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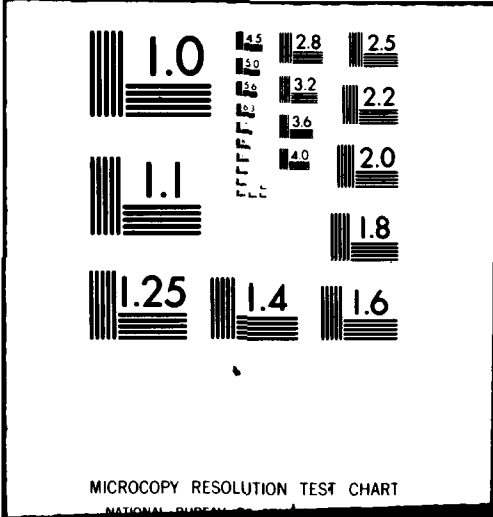
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18. ABSTRACT (UNCLASSIFIED) This study of termination policies is the result of a GAO audit report that claims the current Air Force policy results in permissive overstockage. Simulation of the EOQ system is used to show the need for a buffer zone before termination notices are generated. It also demonstrates that when a termination notice is generated, it is better to adjust the purchase request so that the inventory position equals the requirements objective than it is to cancel the entire purchase request. (Cont. on next page.)				
19. CONCLUSIONS (UNCLASSIFIED) "See Abstract"				
20. RECOMMENDATIONS (UNCLASSIFIED) "See Abstract"				
21. IMPLEMENTING ACTIONS (UNCLASSIFIED)				

(Abstract Cont)

Although the simulation shows that the Army, Air Force and DLA policies are all more cost effective than the GAO recommendation, the results did not prove that any services policy was more cost effective than the others. Thus, the final recommendation is that the Air Force should continue to use its current policies to generate termination notices. Also the Air Force should handle termination notices by adjusting the purchase request so the inventory position equals the requirements objective. This is a change from their current policy of adjusting the purchase request so the inventory position equals the termination level.



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COST EFFECTIVE TERMINATION POLICIES
D062 - ECONOMIC ORDER QUANTITY (EOQ) ITEMS.

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FINAL REPORT.

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JULY 1980

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ABSTRACT

This study of termination policies is the result of a GAO audit report that claims the current Air Force policy results in permissive overstockage. Simulation of the EOQ system is used to show the need for a buffer zone before termination notices are generated. It also demonstrates that when a termination notice is generated, it is better to adjust the purchase request so that the inventory position equals the requirements objective than it is to cancel the entire purchase request. Although the simulation shows that the Army, Air Force and DLA policies are all more cost effective than the GAO recommendation, the results did not prove that any services policy was more cost effective than the others. Thus, the final recommendation is that the Air Force should continue to use its current policies to generate termination notices. Also the Air Force should handle termination notices by adjusting the purchase request so the inventory position equals the requirements objective. This is a change from their current policy of adjusting the purchase request so the inventory position equals the termination level.

INTRODUCTION

The purpose of this study is to evaluate policies for canceling purchase requests (PRs) on EOQ items whose requirements objective (RO) has fallen below the inventory position.¹ The GAO has claimed that failing to cancel the entire PR immediately when an item gets in this position is permissive overstockage and the Air Force should change its policy that allows this overstockage. The GAO also addressed terminating a contract when the item is in this position. Although this study does not look at orders on contract directly, the results can be extended to cover orders on contract.

The Air Force position is that a buffer stock is necessary. Since demands fluctuate frequently, if no buffer exists, the workload of item managers and procurement would be impossible. This study addresses the issue by simulating the various policies for generating and handling a termination notice.¹ Statistics from the results of each policy are presented to validate the need for buffer stock and the differences between the cost effectiveness of the policies.

DEFINITIONS

Inventory Position: Current stock on hand and on order.

Reorder Level: The stock expected to be used while waiting for an order plus a safety factor. A new order is started when the inventory position reaches this level.

Economic Order Quantity (EOQ): The most economical quantity to order. For this quantity, the sum of the ordering and holding cost is as low as possible.

Requirements Objective: The sum of the reorder level and the EOQ. This is the maximum the inventory position would reach if demands were constant.

Termination Notice: The product received by an item manager when a item's inventory position has more than the acceptable buffer above the requirements objective and there is an order or purchase request that can be canceled or terminated.

POLICIES EVALUATED

Several policies are evaluated to make the study as comprehensive as possible. Besides the policies for generating a termination notice, there are several alternative actions that can be taken when a termination notice is generated.

The policies evaluated for handling a termination notice when it occurs are:

- a. Cancel the purchase request.
- b. Adjust the purchase request so the requirements objective and the inventory position are equal.
- c. Adjust the purchase request to another specified level.

The policies for generating a termination notice are:

- a. 0 months buffer - The GAO recommendation.

- b. 3 months buffer.
- c. 6 months buffer - The Air Force policy when annual dollar demands are over \$500.²
- d. 9 months buffer.
- e. 1/4 EOQ buffer.
- f. 1/2 EOQ buffer - The DLA policy.
- g. 3/4 EOQ buffer.
- h. Terminate when the holding cost for the amount of stock above the requirements objective is larger than the termination cost and the cost of increased back orders - The Army policy.
- i. Terminate when the above holding cost is larger than the termination cost - A modified Army policy.
- j. Never terminate.

² When annual dollar demands are under \$500, the Air Force uses a 12 month buffer. The increased buffer is used as part of the selective management policy of not placing tight restrictions on low value items. It is not considered cost effective to study these items separately. They represent only 3.3% of the dollars on purchase request and 2.9% of the dollars on contract. If 6 months is an adequate buffer for medium and high value items, 12 months is a reasonable buffer for low value items.

METHOD

Simulation of handling samples of EOQ items for three years is the major tool to evaluate the policies for cancelling a PR. Using current holding, shortage, and ordering costs, historical information on items and Air Force policies, the simulation duplicates normal stock actions. When the various termination policies are used in different simulation runs, the effect of using the termination policies can be determined. Statistics collected include the volume of orders, PR cancellations, and backorder weeks as well as inventory costs associated with running the system (purchase, ordering, cancellation and holding).

Each policy was run with four shortage costs that are close to the current shortage cost for the ALC from which the items are selected. This varies the safety level slightly so that there are different inventory costs and backorders for each shortage cost. The backorder versus inventory cost combinations are plotted and a line drawn between the points. The resulting curve gives the backorders associated with a range of inventory costs for a particular policy. The curves for two policies can be compared to tell if one policy

is better than the other. A policy is better if its backorder versus inventory cost curve shows that it will always give fewer backorders than the other policy for the same level of spending. This comparison of the curves and the volume and size of cancelations are the tools for evaluating policies.

Two sets of samples are used. The preliminary samples of 500 items each are from Sacramento and Warner Robins. Samples of 1500 items each are from Oklahoma City and Warner Robins. The samples were selected randomly from those items who had demand history for the entire FY71-75 time period. They were from a variety of weapon systems and the unit price, demands and dollar demands are well stratified.

The 500 item samples are used to make some preliminary conclusions. When these results are inconclusive the 1500 item samples are used. Two samples are used in each stage. The reason for this is, if both samples give the same result, the size of the samples is large enough to give dependable results.

RESULTS AND CONCLUSIONS

There are ten ways to generate a termination notice and three ways to handle the notice. For ease of presentation, understanding and analysis the results are presented in sections. The results address the following issues:

a. What is the best action to take when a termination notice occurs?

b. What is the best buffer based on months?

c. What is the best buffer based on EOQ?

d. What is the best buffer based on holding cost comparisons?

e. Is there a best policy for termination notices?

The Best Action Following a Termination Notice: Adjusting the purchase request so the inventory position equals the requirements objective is the best action to take when a termination notice occurs. Two other alternatives are evaluated. The first alternative is to adjust the purchase request so the inventory position is at the termination level (requirements objective plus buffer). This is the current Air Force policy. The second alternative is to cancel the entire purchase request. This is recommended by GAO.

When working with the preliminary samples of 500 items, the policy of adjusting the purchase request so the inventory position equals the termination level yielded a high volume of small adjustments to the purchase request. Figure 1 summarizes some results that show this. The data is for 0, 1, 2 and 6 months used as a buffer with the current shortage cost. The first section shows the average number of times each order is adjusted. The second section shows the number of adjustments made in the three year simulations. The last section shows the average number of units in each adjustment.

The average number of adjustments per order decreases as the buffer size increases, but with six months of buffer, an average of 3 out of 10 orders still have an adjustment

FIGURE 1
VOLUME AND SIZE OF ADJUSTMENTS WHEN PURCHASE REQUEST IS
ADJUSTED SO THE INVENTORY POSITION IS AT THE TERMINATION LEVEL

BUFFER SIZE	AVERAGE NUMBER OF ADJUSTMENTS PER ORDER		NUMBER OF ADJUSTMENTS		AVERAGE NUMBER OF UNITS PER ADJUSTMENT	
	SM	WR	SM	WR	SM	WR
0 MONTHS (GAO)	1.3	1.5	1063	1264	6	6
1 MONTH	.8	.9	661	779	8	7
2 MONTHS	.6	.7	498	541	9	8
6 MONTHS (AF)	.3	.3	223	235	10	10

to their purchase request. What can happen is that an item whose demand decreases also has its termination level decrease. Items have their levels recomputed every week. Thus it is possible for an item to be in a termination position one week, have its purchase request adjusted and one week later be in a termination position again.

Because the adjustments are numerous and small this method of handling a termination notice is not tested fully with the larger samples. However it is tested with the six months buffer as shown below where it is not cost effective.

Canceling the entire purchase request when a termination notice occurs is found not cost effective. Comparisons were made on the 1500 item samples of the backorder versus inventory costs curves for groups of simulation runs with the same policy generating the termination notice, but the notice being handled by canceling the purchase request or by adjusting the purchase request so the inventory position equals the requirements objective. The methods for generating the termination notice include 0 months (GAO recommendation), 6 months (Air Force policy), 1/2 EOQ (DLA policy), 1/4 EOQ, the Army policy and a modified Army policy.

The backorder versus inventory cost curves for one set of simulations which are based on six months of buffer are shown in Figure 2 (Oklahoma City sample) and Figure 3 (Warner Robins sample). Besides the results for canceling the purchase request and adjusting to the requirements objective, the results of adjusting to the termination level is shown as further justification for not recommending adjusting the PR so the inventory position equals the termination level. The three policies all have about the same range of inventory cost when the shortage cost is varied. However, there is a definite difference in the level of backorders. On both graphs, canceling the purchase request gives the worst support (highest level of backorders as the line connecting the four simulation results based on this policy are always on top). Adjusting the inventory position to the termination level does not provide the best support either. This is further justification for not adjusting to the termination level.

Groups of backorder versus inventory cost curves were compared for the six policies listed above for each of the samples from Oklahoma City and Warner Robins. These twelve groups of curves all compared the cost effectiveness of canceling the purchase request and adjusting the purchase request so the inventory position equals the requirements objective.

FIGURE 2

SUPPORT-INVENTORY COST CURVES FOR SIX MONTHS' BUFFER
TERMINATION NOTICE FOLLOWED BY 3 DIFFERENT ACTIONS
OKLAHOMA CITY SAMPLE OF 1500 ITEMS

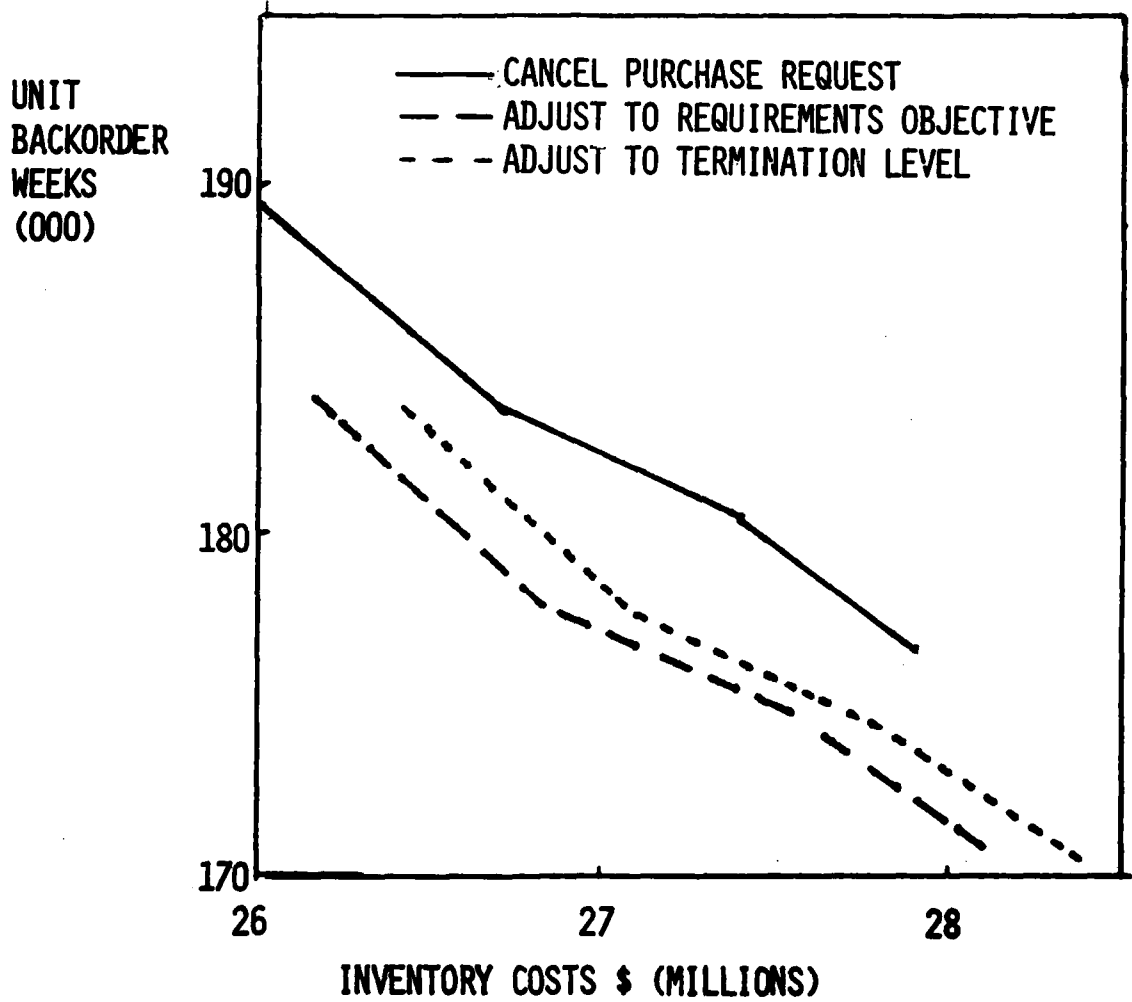
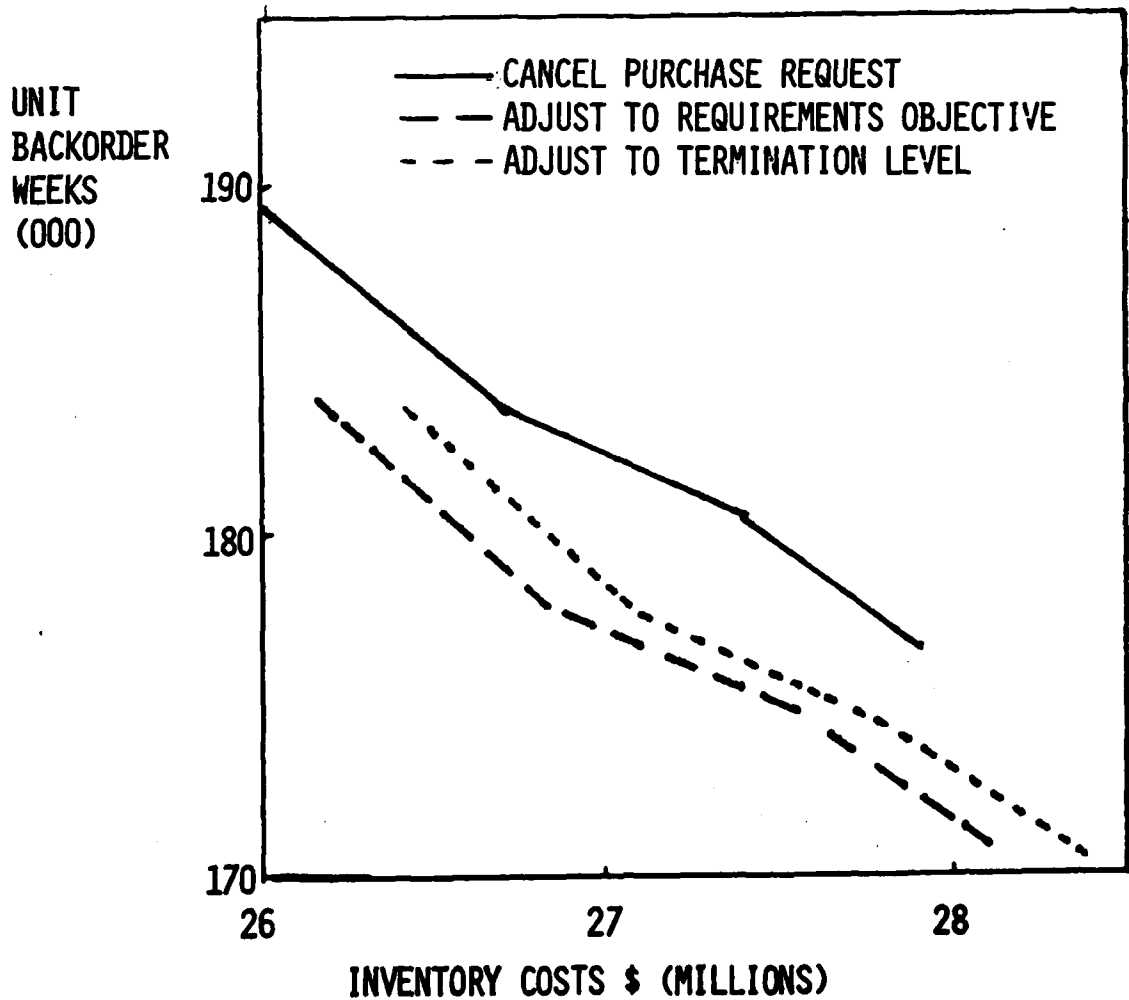


FIGURE 2

SUPPORT-INVENTORY COST CURVES FOR SIX MONTHS' BUFFER
TERMINATION NOTICE FOLLOWED BY 3 DIFFERENT ACTIONS
OKLAHOMA CITY SAMPLE OF 1500 ITEMS



In eleven out of the twelve comparisons adjusting to the requirements objective gave better support per dollar. Thus it is considered the best way for the Air Force to act when a termination notice occurs. In all further comparisons it is the only way a termination is handled.

Buffer Based on Months: Based on the backorder versus inventory cost curves for using 0, 3, 6 and 9 months of stock as a buffer before generating a termination notice, it is not possible to say which method gives the best support. However, 0 months or no buffer, which was recommended by GAO, does the worst. Figure 4 shows the curves for Oklahoma City and Figure 5 shows the curves for Warner Robins. No buffer always has the highest level of backorders.

Six months of buffer will be used in further comparisons of the better policies. It is the current Air Force policy and on the curves it is always in first or second place. Three and nine months drop to third place in one sample.

Buffer Based on EOQ: While comparing the backorder versus inventory support curves for buffers based on 0, 1/4, 1/2, and 3/4 EOQ again no one policy was the best but 0 EOQ or no buffer does the worst. Figure 6 shows the results for the Oklahoma City sample and Figure 7 shows the results for the Warner Robins sample.

One-half an EOQ, the DLA policy, will be used for further comparison -- not because it is always better, but because it is rarely third.

FIGURE 4
SUPPORT-INVENTORY COST CURVES
BUFFER BASED ON MONTHS
OKLAHOMA CITY - 1500 ITEMS

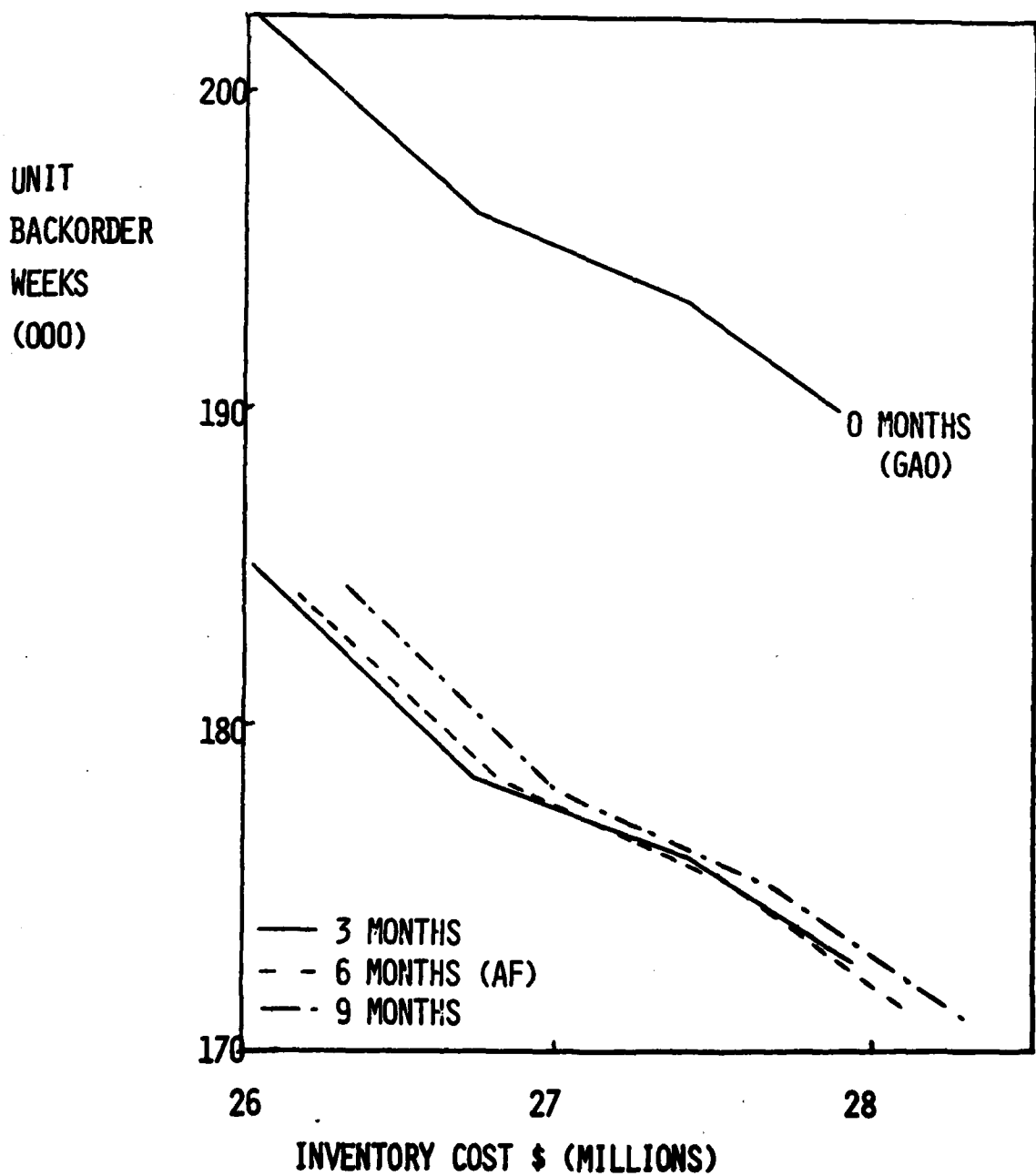


FIGURE 5

SUPPORT-INVENTORY COST CURVES
BUFFER BASED ON MONTHS
WARNER ROBINS - 1500 ITEMS

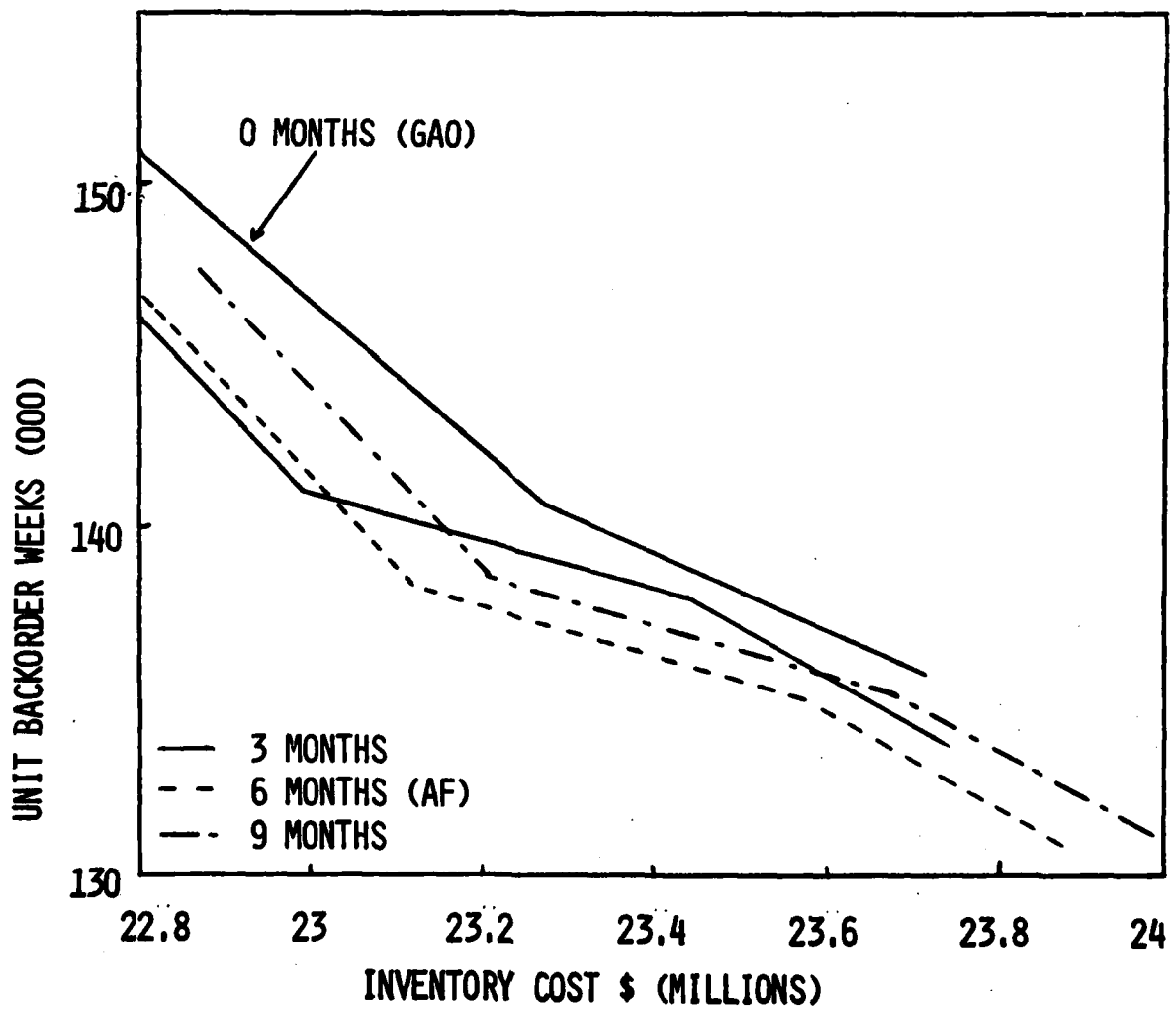


FIGURE 6
SUPPORT-INVENTORY COST CURVES
BUFFER BASED ON EOQ
OKLAHOMA CITY - 1500 ITEMS

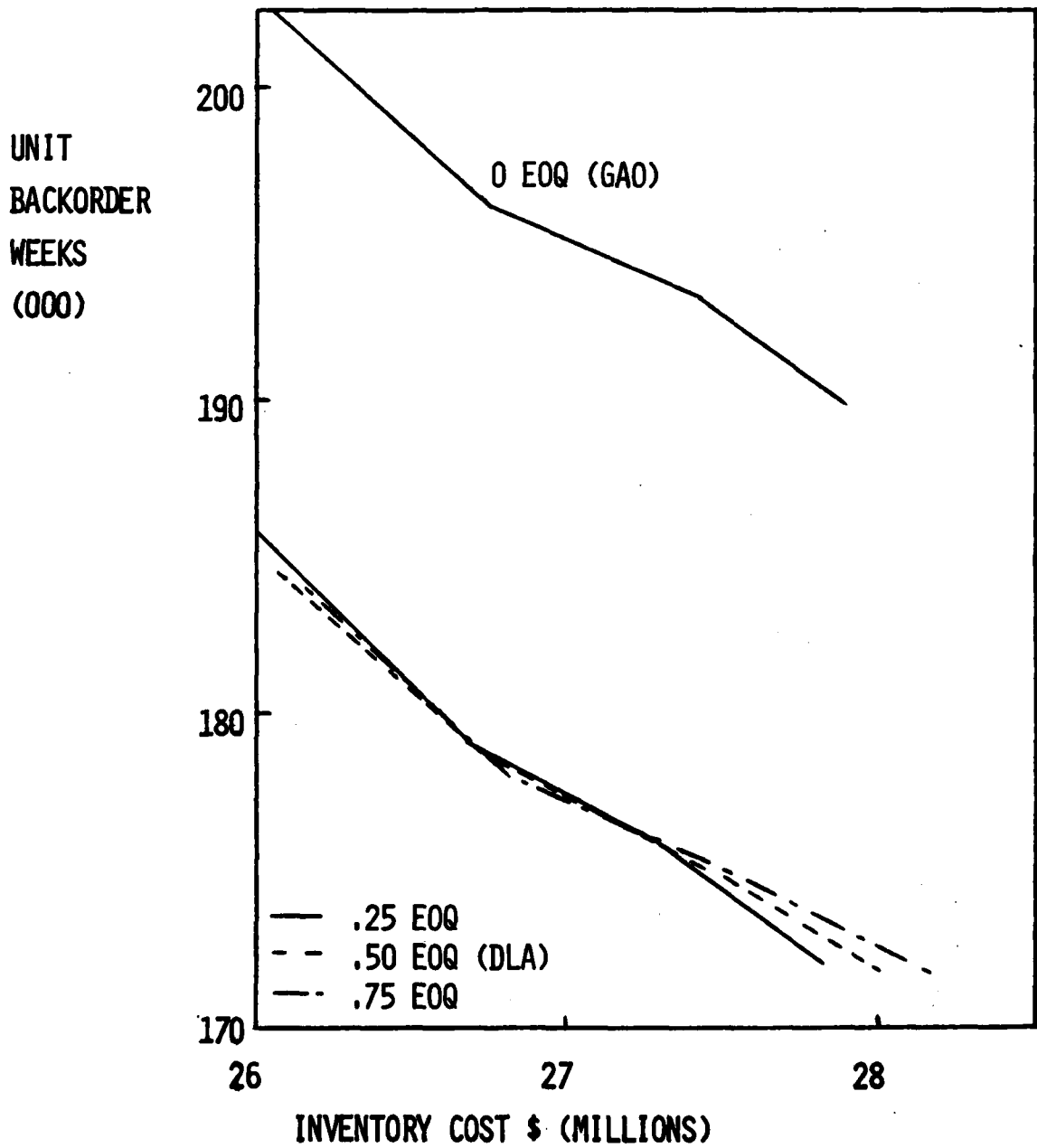


FIGURE 7
SUPPORT-INVENTORY COST CURVES
BUFFER BASED ON EOQ
WARNER ROBINS - 1500 ITEMS

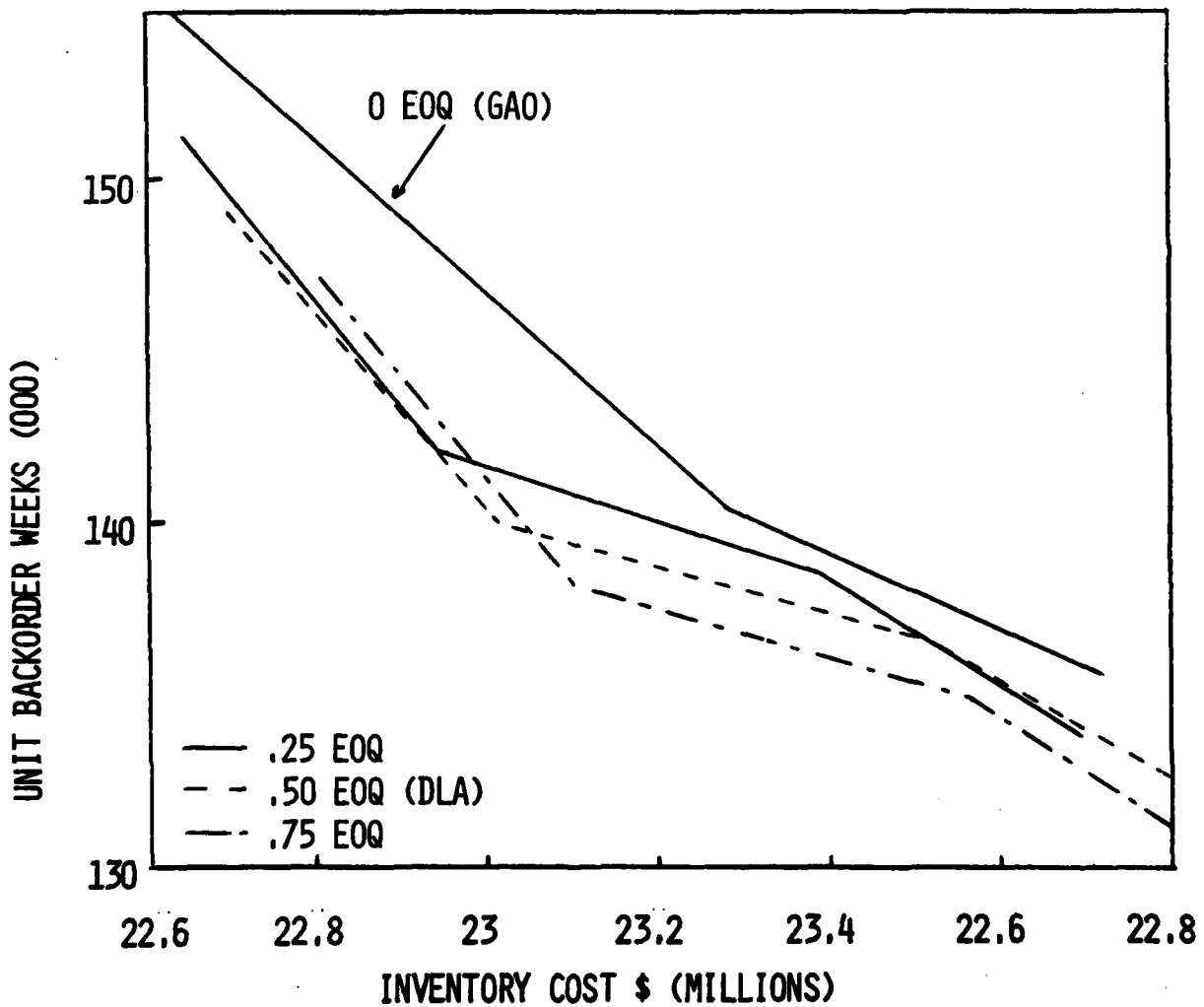


FIGURE 8
SUPPORT-INVENTORY COST CURVES
BUFFER BASED ON HOLDING COST COMPARISON
OKLAHOMA CITY - 1500 ITEMS

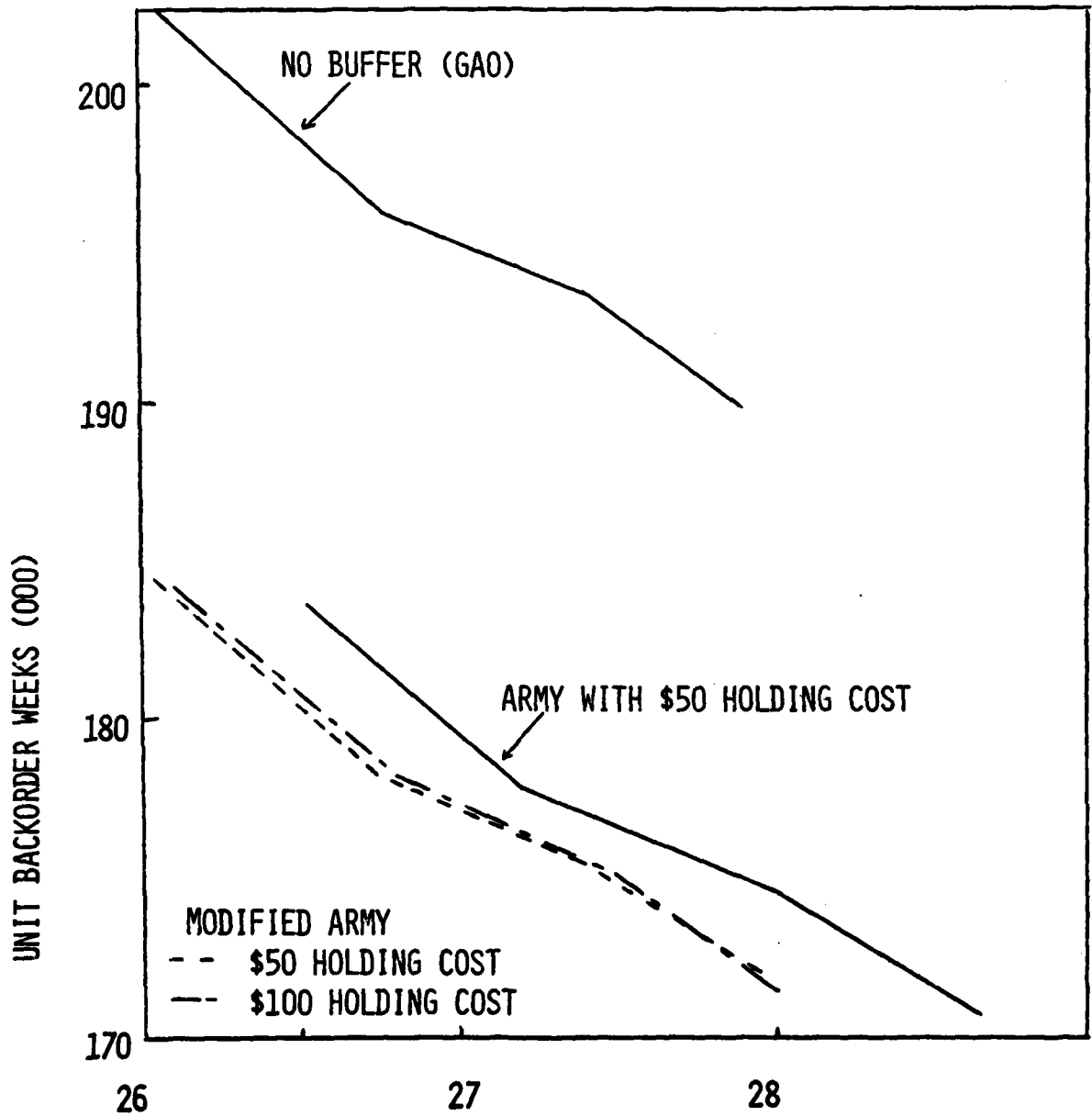


FIGURE 9
SUPPORT-INVENTORY COST CURVES
BUFFER BASED ON HOLDING COST COMPARISON
WARNER ROBINS - 1500 ITEMS

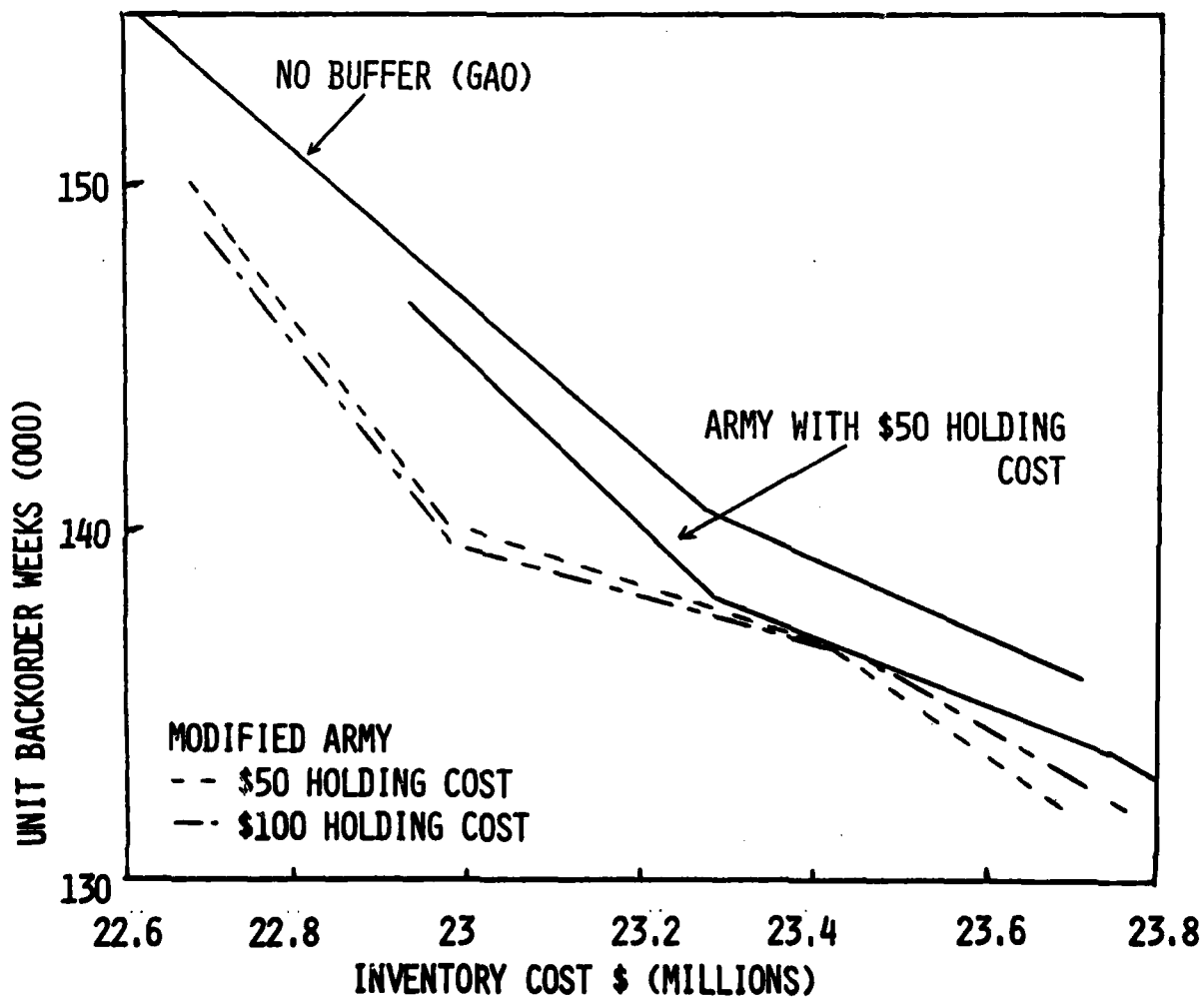


FIGURE 10
SUPPORT-INVENTORY COST CURVES
COMPARISON OF BETTER POLICIES
OKLAHOMA CITY - 1500 ITEMS

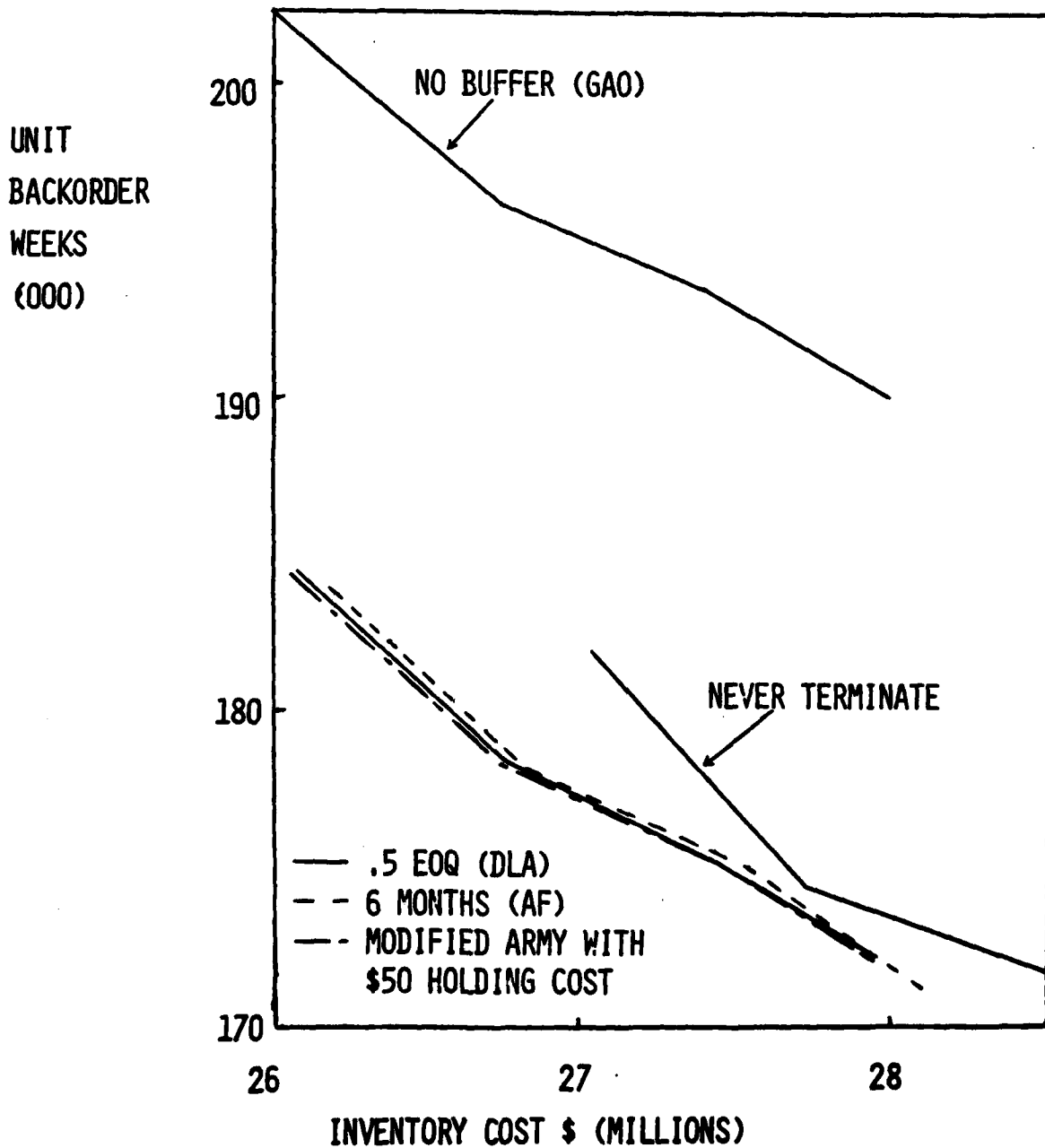
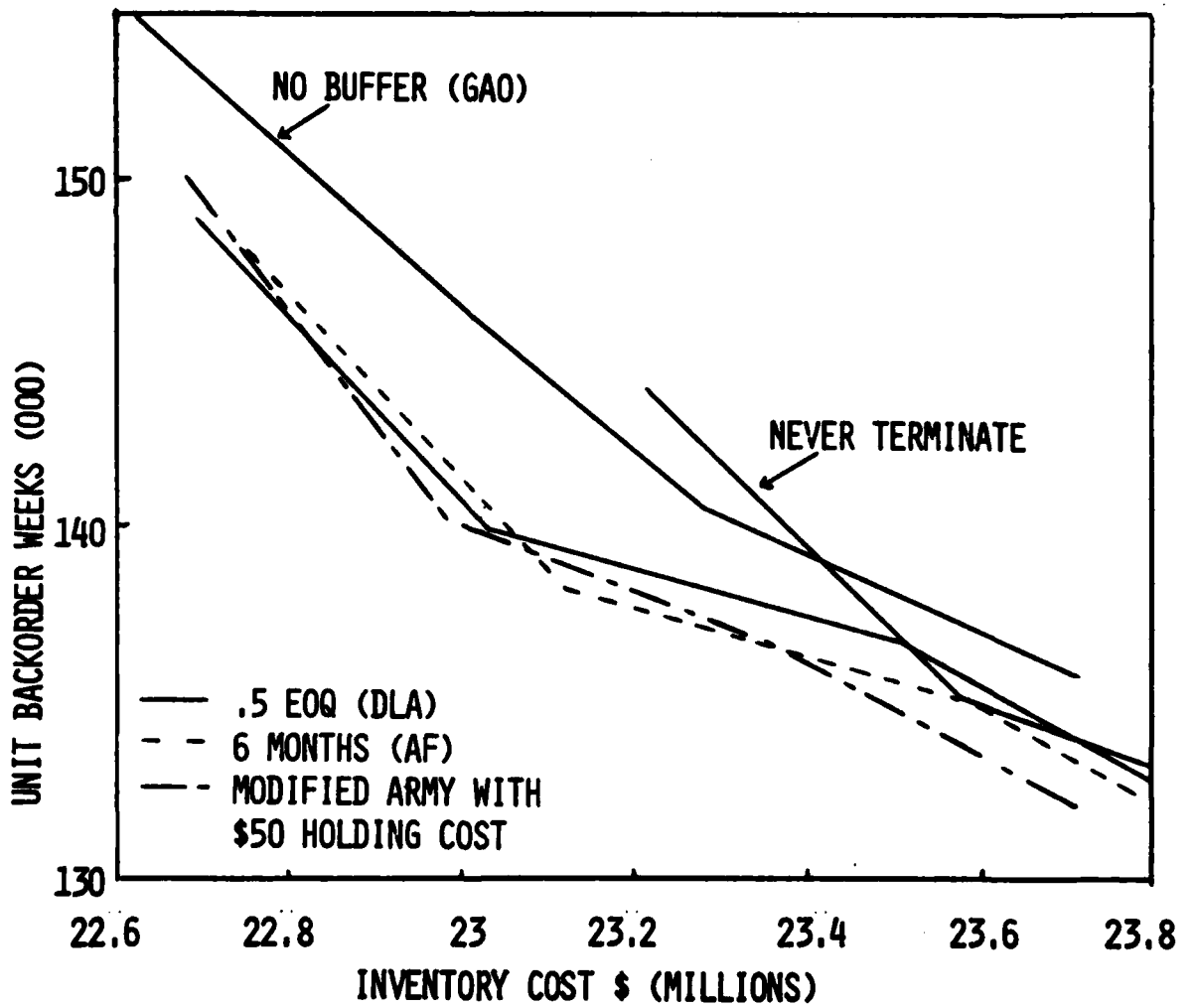


FIGURE 11
 SUPPORT-INVENTORY COST CURVES
 COMPARISON OF BETTER POLICIES
 WARNER ROBINS - 1500 ITEMS



Buffer Based on Holding Cost Comparison: Figures 8 and 9 show the backorder versus inventory cost curves for the buffers based on holding cost. Again the result when no buffer is used is shown for comparison purposes and again it does poorly. The modified Army policy, additional holding cost compared to \$50 termination cost, provides better support than the Army policy, additional holding cost versus \$50 termination cost and additional backorder costs.

The cost of termination at \$50 was an arbitrary figure chosen as it was a minimum cost for those order actions repeated when a purchase request is canceled or adjusted. Since \$100 was suggested as a more appropriate figure for termination cost, the modified Army policy was simulated using \$100. The support-inventory cost curves shown in Figures 8 and 9 were slightly different from using the same policy with \$50 but neither curve was consistently better. However, both curves for the modified Army policy were better than the Army policy.

The modified Army policy is used in the final comparison of best policies. Although this study does not yield better support-inventory cost curves with the pure Army policy, the cost of a backorder used may have affected the result. If a true cost of a back-order was available, the results could be different.

Comparison of the Better Policies: There is no best policy. Figures 10 and 11 show the support-inventory cost curves for the best, or one of the better, policies from each group of policies already discussed. The policies of no buffer and never terminating are shown for comparison and neither does well.

The support-inventory cost curves and volume and size of terminations demonstrate two things. There is a need for a buffer zone. Adjusting PRs is better than canceling PRs. However, simulation is not capable of determining the best policy for generating termination notices with samples of 1500 items.

RECOMMENDATIONS AND SUMMARY

There were three major findings in this study.

1. The GAO recommendation of no buffer is not cost effective.
2. The Air Force policy of six months buffer for items with over \$500 annual demand and twelve months for items with under \$500 annual demand and does as well as any other method recommended and should be continued.
3. The best action for the Air Force to take when a termination notice is generated is to adjust the purchase request so the inventory position equals the requirements objective. This is different from the current Air Force policy of adjusting the purchase request until the inventory position equals the termination level.