing*

multi-echelon methods, it has no choice but to adopt the unit-based approach.

A second reason for adopting the unit approach is that it does not distort the safety level mix in ways that the line approach does. As noted earlier, the line approach is biased in favor of small-requisition-size items and against large-requisition-size items. In particular, under the line approach, items that are otherwise identical in terms of demand, demand variance, and price will receive different safety levels if they have different ARQs. The rationale usually advanced for this practice is that items with large ARQs tend to be cheaper and cheaper items are not as important or essential as more expensive items. Cheaper items, however, are not always less important or less essential than expensive ones. The class of consumable line replaceable units (i.e., consumable LRUs that apply directly to weapon systems and can ground those systems if they fail) contains cheap items.³ Unit price and average requisition size are not good surrogates for item essentiality.

A third reason for adopting the unit approach is that the unit approach avoids a data problem that the line approach cannot avoid. Correct conversion of an item's unit EBOs into line EBOs requires treatment of the variability of requisition size across all backordered requisitions for that item. Computing line EBOs by simply dividing unit EBOs by an average requisition size fails to account for that variability. For any particular item,

³ LMI Report DL101R1, *Weapon-System-Oriented Supply Management at DLA: Relating Inventory Investment to Readiness*, Christopher H. Hanks, March 1993. In Table 2-1 on page 2-12 of that report, the author presents a list of some 30 LRUs managed by the Defense General Supply Center, seven of which cost less than \$1. The absence of any one of these LRUs would render an F-15 aircraft "not mission capable-supply" or "partially mission capable-supply."

THE ADVANTAGES OF UNIT-BASED CALCULATIONS

- Unit backorders - not line backorders - drive readiness in the field.
- The line approach can distort the safety level mix.
- The line approach presents a data problem.

THE ADVANTAGES OF UNIT-BASED CALCULATIONS (Continued)

requisition sizes may be distributed in such a way that use of an average significantly distorts the number of line EBOs. But even for items for which use of an average requisition size poses no problem, converting unit to line EBOs still requires knowing the average *backordered* requisition quantity (ABRQ), rather than the ARQ across all requisitions. If the ABRQ and ARQ are not the same, dividing by ARQ to convert unit backorders to line backorders gives incorrect results.

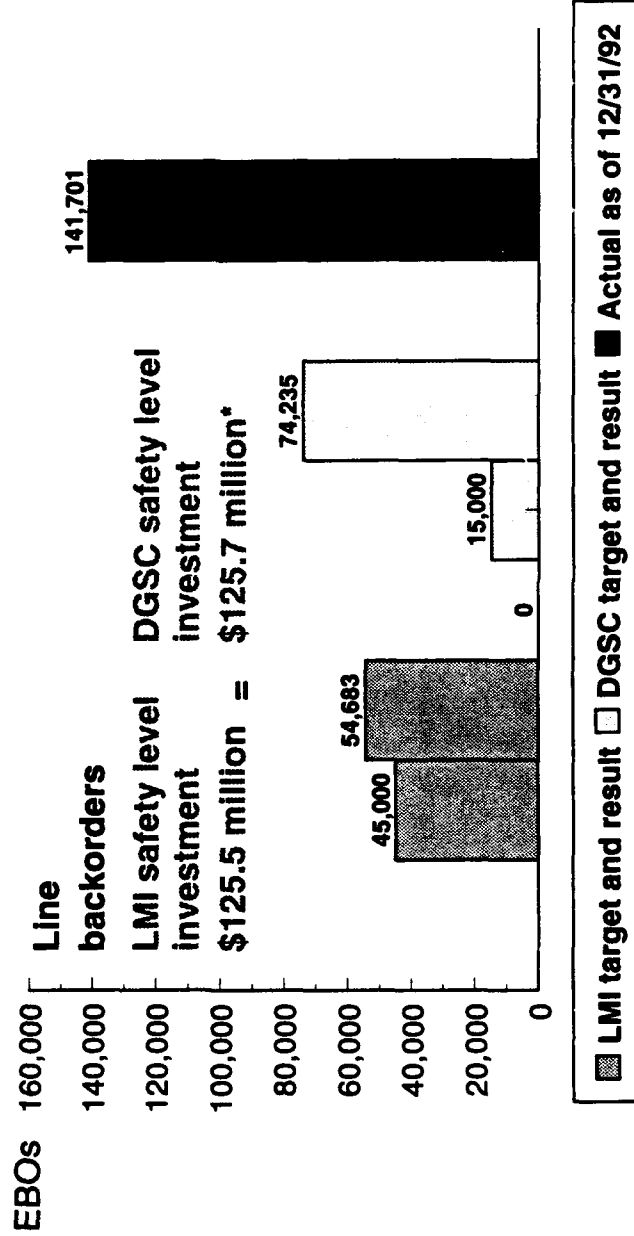
Changing SAMMS to account for the variability of requisition size might involve considerable effort. Even introducing an ABRQ would still require a new application program in SAMMS to create this data element. Rather than making these changes, DLA could simplify and improve the accuracy of its requirements calculations by adopting the unit approach.

**THE UNIT APPROACH IS NOT
REQUIRED, HOWEVER, TO GET
BETTER RESULTS AT THE
CENTERS.**

**WE CAN DO IT WITH THE
TRADITIONAL LINE-ORIENTED
APPROACH, TOO.**

FOR EXAMPLE,

DGSC WITH A LINE-ORIENTED BACKORDER CALCULATION



*To the nearest \$0.5 million.

DGSC WITH A LINE-ORIENTED BACKORDER CALCULATION

In spite of the case just made for the unit approach, the debate over unit versus line is likely to continue until wholesale supply managers get used to the idea. Wholesale supply points will continue to receive requisitions (not demands for individual units), and wholesale supply managers will continue to look at line supply availability rates and line backorders as key measures of performance. For that reason, it is important that DLA understand that the unit approach is *not* a necessary prerequisite for improving system safety levels. Improvements are also possible even if DLA continues with its traditional, line-oriented approach. The chart on the facing page shows an example. It compares line-oriented safety levels calculated by LMI for items at DGSC with safety levels DGSC actually had in its file as of the end of December 1992.

The LMI calculation was done with the idea of matching DGSC's aggregate safety level investment requirement of \$125.7 million. To do that, we had to find a line backorder target that, after the system calculation is performed and upper and lower safety level constraints are applied, yields a set of safety levels worth about \$125.7 million. We experimented with various line backorder targets until we found one (namely, 45,000 line backorders for a system of 97,893 items) that produced an aggregate safety level requirement of \$125.5 million.

With the safety levels that result, expected line backorders at DGSC are 54,683. (Because upper and lower safety level constraints cause some safety levels to change, input EBO targets generally do not match output EBO values. It is for this reason that input backorder targets are generally viewed in DLA, and in DoD supply systems in general, as "control knobs" for ad-

justing safety level requirements, rather than as accurate indicators of expected supply performance.

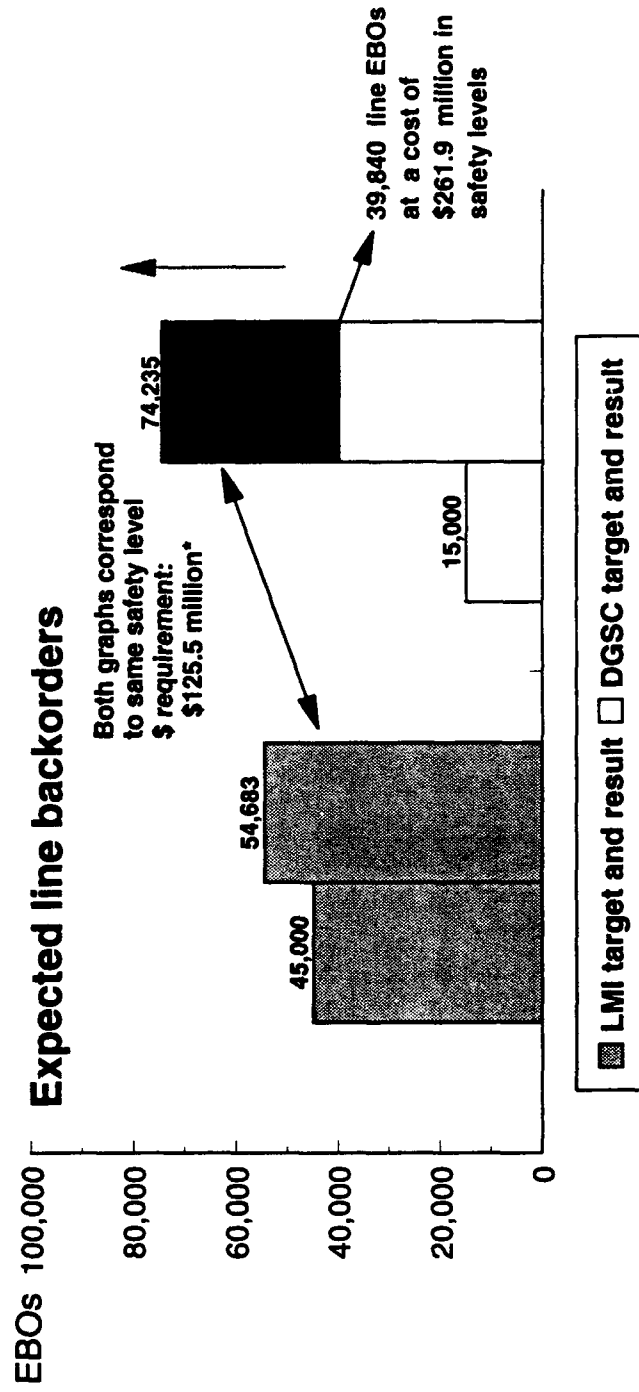
In comparison, in December 1992, DGSC was using a line backorder target of 15,000. With that target, and after DGSC managers had done everything else they do to set safety level requirements, the resulting safety levels at DGSC yield expected line backorders of 74,235.

Thus, without increasing safety level investment, and using the line approach, LMI can reduce expected outstanding line backorders at DGSC by almost 20,000 line EBOs.

Even though the LMI output results are better than the DGSC results, some might object to the significant increase in the input EBO target, from the DGSC value of 15,000 to the LMI value of 45,000. To counter that concern, the rightmost bar shows the actual number of outstanding line backorders in place at DGSC as of the end of December 1992. At over 140,000 outstanding line backorders, that figure is substantially higher than the LMI target.

A more fundamental question is how DGSC is able to go in with a lower target and yet still generate more expected backorders than LMI while spending the same on safety levels. With a lower setting of the EBO (beta) "control knob," DGSC should have gotten a set of safety levels that cost more and yielded better performance. The next chart explains what DGSC did. It is the most important chart in the report because it goes to the heart of how and where DLA is making mistakes in setting system safety levels.

HOW CAN DGSC START WITH A LOWER TARGET AND GET MORE BACKORDERS THAN LMI WHILE SPENDING THE SAME MONEY ??



HQ DLA execution orders and DGSC local "uniques" reduce costs - but do so inefficiently!

*To the nearest \$0.5 million.

HOW CAN DGSC START WITH A LOWER TARGET?

On the left of the above chart are the LMI input and output results for DGSC from the preceding chart. On the right are the DGSC results. On the right, however, we have included the expected value of 39,840 line EBOs that result from an input target of 15,000 line EBOs. Those 39,840 line EBOs are indeed less than the LMI output figure of 54,683 line EBOs. The problem is that they correspond to a set of safety levels worth \$261.9 million — substantially more than the \$125.5 million requirement that DGSC could afford in December 1992.

The problem that DGSC and every other DLA hardware center faces is that current and continuing budget pressures do not allow them to simply run their system safety level machinery and settle on the results as the requirement. In this case, DGSC could not accept a \$261.9 million safety level requirement. Under the gun to reduce stockage requirements and reduce spending for stock replenishment, DGSC and the other hardware centers have been forced to take extra steps that they believe are necessary to reduce their stockage requirements.

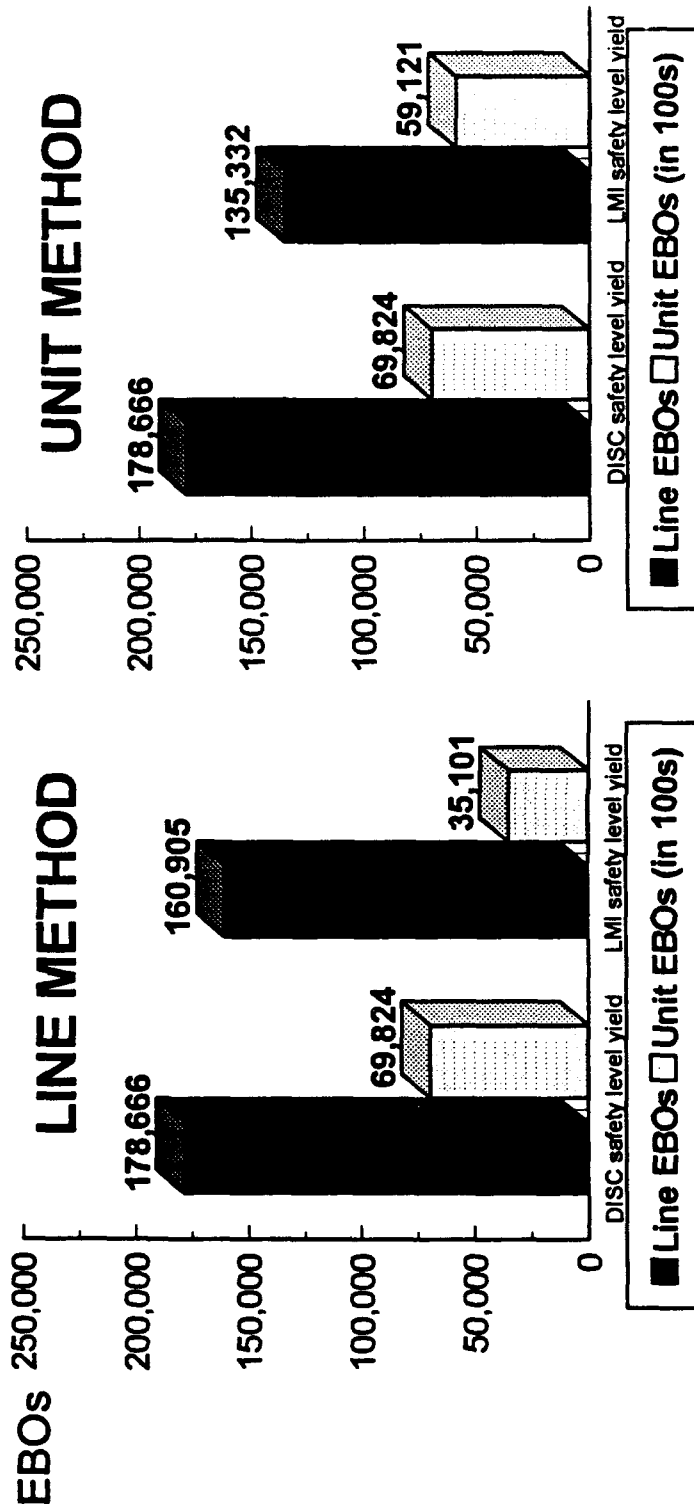
What this chart suggests is that rather than “manually” manipulating safety levels downward to meet budget constraints, DGSC (and in all likelihood the other DLA hardware centers) would be better off to simply adjust their system backorder targets and let the SAMMS arithmetic work — as LMI has done.

It is important to note that the LMI/SAMMS solution is not and does not claim to be the best possible solution. A truly optimal solution would require the incorporation of the upper and lower safety level constraints into the overall constrained optimization problem. That requires the development of a more complicated solution algorithm (an important topic for further research). The LMI/SAMMS solution is simply more efficient than the DGSC solution — probably because most of the “local unique” adjustments DGSC makes are item-oriented rather than system-oriented.

SOMETIMES BOTH METHODS WORK

No matter whether we use LINE- or UNIT-oriented methods, we can improve DISC's expected supply performance without increasing the total safety level requirement.

DISC's safety level requirement as of 31 December 1992 = \$192.7 million.



SOMETIMES BOTH METHODS WORK

This chart shows that the Defense Industrial Supply Center can improve performance without spending any more on safety levels, no matter whether it uses the line or the unit approach.

On the left in both charts, we show the expected supply performance from DISC safety levels in terms of both line and unit EBOs. On the right, we show what is possible with an alternative mix of safety levels — holding the total investment roughly constant at about \$192.7 million (which was DISC's safety level requirement as of 31 December 1992). The LMI results in the "line method" chart were obtained using a line backorder (beta) target of 30,000 line EBOs. The LMI results in the

"unit method" chart were obtained using a unit backorder target of 700,000 unit EBOs.

Not surprisingly, the line method leads to a greater decrease in line EBOs (from 178,666 to 135,332) than the unit method (from 178,666 to 160,905). On the other hand (and again not surprisingly), the unit method reduces unit EBOs by more (from 6,982,400 to 3,510,100) than the line method does (from 6,982,400 to 5,912,100).

MORE EXAMPLES

- DGSC (12/92)		- LMI - UNIT METHOD	
- Line EBOs	74,235	-	72,423
- Unit EBOs	1,213,820	-	620,894
- Line SA	94.8%	-	94.9%
- Unit SA	95.5%	-	98.4%
- SL cost	\$125.7 million	-	\$124.9 million
			↓
- DCSC (12/92)		- LMI - LINE METHOD	
- Line EBOs	39,364	-	29,994
- Unit EBOs	718,815	-	635,489
- Line SA	96.8%	-	98.0%
- Unit SA	95.8%	-	96.9%
- SL cost	\$189.1 million	-	\$188.5 million
			↓

Note: SL = Safety level.

MORE EXAMPLES

In previous charts we have shown

- results for DESC using the unit approach, with improved performance across the board at less cost (pg. 6);
- results for DGSC using the line approach, with improved line performance for the same cost (pg. 18); and
- results for DISC using either the line or unit approach, with improved line and unit performance for the same cost (pg. 22).

This chart contains results for the one center we have not addressed yet, the Defense Construction Supply Center (DCSC). It also presents some additional results for DGSC.

Whereas before we showed results using the line approach, for DGSC we show how the unit approach could be used to

improve performance for the same investment. The unit backorder (beta) target was 360,000 unit EBOs.

In this chart, we show how DCSC can use the line approach to reduce both unit and line EBOs, increase unit and line supply availability rates, and do so without increasing its total safety level requirement. The line backorder (beta) target we used was 22,000 line EBOs.

Again, the point is that improvements are possible in system safety levels at DLA regardless of whether DLA adopts the unit approach or the line approach. The unit approach is preferable for the reasons given earlier, but DLA does not have to make a decision on units versus lines before it can make improvements in system safety levels.

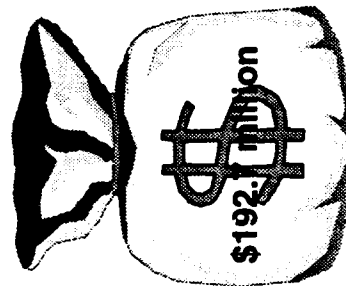
**The centers have substantial
safety level requirements . . .**

THE CENTERS HAVE SUBSTANTIAL SAFETY LEVEL REQUIREMENTS...

As the next chart shows, DLA's four hardware centers have substantial safety level requirements.

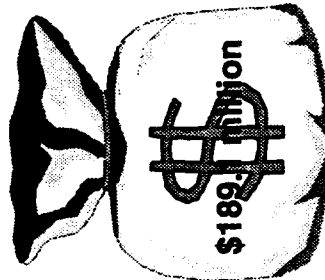
CENTER SAFETY LEVEL REQUIREMENTS

Aggregate safety value of items with ARQ > 0
in DIDB/SAMMS file as of 31 December 1992



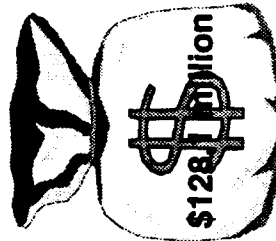
DISC

222,409 items



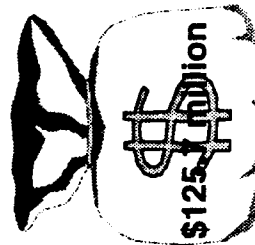
DCSC

88,644 items



DESC

115,584 items



DGSC

97,893 items

Total value: \$635.6 million

CENTER SAFETY LEVEL REQUIREMENTS

The value of the safety level requirements at DLA's four hardware centers for active demand-based items as of 31 December 1992, totals more than \$600 million. Against that requirement, item managers make stockage replenishment decisions as items reach their reorder points. Anything DLA can do to reduce the requirement translates into replenishment savings over time.

(Note: Based on information provided by Mr. Michael Pouy of DLA Headquarters, LMI believes the safety level requirements shown on this chart are true "execution" safety levels that were appearing on supply control studies being used by item managers in the first quarter of FY93 to make replenishment decisions. At each center at the end of each quarter, standard SAMMS safety level calculations generate a set of official safety

level requirements. Then, over the next 2 weeks, the centers adjust those safety levels in ways they perceive as necessary or required in order to control spending and follow execution guidance as laid down by Headquarters DLA, the DoD Comptroller, the Office of Management and Budget, and the Congress. The safety levels shown here reflect those changes as made in the first quarter of FY93, before the next standard SAMMS calculation would have been performed. While LMI believes this to be a correct statement, we did not -- for time and funding reasons -- verify this assertion by examining center "execution tapes.")

**AND THEY HAVE SUPPLY
PERFORMANCE
PROBLEMS,
whether we measure
outstanding *line*
backorders...**

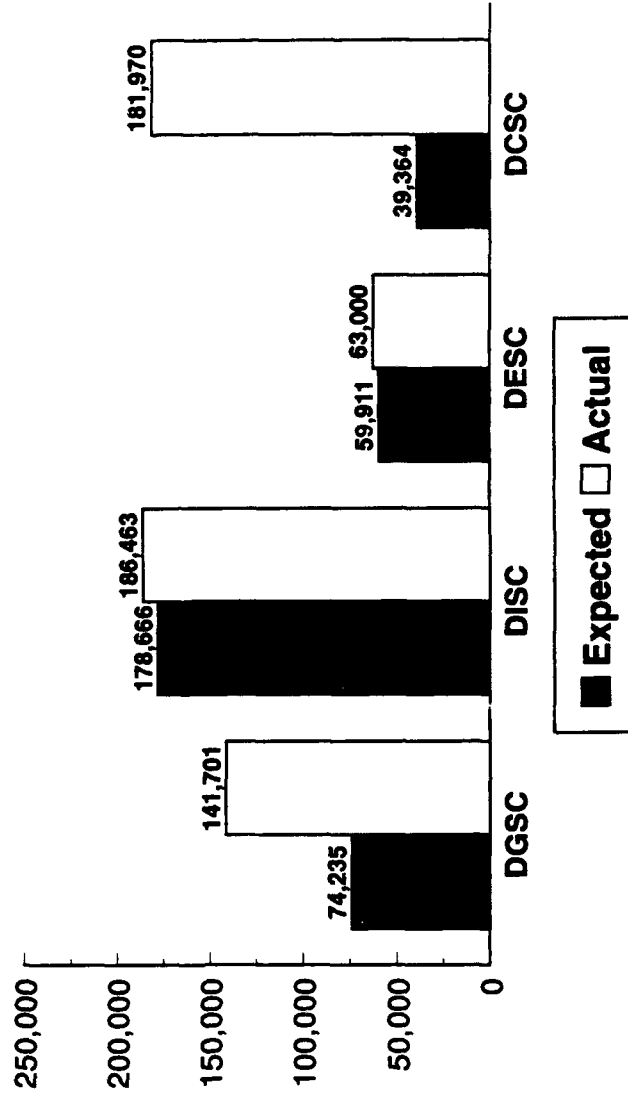
AND THEY HAVE SUPPLY PERFORMANCE PROBLEMS

Against more than \$600 million in safety level requirements, the hardware centers still continue to experience supply performance problems — whether we look at actual outstanding

line backorders as shown on the next chart, or outstanding unit backorders as shown on the chart after next.

LINE BACKORDERS - EXPECTED AND OUTSTANDING

December 1992



LINE BACKORDERS -- EXPECTED AND OUTSTANDING December 1992

This chart compares the average number of outstanding line backorders the hardware centers can expect to experience given the safety levels they carry with the actual number of outstanding line backorders in place at each hardware center as of

the end of December 1992. While DISC and DESC are holding line backorders at their expected levels, DGSC and DCSC are not.

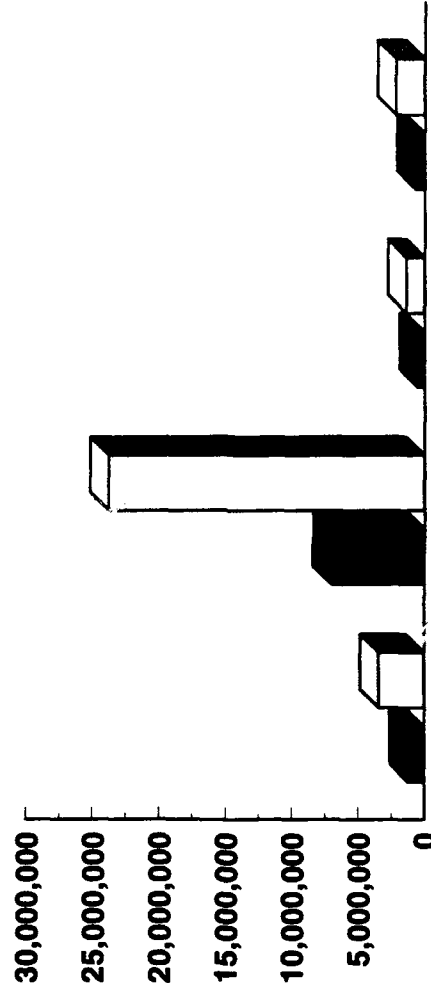
or outstanding *unit* backorders...

OR OUTSTANDING UNIT BACKORDERS...

The picture changes if we look at unit backorders.

UNIT BACKORDERS - EXPECTED AND OUTSTANDING

December 1992



	DGSC	DISC	DESC	DCSC
Expected	1,213,820	6,982,402	486,764	718,815
Actual	3,457,333	23,820,371	1,404,499	2,184,474

UNIT BACKORDERS – EXPECTED AND OUTSTANDING

December 1992

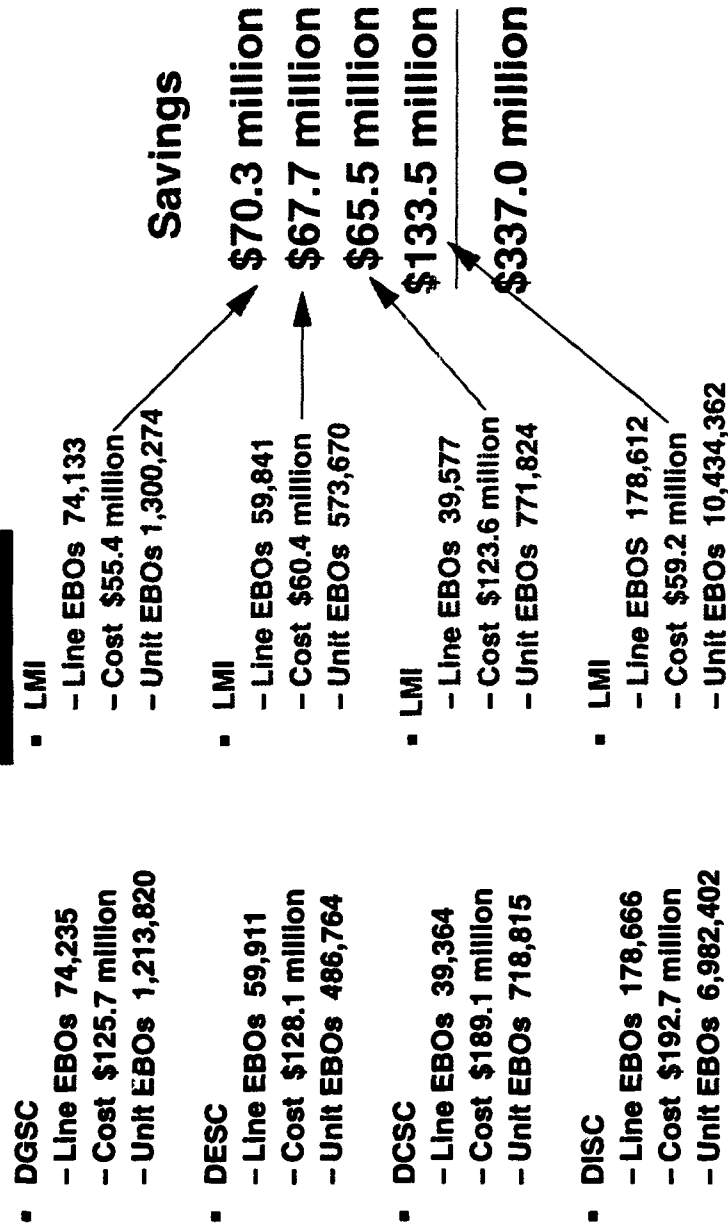
This chart compares the average number of outstanding unit backorders the hardware centers can expect to experience (given the safety levels they carry) with the actual number of outstanding unit backorders in place at each hardware center as of the end of December 1992. Every center has substantially more outstanding unit backorders than expected. The situation at DISC is particularly interesting because DISC adjusts safety levels with a unique stockage methodology developed to keep line supply availability rates high.

In DISC's defense (and probably the other hardware centers as well), earlier LMI research⁴ suggests that many outstanding unit (and, therefore, line) backorders may be of the

"unexpected" variety. Unexpected backorders are backorders that occur not because of where stockage and safety levels happen to be set but for other reasons entirely beyond the control of inventory managers. For example, if all suppliers for a particular item or set of items have either gone out of business or have been barred from doing business with the government, then no matter how stockage levels are set, backorders will occur. If suppliers are not supplying but demand continues, inventory managers can do nothing to keep backorders from accumulating. Such a situation occurred at DISC in the late 1980s in connection with fasteners and other related hardware items

⁴LMI Report DL901R1, *How DLA's Supply Performance Affects Air Force Readiness*, Christopher H. Hanks, October 1990, Chapter 4, "The Problem of Unexpected Backorders," pp. 4-1 to 4-4.

ONE OPTION FOR \$ SAVINGS



ONE OPTION FOR \$ SAVINGS

So far we have shown that the unit approach enables us to improve both line and unit performance at DESC while reducing safety level investment (the initial DESC results on page 6). We have also matched on total safety level investment and improved projected performance — using both the line- and the unit-oriented approaches (the DGSC, DISC, and DCSC results on pages 18, 22 and 24).

Here, instead of matching safety level investment, we match on backorder performance and show the reductions possible in safety level requirements. For each of the four hardware centers, we selected an input backorder target that, after calculating and constraining safety levels, yields output backorders equal to current line EBOs projected for the center.

To simplify matters and avoid the units-versus-lines debate, all the results shown were obtained using the line-based method. That is, we used a *line* backorder target (beta) for the system calculations at each center. The line backorder targets we used are as follows:

- DGSC — 103,400 line backorders
- DESC — 50,000 line backorders
- DCSC — 39,364 line backorders
- DISC — 152,000 line backorder.

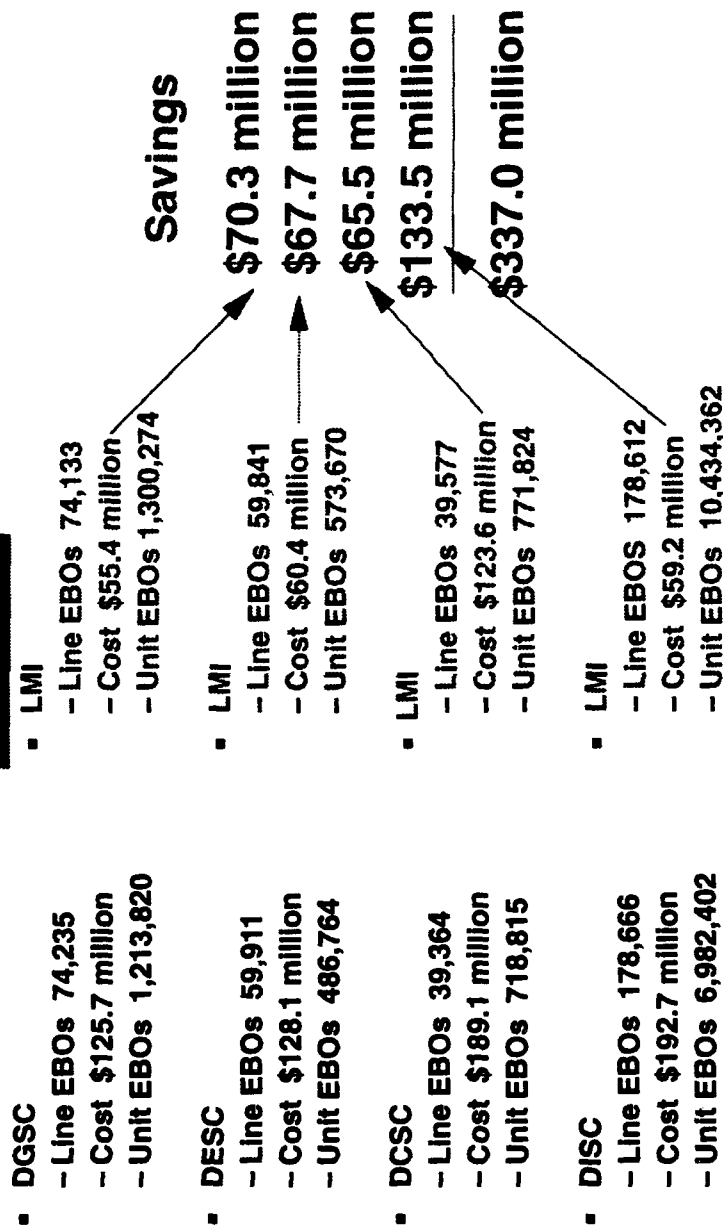
On the left side of the chart, we show expected line backorders at each center given current safety levels, the aggregate

value of those safety levels, and the corresponding expected unit backorders. On the right, we show projected line and unit EBOs corresponding to an alternative mix of safety levels computed by LMI using the targets above.

As the chart shows, the possible savings at each center are substantial. The total possible reduction in system safety level requirements is \$337 million — more than half the total safety level requirement at the centers as of 31 December 1992. If it chooses, DLA could realize these safety level reductions at its four hardware centers by placing the line backorder targets shown above into the management policy tables the centers use in their *standard* SAMMS requirements calculations. No other changes are required in SAMMS programming or procedures.

Before using the alternative line targets, DLA managers should note that the new targets are significantly larger than the line backorder targets (betas) currently in use. At DGSC, for example, the current target is around 15,000 line backorders. The suggestion here is to use a substantially larger target at DGSC of 103,400 line backorders. With a target of only 15,000 line backorders, DGSC is generating very high safety levels, most of which (more than 50 percent according to a DORO analysis) have to be lowered to meet the lead-time constraint. The new, higher line backorder target suggested for DGSC simply generates a more efficient (i.e., cheaper) mix of safety levels to achieve the line EBO performance (74,235 outstanding line backorders in place on average) that DGSC “expects” anyway, given its current safety level.

ONE OPTION FOR \$ SAVINGS



ONE OPTION FOR \$ SAVINGS (Continued)

This chart also shows that the larger line backorder targets and savings they generate do incur penalties in expected unit backorders. Expected unit EBOs increase at every hardware center. As one would expect, line-oriented calculations do not always improve unit performance, nor do unit calculations always improve line performance. The unit EBO projections shown here illustrate that point. The increases in unit backorders are relatively small at DGSC, DESC, and DCSC, but they are large enough at DISC that DLA might want to experiment with other

line backorder targets rather than the suggested target of 152,000 to mitigate the size of unit backorder increases.

Since the difference between DISC and LMI safety level investments is more than \$130 million, there is ample room to trade some of these savings for a smaller increase in unit backorders.

THE BOTTOM LINE

**DLA MAY BE ABLE TO IMPROVE
SUPPLY PERFORMANCE AND SAVE
ON INVENTORY COSTS BY RETURNING
TO THE STOCKAGE POLICY IT IS
SUPPOSED TO BE FOLLOWING
ANYWAY.**

THE BOTTOM LINE

Whatever DLA decides to do — either to stay with the line-based approach or to adopt the unit-based approach to system safety level calculations — the bottom line is that DLA has the opportunity to improve supply performance and save on inventory costs at its four hardware centers by simply following the basic system policy it is supposed to be following anyway. Rather than making *ad hoc* adjustments to system safety levels after SAMMS calculations have been completed, DLA and its customers would be better served if alternative methods were available at the DLA hardware centers for experimenting with different system backorder targets and performing system

calculations to establish levels. All of the results presented in this briefing were obtained at LMI with DIDB data, standard Presutti-Trepp inventory models (line and unit) programmed in "C," and a 486 DOS-based personal computer. Similar calculations could be done at the centers on personal computers and the resulting safety levels could be loaded into the SAMMS files. The programs developed at LMI for this work produce files of individual item safety levels by national stock numbers.

GLOSSARY

ABRQ	=	average backordered requisition quantity
ARQ	=	average requisition quantity
DCSC	=	Defense Construction Supply Center
DESC	=	Defense Electronics Supply Center
DGSC	=	Defense General Supply Center
DIDB	=	DLA Integrated Data Bank
DISC	=	Defense Industrial Supply Center
DLA	=	Defense Logistics Agency
DORO	=	DLA's Operations Research Office
EBOs	=	expected backorders
LMI	=	Logistics Management Institute
LRUs	=	line replaceable units
SA	=	supply availability
SAMMS	=	Standard Automated Materiel Management System
SL	=	safety level

REPORT DOCUMENTATION PAGE

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