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LOGAM
EXECUTIVE SUMMARY
VOLUME I

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February 1980

U.S. ARMY MISSILE COMMAND
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This executive summary describes the Logistic Analysis Model (LOGAM) and its use for evaluating logistic operations as applied to US Army materiel systems The objective is to develop methodology for generating quantitative data for analysis of activities necessary to equip, operate, maintain, and support a materiel system. LOGAM is a deterministic model, analytical in design through its sensitivity feature, and highly versatile in its ability to evaluate many alternatives rapidly and inexpensively. Through the sensitivity median,

ABSTRACT (continued)

ABSTRACT (Concluded)

support alternatives are tested for evaluating life cycle costs and for recommending optimum repair levels; repair versus discard at failure; manpower, provisioning and test equipment requirements; table of organization and equipment adjustment or development; and other operational elements by quantities and costs.

FORWARD

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LOGISTIC ANALYSIS MODEL

(LOGAM)

VOLUME I
EXECUTIVE SUMMARY
ABSTRACT

The Logistic Analysis Model LOGAM can be applied in two modes of operation. First as its predecessor LOCAM 5, it can be operated as a maintenance cost analysis model including its sensitivity testing feature and summation of support costs for several theaters of operation on an individual LRU basis. Secondly, it can analyze operations and support functions and costs on a life cycle basis. In this latter mode, the analysis pertains to a TOE organization and a single theater of operations. The model first computes the maintenance costs for the equipment in the TOE organization and presents the output in the same format as the output of its predecessor LOCAM 5. It then presents a formatted output of the operational costs as defined in DA Pamphlet 11-4 and combines the maintenance costs with the operational costs to produce the resulting life cycle operations and support costs.

1. INTRODUCTION

The Logistic Analysis Model has been developed over the years from the Cost Analysis of Army Maintenance Policies model (COAMP) through the Logistic Cost Analysis Model (LOCAM) to the current LOGAM model. This evolution is shown in Figure 1. The COAMP model was basically to analyze maintenance policies, the LOCAM model to evaluate prime system support costs and the LOGAM model the prime system and all support personnel and supporting systems costs. LOGAM is an operations and support model.

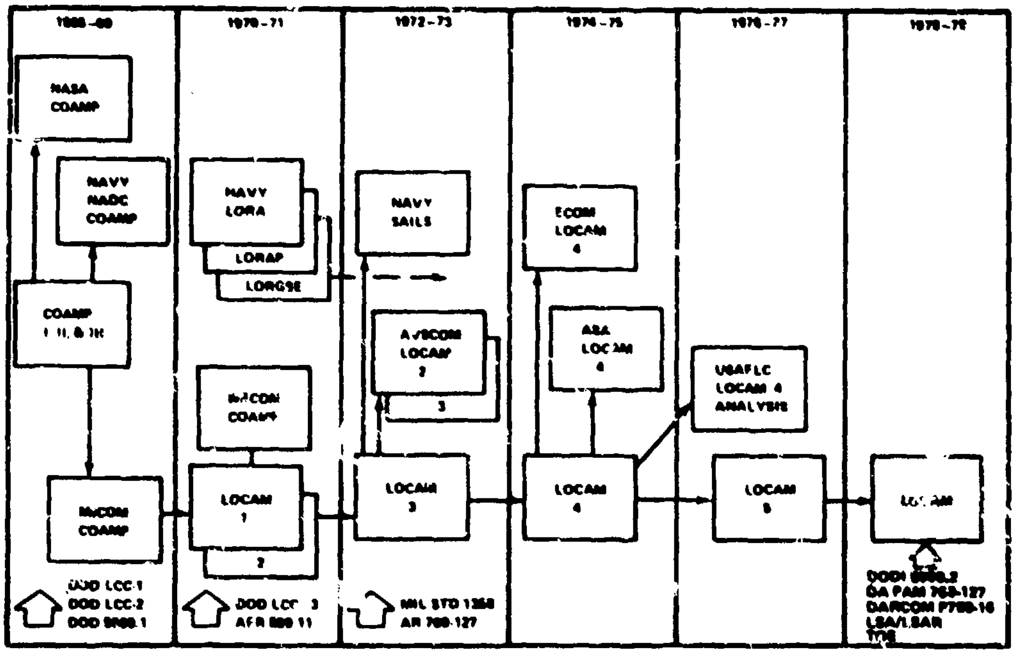


FIGURE 1. EVOLUTION OF U.S. ARMY MISSILE COMMAND (MICOM) LOCAM.

In the LOGAM model the objective is to bring together the elements of the:

a. Materiel System

b. Support Equipment

c. Support organization.

The materiel system and organizational equipment are developed with their operator and maintenance support requirements. These form the nucleus of the organization to which Army standard rates for overhead personnel are added to develop a total TOE.

2. GENERAL DESCRIPTION

Figure 2 shows the operational and support cost elements evaluated in LOGAM. To show the expansion of LOGAM from LOCAM, the boxes marked with an * were developed in LOCAM. The basic headings of military personnel, consumption depot maintenance, modifications materiel, other direct support operations, and indirect support operations indicate the detail of output data that is to be accommodated in LOGAM.

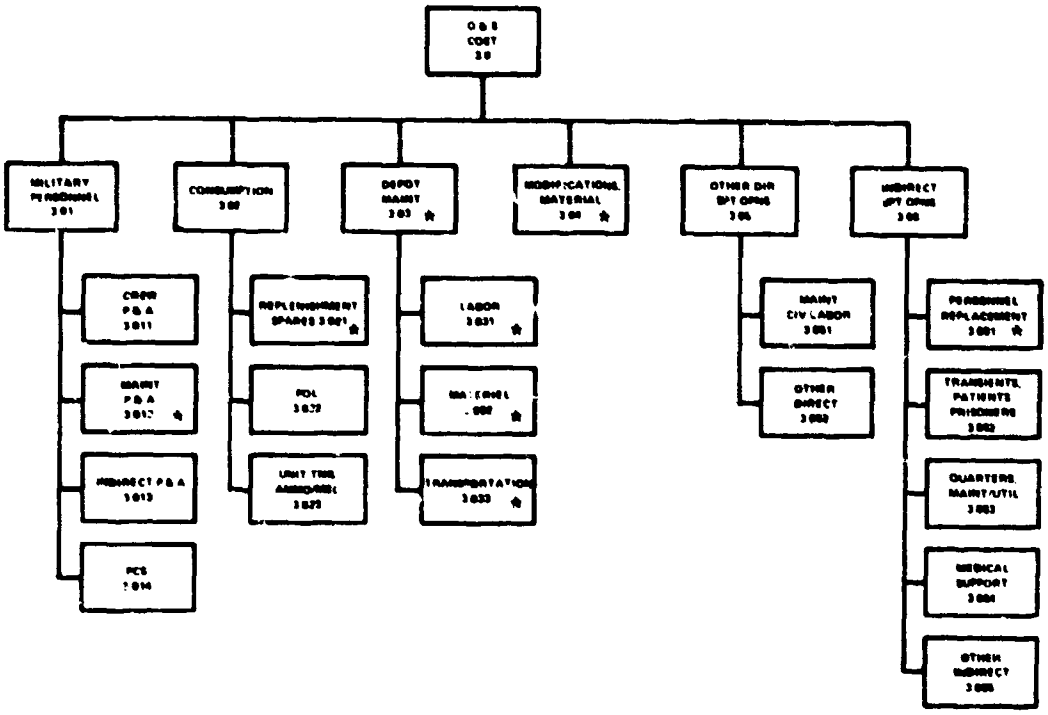


FIGURE 2. OPERATING AND SUPPORT COST ELEMENT STRUCTURE.

3. LOGAM SYSTEMS ANALYSIS

To perform our analysis with the LOGAM model we establish a simulation of real life activities for the prime system to include the expected deployment for the system, the support structure, bring into play the current basic factors for support of missile system, develop individual line replacement unit data factors and perform a LOGAM system synthesis. These may be summarized as follows:

a. Simulate Expected System Deployment

b. Establish Support Structure

c. Introduce Basic Factors for Analysis

d. Develop Individual Line Replaceable Unit Data Factors

e. Perform System Sunthesis.

The nucleus for system synthesis, therefore, becomes the deployment scenario, support structure, basic data factors and the individual line replaceable unit data.

3.1 Deployment may be subdivided into various locations:

a. The United States Army Europe (USAREUR)

b. The Continental United States (CONUS)

c. The United States Army Pacific (USARPAC)

When performing maintenance analysis only, these may be combined in a single run and baseline support cost totals obtained for the sum of all locations. LRU support cost totals may be obtained on an individual LRU basis and sensitivity analysis can be performed. When operations and support costs are investigated, it is required that the TOE for a specific organization in a single theater of operations be investigated. If more than one theater is involved, successive runs are required due to the variations in the TOE's for different locations.

3.2 The support structure is developed by establishing organization direct, general and depot support units, pipelines are determined, and alternative maintenance policies selected.

3.3 The basic data for inputting the LOGAM model includes many factors that are relatively constant. That is, they are changed only about once a year. LOGAM model inputs that are representative of basic data factors are as follows:

a. Maintenance manpower labor rates

b. Training costs

c. Shipping costs

d. Storage costs

e. Supply administration costs

f. Life cycle (years)

g. Factory lead times for consumables

h. Equipment operating time fractions

i. Manpower productivity factors

j. Work weeks.

3.4 Included in the individual LRU data category are those input factors which are likely to vary from line replaceable unit to line replaceable unit. Factors representative of this variable type of data requirements are as follows:

a. LRU, Module, Part Cost

b. Reliability (LRU removal rates)

c. Mean Time to Repair (MTTR)

d. Test and Repair Times

e. Physical Characteristics (weight, cube)

f. Modification Work Orders

g. Other Equipment Identifying Data Factors.

3.5 Upon integrating the deployment, support structure, and basic and LRU data, the total materiel system is synthesized with its test equipment, personnel, support materiel, administrative functions, pipeline times, repair turn-around and maintenance-incident rates.

4. SYSTEM ENGINEERING APPROACH TO LOGISTIC EVALUATION

Applications of LOGAM involve a system engineering approach to the evaluation of alternative logistic postures costs. Referring to Figure 3, we feel that the systems engineering approach parallels the support cost effectiveness study flow also shown in Figure 3 and the systems engineering approach can be subdivided into several distinct activities:

a. Establish requirements

b. Establish the data base

c. Define alternative logistics postures

d. Conduct trade-off evaluation of alternatives through logistics modeling techniques and sensitivity analysis.

e. Evaluate the results of trade-off studies

f. Present results and recommendations for cost effective approaches to logistics support.

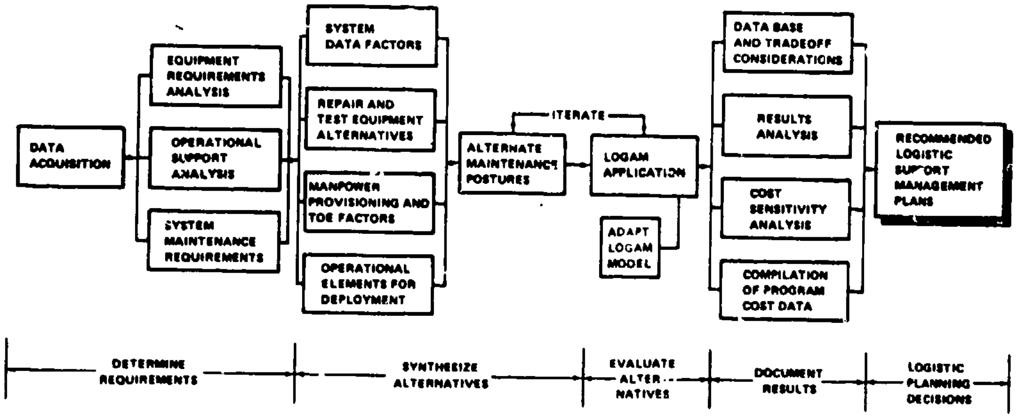


FIGURE 3. SUPPORT COST EFFECTIVENESS STUDY FLOW.

5. QUESTION RELATED TO DESIGN COST, PRODUCTION AND MAINTENANCE

There are many questions related to logistics that a project manager wants answered. Here are some that may be critical to a system's success:

a. What spares should be stocked and where located?

b. How much reliability and maintainability should be designed into the equipment?

c. Is modular design feasible?

d. Is repair or throwaway feasible and at what level?

e. How many maintenance personnel are needed at field, intermediate, and depot levels?

f. What is the optimum operating and support cost package?

To develop needed answers, the LOGAM model can be used to address a variety of logistic support functions, for example:

a. From a wide variety of support probabilities determine repair at Equipment, Direct Support, General Support, Depot or Contractor facility.

b. Study effects of pipeline lengths and transport costs.

c. Balance cost to repair versus downtime cost. Optimize repair time (and thus cost).

d. Evaluate administrative and clerical costs of supply and replenishment.

e. Develop TOE personnel and equipment quantities.

f. Study operation, maintenance, and support manpower costs.

g. Allocation of manpower, provisioning, and maintenance organization.

h. Investigate the cost effect of replenishment procedures.

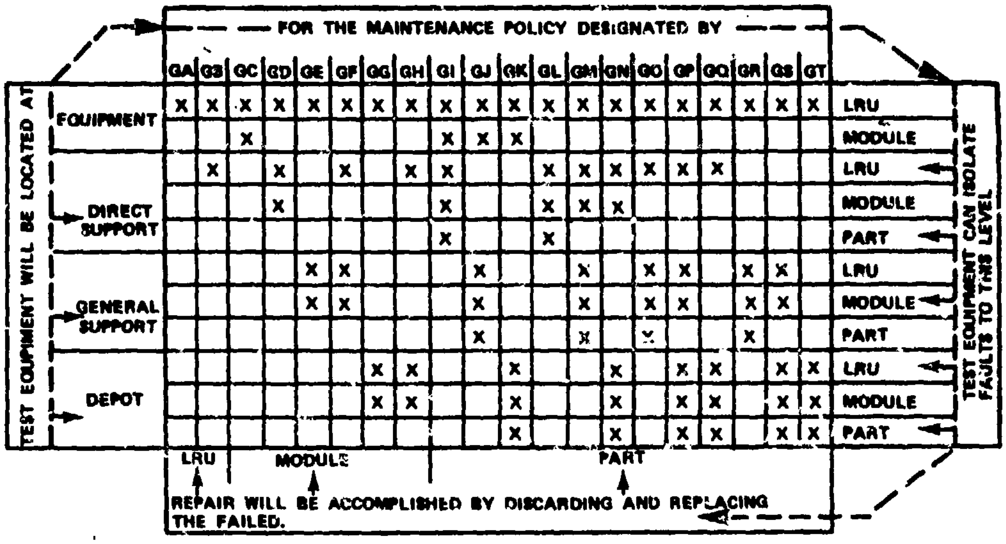
i. Determine sensitivity of support concepts to critical parameters.

j. Determine feasibility of repair versus throwaway.

k. Evaluate engineering design/logistic support interfaces. There are many other outputs we can derive, especially those related to provisioning, manpower and support policies.

6. MAINTENANCE POLICY EXAMPLE

LOGAM has the capability of modeling twenty maintenance policies or combinations thereof, commonly used in support of a system. In Figure 4, an X indicates that some action occurs as described in the comments around the perimeter of the matrix. For better understanding of the matrix shown in Figure 4, the maintenance policy GP is shown in Figure 5.



FOR THE MAINTENANCE POLICY DESIGNATED BY

TEST EQUIPMENT WILL BE LOCATED AT

	GA	GB	GC	GD	GE	GF	GG	GH	GI	GJ	GK	GL	GM	GN	GO	GP	GQ	GR	GS	GT	
EQUIPMENT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	LRU
			X						X	X	X										MODULE
DIRECT SUPPORT		X		X		X		X	X			X	X	X	X	X	X				LRU
				X					X			X	X	X							MODULE
									X			X									PART
GENERAL SUPPORT					X	X				X			X		X	X		X	X		LRU
					X	X				X			X		X	X		X	X		MODULE
										X			X		X			X			PART
DEPOT							X	X			X			X		X	X		X	X	LRU
							X	X			X			X		X	X		X	X	MODULE
											X			X		X	X		X	X	PART

TEST EQUIPMENT CAN ISOLATE FAULTS TO THIS LEVEL

LRU MODULE PART

REPAIR WILL BE ACCOMPLISHED BY DISCARDING AND REPLACING THE FAILED.

FIGURE 4. MAINTENANCE POLICY MATRIX.

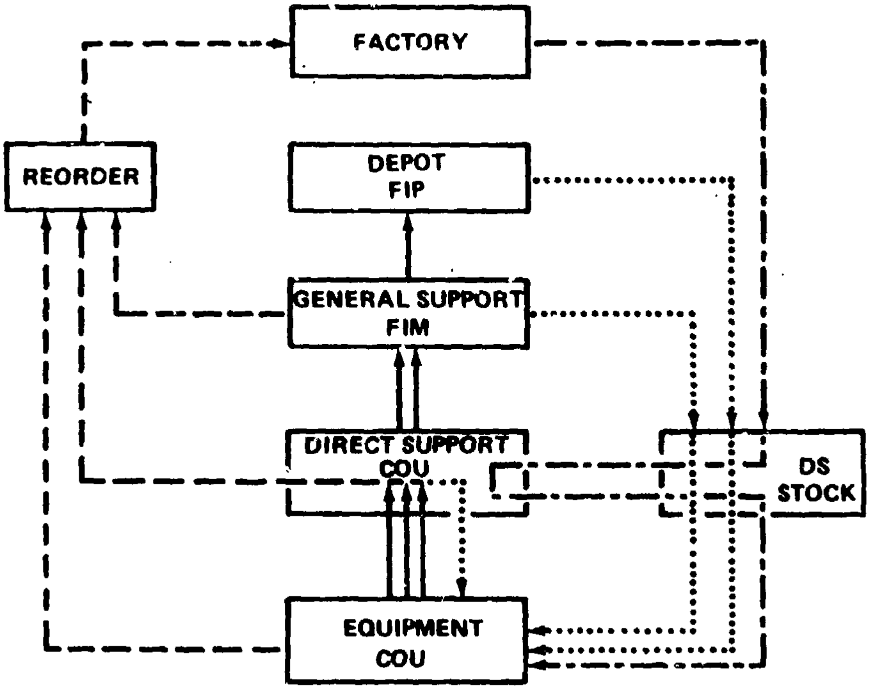


FIGURE 5. MAINTENANCE POLICY GP.

7. PROGRAM OUTPUT

The LOGAM program output can predict life cycle operation and maintenance cost for a specific organization operating as a unit in a particular theater. Inherent and operational availability, manpower requirements, provisioning requirements, and test equipment requirements are also provided whether the model is operated in its maintenance analysis or operations and support modes.

7.1 The model output is used to provide support to the project manager for his requirements in development of logistic plans and analysis. Some of the more important with which we are concerned are:

a. Operations and Support cost plans

b. Integrated Logistic Support plans

c. Army and Department of Defense reports

d. Equipment design planning/analysis

e. Operational analysis

f. Cost effectiveness/analysis studies

7.2 Some examples of data reporting of output of maintenance analysis studies are shown in the next few tables/figures.

In Table 1, data is presented based on two cases where different maintenance policies were analyzed. In Case 1, a portion of the maintenance requirement was performed in the field. In Case 2, all maintenance above organization was performed at the depot. Note the variety of data both recurring and investment.

The same results are present in simpler bar graph form in Figure 6. The model also determines operational and inherent availability. Here A_O is compared for Cases 1 and 2.

The model, when used in the maintenance mode, has a sensitivity feature in which any of the inputs may be increased or decreased to determine the effect of input variation. Figure 7 shows the effect of maintenance incident rate variation.

TABLE 1. EXAMPLE OF DATA TABLE REPORTING ($ IN THOUSANDS)

			Case I	Case II
(A) Ten-Year Operating Costs	Maintenance Manpower	Field	352	-
		Depot	329	1202
	Test Equipment Maintenance		340	251
	Supply Material		8267	9412
	Inventory Management		1188	1188
	Order, Store, Ship, and Handle		138	324
	Subtotal		10,614	12,377
(B) Initial Provision Investment	LRUs		6272	11,866
	Modules/Parts		642	253
	Cost to Enter		294	294
	Subtotal		7208	12,413
(C) Test Equipment Acquisition	Integrated Direct Support Maintenance (IDSM) Test Sets		1000	1000
	Direct Support (DS) Test Sets		263	-
	General Support (GS) Test Sets		220	-
	Depot Test Stations		264	220
	Subtotal		1747	1220
(D) Test Equipment Development	IDSM Test Sets		425	425
	DS Test Sets		1824	-
	Depot/GS Test Stations		1370	3285
	Subtotal		3619	3710
	Total Support Costs		23,188	29,720

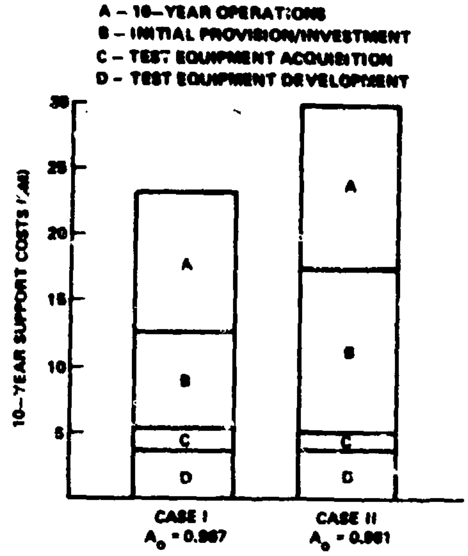


FIGURE 6. EXAMPLE OF BAR GRAPH REPORTING.

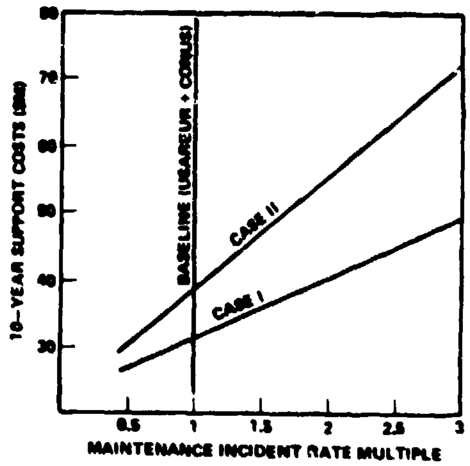


FIGURE 7. EFFECT OF MAINTENANCE INCIDENT RATE VARIATION.

The model also permits more than one input to be varied simultaneously. In Figure 8, maintenance incident rate and the number of deployed systems are varied. The dotted lines reflect the previous results for comparison.

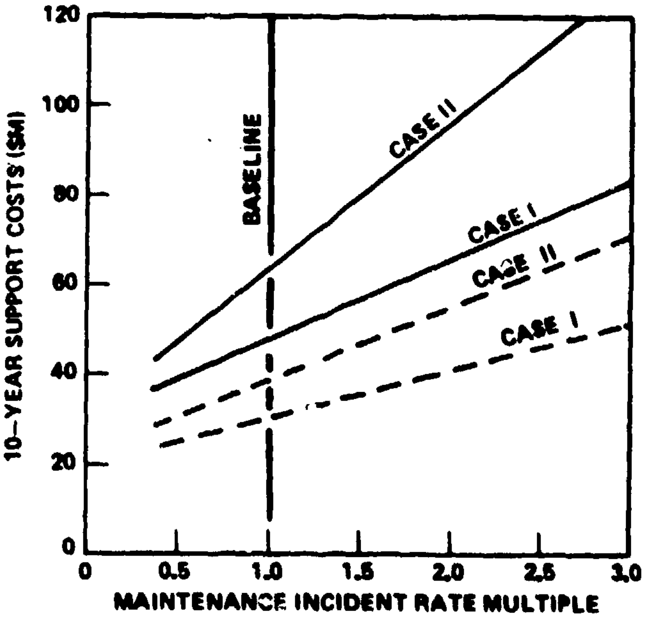


FIGURE 8. EFFECT OF SIMULATANEOUS VARIATION OF MAINTENANCE INCIDENT RATE AND DOUBLING THE NUMBER OF DEPLOYED SYSTEMS.

Since we need to develop a new system from the bottom up, we also must develop the support structure as well. Our test and repair channel development of manpower permits us to identify direct labor requirements for the prime system, support systems, and overhead. Table 2 is one example of prime equipment manpower for field and depot. Based on the maintenance policy, manpower is developed by site and totals shown here. In Case 1, we have two DS sites at 8.08 men each or 16.15 total required. The GS site requires 6.23 men and the depot requirement is 20.1 men. The Case 1 total is 42.48 men. For Case 2, all maintenance is performed at the depot which requires 47.25 men. Of course, we cannot have less than a whole man; therefore, we must round off at each location to the next higher number of men. For example, 8.08 = 9 men.

TABLE 2. SAMPLE TEST AND REPAIR CHANNEL UTILIZATION AND MANPOWER REQUIREMENTS DATA

	DS SITES				GS SITE				DEPOT			
	TEST TIME (HOUR/DAY)	NO. OF TEST MEN	REPAIR TIME (HOUR/DAY)	NO. OF REPAIR MEN	TEST TIME (HOUR/DAY)	NO. OF TEST MEN	REPAIR TIME (HOUR/DAY)	NO. OF REPAIR MEN	TEST TIME (HOUR/DAY)	NO. OF TEST MEN	REPAIR TIME (HOUR/DAY)	NO. OF REPAIR MEN
CASE I	15.4	3.85	16.9	4.23	6.3	1.58	18.6	4.65	30.1	7.53	50.2	12.55
NO. OF MEN PER SITE	8.08				6.23				20.1			
TOTAL MANPOWER	16.15				6.23				20.1 (42.48)			
CASE II									86.6	21.65	102.4	25.60
NO. OF MEN PER SITE									47.25			
TOTAL MANPOWER									47.25			

8. MANPOWER DEVELOPMENT FOR A MATERIEL SYSTEM

In Table 3, the manpower development is accomplished by establishing the table of organization and equipment for the prime system and its supporting equipment. Personnel are established as shown here, *** are those personnel required for operation and maintenance of the prime system, ** show those personnel required to operate and maintain the equipment necessary to support the prime system, * are those overhead personnel added according to Department of Army standards. Typical of these are company commanders, other officers, first sergeant, cooks, etc.

TABLE 3. MANPOWER DEVELOPMENT FOR A MATERIEL SYSTEM

BATTERY HEADQUARTERS
*
*
*
**
**
*

SERVICE PLATOON	FIRING PLATOON (3)
*	*
*	*
*	*
**	***
**	***
**	***
***	***
***	***
**	**

*OVERHEAD PERSONNEL.

**PERSONNEL FOR OPERATION AND SUPPORT OF SUPPORTING EQUIPMENT.

***PERSONNEL FOR OPERATION AND SUPPORT OF THE PRIMARY SYSTEM.

9. DESIGN SUPPORT INTERFACE CONSIDERATIONS

A major problem in design of new systems is the cost to support the system throughout its operation and support life. The value of the LOGAM model is in its use to predict the O&S costs, identify engineering considerations which may affect high support cost and introduce changes to reduce O&S costs prior to product baseline approval. Figure 9 is shown to convey the idea that LOGAM can be applied early in the development cycle and by successive applications prior to production will reduce the chance for costly modifications after a system becomes operational.

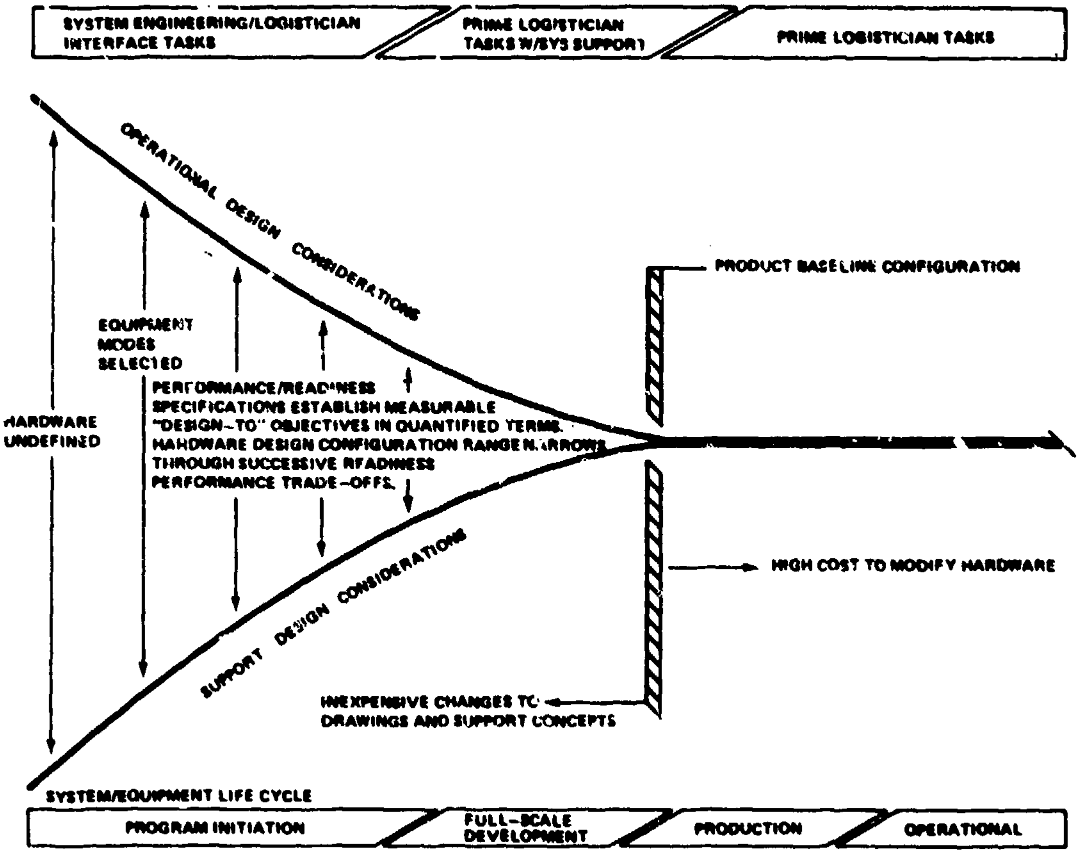


FIGURE 9. DESIGN-SUPPORT INTERFACE CONSIDERATIONS.

10. EFFECT OF MTBMA VARIATION

Figure 10 is an example of the capability to predict O&S costs through a sensitivity evaluation of the mean time between maintenance actions for the cases we have previously shown. We can see that if we can confidently increase the time between maintenance actions to 1.6 times the baseline we can reduce the maintenance life-cycle cost $32.2M to $27.1M for Case I and $41.0M to $32.2M for Case 2. This is over 15 percent for Case I and 21.5 percent for Case 2. Thus, if a R&D program, costing less than $5M for Case I has a high probability of success in increasing the reliability of the system to 1.6 times current baseline, it should be considered.

We can see, therefore, that the design-support interface is highly important. Operational costs must be minimized by goal oriented engineering design and not left to chance. In the LOGAM model, the functions shown in Figure 11 under the T-square are all evaluated and optimized toward cost effective design considerations.

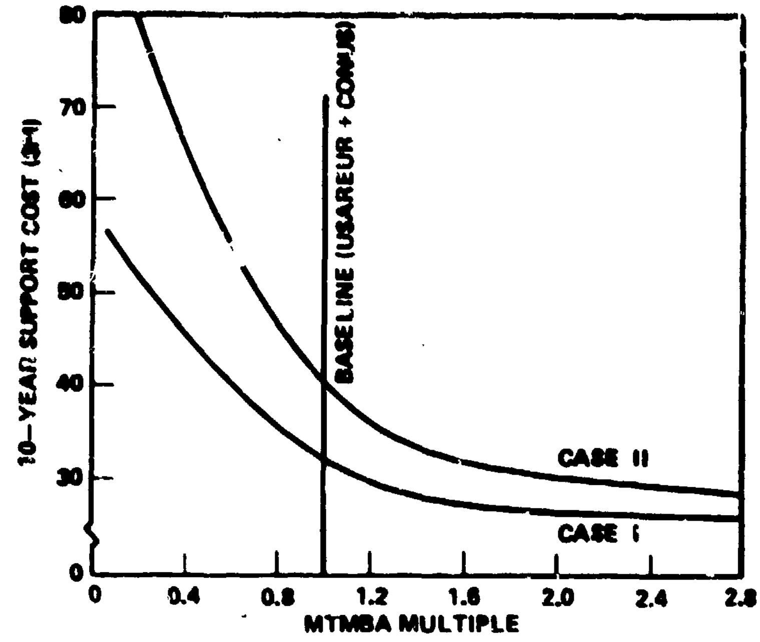


FIGURE 10. EFFECT OF MTBMA VARIATION.

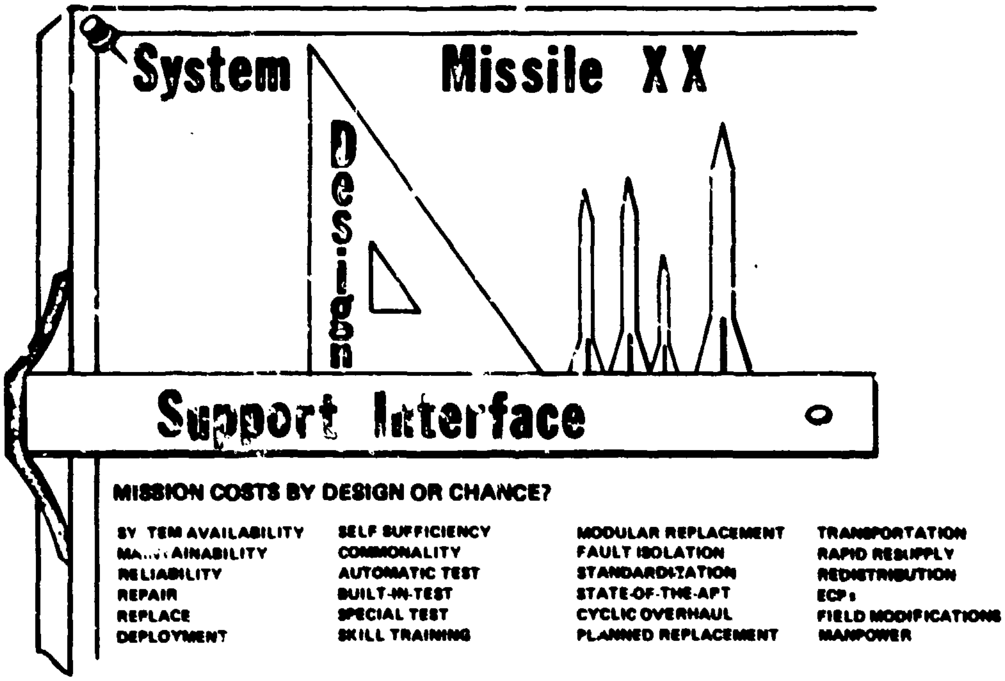


FIGURE 11. COST-EFFECTIVE LOGISTICS.

11. LOGAM LIMITATIONS

LOGAM, although the best of its type, does have limitations. Most prominent of these are as follows:

a. Accuracy of input data (particularly failure rate and equipment utilization data)

b. Improper data usage

c. Interjection of bias

d. Poor assumptions

e. Failure to re-appraise

f. Future uncertainties.

The first of these limitations can be minimized by reducing input data error. The limitations again point out that your results are only as good as your data inputs. We have found that data based on carefully developed design engineering requirements, achievable reliability and maintainability factors, and past and projected logistic applications can minimize these limitations. The results thus developed will influence the design of equipment and manpower systems in such a way that optimum support and cost may be realized when the primary system is fielded.

12. SUMMARY

In summary (see Figure 12), LOGAM can provide the engineer and logistician with data from which they may make enlightened decisions. When used to evaluate design/support considerations, early in the system design, LOGAM may affect decisions that influence the design of equipment such that optimum support may be realized when the prime system is fielded.

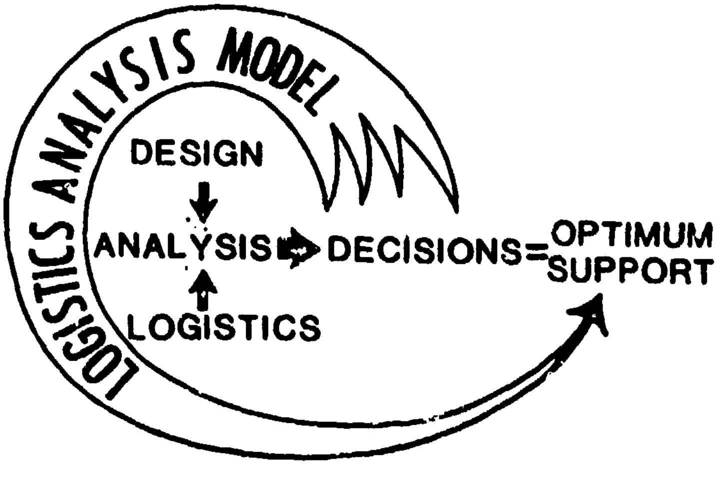


Figure 12. Summary

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