2126

117804

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

PROCUREMENT, LOGISTICS,
AND READINESS DIVISION

MARCH 15, 1982

Dr. Donald P. Hearth
Director, Langley Research Center
National Aeronautics and Space
Administration

117804

Dear Dr. Hearth:

Subject: The Requirements Determination Process Can Be Improved At NASA's Langley Research Center (PLRD-82-56)

We have completed our review of the requirements determination process for stores stocks at the National Aeronautics and Space Administration's (NASA's) Langley Research Center. Our objective was to determine the accuracy and reasonableness of the data elements and methods used to compute requirements.

Langley manages a stores stock inventory of about 8,000 items with an inventory value of about $2.6 million. Stores stock items consist of general support type items of an expendable nature. As such, Langley uses the Economic Order Quantity (EOQ) method to determine when and how much to buy. The EOQ principle was designed to optimize the tradeoffs between the cost of carrying on-hand stock and the cost of repetitive procurement. Improper decisions concerning when and how much to buy not only result in unnecessary inventory management costs, but also cause the inventory management activity to maintain and store either too much or too little stock. In either case, resources are not used prudently, and the benefits of optimum stock levels are lost.

We selected a statistical sample of 50 stores stock items and used these items as the basis for evaluating Langley's demand and leadtime forecasting methods, safety level requirements, and EOQ method. We later reduced the sample to 46 items because the low demand for 4 items resulted in a zero stockage objective.

To improve the requirements determination process, we believe that you should

--change the demand forecasting technique from a moving average to a weighted average,

(943125)

720966

--use actual leadtime data in forecasting procurement leadtime,

--reduce manual adjustments to computed replenishment orders,

--relate safety stock levels to the mission essentiality of individual stock items, and

--revise the EOQ method to include the cost of being out of stock.

The above issues and corresponding conclusions are discussed in detail in enclosure I. Although we made our review only at Langley, we believe that these matters may also apply to other NASA inventory management activities. For that reason, we are sending copies of the report to the NASA Administrator.

We discussed the results of our review with Langley officials. They generally agreed with our conclusions and provided comments on actions planned to correct the noted deficiencies. We have incorporated their comments, as appropriate, in the report.

We appreciate the cooperation shown to our staff by Langley officials and would like to receive your comments on the findings and planned corrective actions. If you have any questions or wish to further discuss the reported matters, we would be pleased to meet with you.

Sincerely yours,

Henry W. Connor
Senior Associate Director

Enclosures - 4

REQUIREMENTS AREAS NEEDING IMPROVEMENT AT NASA's LANGLEY RESEARCH CENTER

DEMAND FORECASTING SHOULD USE WEIGHTED AVERAGES

Accurate demand forecasting is an integral element of an efficient, effective supply system. Without accurate forecasting, needed items may not be bought in quantities sufficient to meet customer needs, or purchased quantities may prove excessive. In either case, valuable resources are not used prudently.

Forecasting demand is not an easy task because item demands are seldom constant. They can fluctuate due to mission changes, systems being phased into and out of the inventory, and a host of other reasons. Thus, the forecasting method used should ensure that sufficient but not excessive stocks are available to meet an agency's needs.

There are various forecasting techniques, ranging from relative simple methods--such as a moving average--to more complex methods involving exponential smoothing techniques that apply weighting factors to demand observations based on the currentness and frequency of demand.

To forecast demands, Langley Research Center uses a 12-month moving average of past demands. A moving average method best suits a situation where demands are relatively constant and thus predictable. However, such is not the case at Langley. For the most part, Langley's stores stock items have erratic demand patterns.

Previously, we have reported that when there are wide fluctuations in demands, a weighted average method of forecasting is best, because it responds quicker to item trends than does a moving average method. Department of Defense studies have concluded that a forecasting system which uses varying weighting factors is more responsive and accurate than a system which uses a moving average as the basis for forecasting demands. Additionally, an October 1980 Defense study identified inaccurate demand forecasting as the major contributor to long supply situations.

At the time of our review, about 30 percent (2,433) of the 8,000 stores stock items managed by Langley were in long supply. These items represented about 17 percent ($454,000) of the $2.6 million stores stock inventory.

While we could not quantify the extent that the forecasting method contributed to the long supply situations, the fact that Langley's forecasting method does not rapidly respond to changes in demand no doubt was a factor.

Langley officials said that although a weighted average forecasting method would be responsive to cyclical demand patterns, NASA studies have found no significant benefits from using this method. We followed up on the NASA studies and were advised that no formal studies, as such, had been performed. However, limited tests on the use of a weighted average forecasting method for selected items had not shown significant benefits.

In our opinion, such limited tests should not be the basis for not using a forecasting method which has been shown to provide more accurate and responsive forecasts and can reduce long supply situations.

PROCUREMENT LEADTIME FORECASTING SHOULD CONSIDER ACTUAL LEADTIME DATA

Procurement leadtime is the period between initiation of an order and receipt of the stock. As such, leadtime dictates the amount of stock which must be on hand to meet demands during the period an activity is awaiting receipt of the ordered items. If the leadtime is overstated, the corresponding requirements are overstated, and if the leadtime is understated, an activity risks not being able to meet customer demands.

Langley Research Center assigns item leadtimes in 30-day increments. Generally, an item's leadtime is initially established as 30 days; if experience shows it to be longer, the leadtime will be increased to 60 days, or 90 days, or more. However, item managers' reviews of the leadtimes are infrequent as evidenced by the fact that only 112 of approximately 8,000 line items in stores inventory were updated during the 12-month period ended August 1981.

Of the 46 stock items we selected for review (see encl. II), 32 had at least one procurement order and delivery receipt during the last year. A comparison of actual leadtime with system leadtime used to compute requirements showed that the actual leadtime was less than the system leadtime for 21 items, and that the actual leadtime was greater than the system leadtime for the remaining 11 items. As a result, leadtime requirements were overstated about $560 and understated about $375 for the items reviewed. (See encl. III.) When the above results are projected to the universe of stores stock items, we estimate that leadtime requirements for 3,347 items were overstated $89,000 and for 1,753 items were understated $60,000. (See encl. IV.)

Langley officials told us that item managers will be required to update the leadtimes at the time an item is reviewed for reorder. The officials also said that the leadtime will be determined by averaging the last receipt leadtime data with the historical leadtime data to arrive at a current leadtime in terms of actual days rather than increments of 30 days.

COMPUTED ORDER QUANTITIES ARE FREQUENTLY MANUALLY ADJUSTED

The purpose of EOQ is to optimize replenishment order quantities so as to minimize inventory procurement and carrying costs. Buying a quantity different from that computed under EOQ can negate these benefits. Langley's EOQ process is designed to allow automated stock ordering with little intervention by managers. However, the computed quantities are frequently adjusted by Langley's five item managers. Shown below is the item managers' estimate of the percentage of manual adjustments to computed EOQ quantities.

Item manager	Manual adjustments (percent)
1	15
2	100
3	40
4	75
5	75

Although several reasons were given for the adjustments, a change in demand was the reason most frequently cited by the managers. Other less frequently cited reasons for the adjustments included minimum order quantity and price discount. We reviewed 51 General Services Administration and 31 open market replenishment orders and determined that none of the orders from General Services were manually adjusted. However, 28 of the 31 open market purchases orders 1/ were adjusted, primarily because of demand changes.

In a majority of the cases, the order quantities were adjusted downward. While we applaud the efforts of the item managers not to buy more stock than is needed, the extensive review and adjustment process would be lessened if Langley's demand and leadtime forecasting methods were more accurate.

1/Open market purchases account for about 50 percent of Langley's annual purchase expenditures.

Langley officials agreed with our observations concerning the frequent manual adjustments made to replenishment order quantities. They advised us that the item managers have been instructed not to adjust the quantities unless a valid reason exists and the reason has been documented.

SAFETY LEVEL DETERMINATIONS SHOULD CONSIDER INDIVIDUAL ITEM CHARACTERISTICS

Safety level stock permits continuous operations in the event of delivery delays or unpredicted demand increases. In other words, safety level stock is added protection against the unanticipated.

Safety level stock can represent a sizable investment in material that may never be used. On the basis of the 46 sample items reviewed, we estimate that Langley's safety stock investment is $310,000 or about 12 percent of the stores stock inventory. When such an investment is made, managers should ensure that it is not excessive but, at the same time, sufficient to guard against out-of-stock situations caused by unanticipated demand surges and interrupted deliveries of essential items.

Langley's method for determining the amount of safety level stock does not provide these assurances because it bases the safety level requirement (1 or 2 months) on the length of the EOQ period rather than on the characteristics of individual items. The rationale for basing the safety level amount on the EOQ period is that items ordered more frequently involve larger dollar buys and must be procured competitively. This, in turn, lengthens the leadtime and increases the chance of encountering delivery delays.

Langley's safety level formula does not consider such item characteristics as demand and leadtime variance or item essentiality. This means that all items in the inventory are considered equally essential in terms of the number of out-of-stock situations Langley is willing to accept. However, the nature of some items makes it questionable as to whether a safety level is needed. For example, in our sample, such items as paper bags, garbage cans, graph paper, pencils, envelopes, lacquer, and staples had safety level stock. We doubt whether Langley's mission would be adversely affected if some of these items were out of stock. Obviously, Langley benefits by having a safety level on all items because it aids in achieving a high requisition fill rate. However, the more important concerns should be: Is a safety level needed for non-essential type items and does the safety level investment represent a prudent use of resources?

Langley officials commented that the safety level amount is fixed by NASA Headquarters as part of the EOQ formula and that the need for safety levels will always be questioned due to the different types of ongoing projects at Langley. Thus, not having an item, such as copy paper, could be as critical as not having an electronic part.

In our opinion, the key is for Langley to first identify those stocked items which are essential to mission accomplishment. There are various safety level formulas which distinguish among varying levels of essentiality in computing a safety level requirement. These formulas also consider leadtime and demand variance--important elements in the determination--and the result is a safety level which is based on the importance of items in terms of mission accomplishment.

EOQ MODEL NEEDS TO RECOGNIZE SHORTAGE COSTS

Langley's EOQ model considers only procurement and carrying costs in determining when and how much to buy. It does not consider another very real cost; that is, the cost of being out of stock (commonly called "shortage cost"). As a result, inventory management costs are not minimized, and stock levels are not optimized. Including shortage costs, as well as carrying and procurement costs, in the requirements determination process is a necessity if the true benefits of an EOQ system are to be realized.

Even though Langley does not compute shortage costs, the cost can be implied from the established fill rate objective. For example, a 90-percent fill rate objective means that a 10-percent out-of-stock rate is accepted. This relationship implicitly values the cost of maintaining one unit on backorder at nine times the cost of carrying one unit in inventory for the same length of time.

To determine the effects of not considering shortage costs for the sample items, we compared the inventory management costs using Langley's EOQ model with the inventory management costs using a more refined model which does consider shortage costs. On the basis of this analysis, we estimate that Langley could reduce its annual inventory management costs by 14 percent or $54,000. (See encl. IV.)

Achieving these reduced costs would not require an extensive reprograming effort on Langley's part because the present EOQ model and requirements determination system contains all the data necessary to compute the EOQ, recognizing a shortage cost.

Langley officials commented that NASA Headquarters established the EOQ formulas currently being used by the NASA Centers, and that Headquarters is studying the benefits available from an EOQ method which considers shortage costs as well as procurement and carrying costs.

CONCLUSIONS

Langley Research Center should improve its methods for (1) forecasting demands and leadtime which, in turn, should reduce the extent of manual adjustments to system computed orders; (2) determining safety level requirements; and (3) determining optimal EOQ orders. These improvements would result in a more effective and efficient supply operation and reduce requirements and inventory management costs.

To achieve these improvements, we suggest that the Director, Langley Research Center:

--Change the demand forecasting method from a moving average to a weighted average. This change would improve the accuracy of the forecast, make the forecast more responsive to fluctuating demands, and reduce the incidence of long supply.

--Use actual leadtime data in forecasting procurement leadtime. Langley currently establishes an item's leadtime in 30-day increments without considering the item's actual leadtime. As a result, we estimate that leadtime requirements were overstated $89,000 for 3,347 items and understated $60,000 for 1,753 items.

--Reduce manual adjustments to computed replenishment orders. Primarily because of inadequate demand and leadtime forecasting, item managers adjust the system-computed order quantities. While most of the adjustments are of a downward nature and appear to be reasonable, we believe that the recommended forecasting methods described above would reduce the need for manual adjustments.

--Relate safety stock levels to mission item essentiality and demand and leadtime variances. The safety level requirement is now based on the length of the EOQ period. Thus, all items have either a 1- or 2-month safety level requirement. Such a method of determination does not consider variability in demand or leadtime--the purpose for a safety level--or whether a safety level is needed based on its essentiality to mission accomplishment.

--Revise the EOQ method to include shortage costs as well as procurement and carrying costs for determining optimal stockage levels and minimal inventory management costs. The EOQ method currently used by Langley does not consider shortage costs as a factor in the EOQ determination process. Our computations, using a model which does consider shortage costs, showed that Langley could save an estimated $54,000 annually in management costs by adopting a similar method.

LIST OF 46 RANDOMLY SELECTED SAMPLE ITEMS AT LANGLEY RESEARCH CENTER

Sample control No.	Stock No.	Description
31	4204-01-021-9594	cartridge, respirator
38	4710-00-882-8198	tube, aluminum
62	4730-00-231-5647	fitting, galvanized
70	4730-00-277-2144	bushing, galvanized
85	4730-00-826-6513	fitting, galvanized plug
91	4730-00-993-4991	male union
96	4940-00-989-1440	gun, air
97	5110-00-223-4972	frame
105	5130-00-580-7946	wheel, abrasive
123	5305-00-052-6887	screw, machine
128	5305-00-165-8074	screw, steel cap
130	5305-00-226-5855	screw
131	5305-00-267-8974	screw, steel cap
146	5305-00-920-0850	screw, machine
155	5305-00-993-1851	screw, machine
156	5305-01-004-8296	screw
159	5306-00-042-6926	bolts, machine
176	5315-00-857-2605	staple
177	5330-00-559-6182	o-ring
200	5905-00-111-8357	resistor
217	5905-00-617-5096	resistor
222	5905-01-000-1022	resistor
230	5910-00-925-3615	capacitor

Sample control No.	Stock No.	Description
249	5935-00-660-7008	receptacle
254	5935-00-902-9964	MS 3112E-14-12P
275	5962-01-004-1272	microcurcuit
279	5970-00-725-0629	sleeving
284	5975-00-178-1223	conduit
286	5975-00-284-5971	conduit
291	5975-00-989-0143	cabinet
293	5975-01-052-9827	coupling
314	6210-00-715-5930	indicator light
323	6625-00-413-6087	ammeter
341	7240-00-160-0440	garbage can
347	7510-00-286-5755	pencil
355	7530-00-014-0180	envelope, wallet
361	7530-00-616-4155	graph paper
370	8010-00-775-5804	lacquer
371	8020-00-205-6510	brush
374	8105-00-281-1156	paper bags
378	8415-00-401-7884	gloves
385	9330-00-689-8472	bakelite sheet
388	9505-00-199-7823	wire, steel carbon
392	9510-00-069-3806	steel bar
411	9530-00-814-2206	brass bar
417	9540-00-251-2563	aluminum angle

COMPARISON OF ACTUAL AND SYSTEM LEADTIME

REQUIREMENTS FOR 32 SAMPLE ITEMS

Stock No.	System leadtime	Actual leadtime	Requirements based on system leadtime	Requirements based on actual leadtime	Increased/decreased (-) requirements (note a) Quantity	Increased/decreased (-) requirements (note a) Dollars (note b)
	----------(days)	-------				
4240-00-021-9594	30	4	196	184	-12	$ -25.68
4710-00-882-8198	60	29	120	112	-8	-5.76
4730-00-277-2144	30	6	14	13	-1	-1.09
4730-00-933-4991	90	53	80	74	-6	-15.36
4940-00-989-1440	60	23	132	118	-14	-85.12
5110-00-223-4972	30	33	70	71	1	3.03
5305-00-165-8074	30	242	14	21	7	92.75
5305-00-226-5855	30	56	14	15	1	10.30
5305-00-993-1851	30	16	14	14	-	-
5305-01-004-8296	30	23	14	14	-	-
5306-00-042-6926	30	25	37	36	-1	-.05
5315-00-857-2605	30	19	28	27	-1	-1.50
5330-00-559-6182	30	26	84	83	-1	-.04
5905-00-111-8357	30	21	182	178	-4	-.16
5910-00-925-3615	30	14	56	54	-2	-.86
5935-00-660-7008	30	35	98	99	1	2.68
5935-00-902-9964	60	22	120	104	-16	-93.76
5975-01-052-9827	60	41	60	57	-3	-4.80
6210-00-715-5930	60	38	150	143	-7	-4.76
6625-00-413-6087	30	73	33	39	6	162.78
6850-01-000-0787	30	33	0	0	-	-

ENCLOSURE III

Stock No.	System leadtime	Actual leadtime	Requirements based on system leadtime	Requirements based on actual leadtime	Increased/decreased (-) requirements Quantity	Increased/decreased (-) requirements Dollars
	--------(days)--------					
7240-00-160-0440	30	102	53	55	2	$35.00
7510-00-286-5755	30	54	1,287	1,381	94	47.00
7530-00-014-0180	60	16	15	14	-1	-17.52
7530-00-616-4155	60	37	108	101	-7	-67.48
8020-00-205-6510	30	50	154	161	7	10.50
8105-00-281-1156	30	50	28	29	1	3.32
8415-00-401-7884	30	15	231	221	-10	-38.20
9330-00-689-8472	60	30	9	8	-1	-153.30
9505-00-199-7823	30	21	14	14	-	-
9510-00-069-3806	60	18	12	11	-1	-43.98
9540-00-251-2563	30	33	77	78	1	7.66

a/For the sample items, increased requirements totaled $559.42 and decreased requirements totaled $375.02.

b/Computed by multiplying the quantity difference by the unit price.

ENCLOSURE III

PROJECTIONS OF OVERSTATED AND UNDERSTATED REQUIREMENTS AND REDUCED INVENTORY MANAGEMENT COSTS

Overstated/Understated Requirements

Comparison of actual and system leadtimes:

	Projection (note a)	Range(note a) Low	High
Number of items with overstated requirements as a result of using system leadtime instead of actual leadtime	3,347	2,292	4,402
Dollar value of overstated requirements as a result of using system leadtime instead of actual leadtime	$ 89,155	$ 24,457	$153,852
Number of items with understated requirements as a result of using system leadtime instead of actual leadtime	1,753	849	2,657
Dollar value of understated requirements as a result of using system leadtime instead of actual leadtime	$ 59,767	$ 375	$119,504

Reduced Inventory Management Costs

Inventory management techniques:

Annual inventory management costs using Langley's EOQ model	$377,112	$298,716	$455,508
Annual inventory management costs using alternative EOQ model	$323,052	$236,580	$409,524
Annual decreased inventory management costs resulting from use of alternative EOQ model	$ 54,060		

a/The projection and range were based on a 95-percent confidence level.