INTERIM TECHNICAL REPORT TR 81-7-329.13

APPLICATION OF ADVANCED DECISION-ANALYTIC TECHNOLOGY TO RAPID DEPLOYMENT JOINT TASK FORCE PROBLEMS

DECISIONS AND DESIGNS INCORPORATED

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by

Robert B. Pirie, Jr., Gary A. Frisvold, and Terry A. Bresnick

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The primary task of this project was to demonstrate the application of advanced decision-analytic technology to the problems of an operational military staff, in this case the Rapid Deployment Joint Task Force (RDJTF) staff. A secondary task was to determine the usefulness of advanced decision-analytic products to the RDJTF staff, and transfer, if possible, a decision-analytic capability for a specific problem to them. As a result of discussions with RDJTF personnel, Decisions and Designs, Inc. (DDI) selected a problem that seemed most promising in terms of applying advanced techniques and of providing the RDJTF with a cont.

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useful product in the near term. This problem concerned the provision of an adequate support architecture in the Persian Gulf/Indian Ocean area for the deployment of the RDJTF. DDI constructed a hierarchical resource allocation model to demonstrate the feasibility of optimizing the support architecture for deployment forces of different sizes, by making trade-offs within and between base structure, prepositioned materiel, and airlift/sealift assets. To avoid classification problems, hypothetical values were assigned to the parameters of the model. However, the base structure sub-model was built in close consultation with members of RDJTF staff, and actual costs and effectiveness estimates were produced. These costs and the effectiveness estimates will greatly facilitate prioritization of support for military construction programs, permit rapid exploration of the usefulness of new proposed base options, and add to understanding whether and how decision-analytic techniques can be transferred to military operational staffs.

The tasks performed on this project so far indicate that the models and techniques developed by DDI are potentially very useful to the RDJTF. Analysis of the models, especially the base structure model, has raised several provocative issues of policy and priority. An account of these will be provided in the classified annex to the final report.

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SUMMARY

Task Objectives

The primary task of this project was to demonstrate the application of advanced decision-analytic technology to the problems of an operational military staff, in this case the Rapid Deployment Joint Task Force (RDJTF) staff. The RDJTF was chosen because of the dynamic nature of the mission and related requirements. A secondary task was to determine the usefulness of advanced decision-analytic products to the RDJTF staff, and to transfer, if possible, a decision-analytic capability for a specific problem to them.

Technical Problem

The technical problem selected was that of resource allocation in support of RDJTF deployment in a contingency operation in the Persian Gulf/Indian Ocean area. Support depends primarily on a mix of bases, prepositioned materiel, and airlift/sealift assets. The RDJTF itself has varying degrees of influence over these resources, from virtually direct control, as in the case of the near-term prepositioned ships (NTPS), to circumstances in which it has strong interest but no real control, as in the case of USAF airlift force improvement programs. An appropriate resource allocation model will permit the RDJTF to determine its own priorities for segments of the support architecture, and to formulate appropriate strategies for using whatever influence or control it has to bring about an optimal outcome. An important example of this is the base structure, where there are redundancies but also unique strategic, tactical and

political aspects associated with different bases. Distributing scarce military construction (milcon) resources among these base locations in an optimal manner is an enormously complex problem. The model of the base structure produced by Decisions and Designs, Inc. (DDI) and provided to the RDJTF is a useful tool to build priority lists, explore potential changes or assess the effect of budget cuts.

General Methodology

The methodology used by DDI to explore the RDJTF support architecture problem is essentially cost/benefit analysis. However, the general model used, called DESIGN, embodies advanced decision-analytic techniques. A complete description of the general model is found in Appendix A.

Technical Results

Cost/benefit models were constructed representing each of the three main components of the support architecture: base structure, prepositioned equipment, and airlift/sealift. A hierarchical "super" DESIGN model was then constructed, permitting trade-offs to be made between items in the three categories as well as within the categories themselves. While the cost and benefit values for the prepositioned equipment and airlift/sealift models are assumed numbers used to demonstrate the methodology only, the base structure parameters were derived by using actual Department of Defense (DoD) program and budget cost data effectiveness estimates obtained from knowledgeable RDJTF staff members. Thus, the base structure model is immediately useful in determining which milcon projects to emphasize, estimating the effects of political changes at home and abroad, assessing the effects of political changes at home and abroad, assessing the desirability of opening up new base locations, and the like. (For the purposes of this report the base structure data have been altered to permit publication in an unclassified form. A classified annex will be provided with the final report giving the actual data.)

Findings and Conclusions

The work so far indicates that the models and techniques developed by DDI are potentially very useful to the RDJTF. Analysis of the models, especially the base structure model, has raised several provocative issues of policy and priority. An account of these will be provided in the classified annex to the final report.

Implications for Further Research

There are at least four areas in which further exploratory work would appear useful:

- Derivation of real world cost and benefit data for the prepositioned equipment and airlift/sealift models.

- Exploration of alternative base locations and milcon options beyond those contained in the DoD program.

- Assessment of the political dimensions of the base structure model by knowledgeable people outside RDJTF staff (i.e., State or NSC personnel).

- Tracking and assessing RDJTF staff use of the models in exploring alternatives and adapting to real world changes.

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APPLICATION OF ADVANCED DECISION-ANALYTIC TECHNOLOGY TO RAPID DEPLOYMENT JOINT TASK FORCE PROBLEMS

1.0 INTRODUCTION

Under DARPA Order No. 4090 Decisions and Designs, Inc. (DDI) conducted an investigation of the possible application of advanced decision-analytic techniques to problems of interest to the Rapid Deployment Joint Task Force (RDJTF). The RDJTF was chosen because of the dynamic nature of the mission and related requirements. A secondary task was to determine the usefulness of advanced decision-analytic products to the RDJTF staff, and to transfer, if possible, a decision-analytic capability for a specific problem to them.

As the result of discussions with RDJTF personnel, DDI selected a problem that seemed most promising in terms of applying advanced techniques and of providing the RDJTF with a useful product in the near term. This problem concerns the provision of an adequate support architecture in the Persian Gulf/Indian Ocean area for the deployment of the RDJTF. DDI constructed a hierarchical resource allocation model to demonstrate the feasibility of optimizing the support architecture for deployment forces of different sizes, by making trade-offs within and between base structure, prepositioned materiel, and airlift/sealift assets. To avoid classification problems, hypothetical values were assigned to the parameters of the model. However, the base structure sub-model was built in close consultation with members of RDJTF staff, and actual costs and effectiveness estimates were produced.

This information (i.e., the actual costs and the effectiveness estimates) will be used to brief the Commander, RDJTF; software usable in IBM 5100 series mini-computers will be provided to RDJTF staff. This will greatly facilitate prioritization of support for military construction programs, permit rapid exploration of the usefulness of new proposed base options, and add to our understanding of whether and how decision-analytic techniques can be transferred to military operational staffs.

Section 2.0 summarizes the technical aspects of the RDJTF project--the problem, the methodology, and the results. More detailed information on the actual analytical process is presented in Sections 3.0 (Model Structure), 4.0 (Model Inputs), and 5.0 (Model Outputs). Finally, Section 6.0 discusses the findings and the implications for further research on this and related RDJTF problems.

2.0 TECHNICAL APPROACH

2.1 Problem

The primary task of this project was to demonstrate the application of advanced decision-analytic technology to the problems of an operational military staff, in this case the RDJTF staff. The technical problem selected was that of resource allocation in support of RDJTF deployment in a contingency operation in the Persian Gulf/Indian Ocean area. Support depends primarily on a mix of bases, propositioned materiel, and airlift/sealift assets. The RDJTF itself has varying degrees of influence over these resources, from virtually direct control, as in the case of the near-term prepositioned ships (NTPS), to circumstances in which it has strong interest but no real control, as in the case of airlift force improvement programs of the United States Air Force (USAF). An appropriate resource allocation model will permit the RDJTF to determine its own priorities for segments of the support architecture, and to formulate appropriate strategies for using what influence or control it has to bring about an optimal outcome. An important example of this is the base structure, where there are redundancies but also unique strategic, tactical, and political aspects associated with different bases. Distributing scarce military construction (milcon) resources among these base locations in an optimal manner is an enormously complex problem. The model of the base structure produced by DDI and provided to the RDJTF is a useful tool to build priority lists, explore potential changes, or assess the effect of budget cuts.

2.2 General Methodology

The methodology used by DDI to explore the RDJTF support architecture problem is essentially cost/benefit analysis. However, the general model used, called DESIGN, embodies advanced decision-analytic techniques. (A complete description of the general model is found in Appendix A).

2.3 Technical Results

Cost/benefit models were constructed representing each of the three main components of the support architecture: base structure, prepositioned equipment, and airlift/sealift. A hierarchical "super" DESIGN model was then constructed, permitting trade-offs to be made between items in the three categories as well as within the categories themselves. While the cost and benefit values for the prepositioned equipment and airlift/sealift models are assumed numbers used to demonstrate the methodology only, the base structure parameters were derived by using actual Department of Defense (DoD) program and budget cost data and effectiveness estimates obtained from knowledgeable RDJTF staff members. Thus, the base structure model is immediately useful in determining which milcon projects to emphasize, estimating the effects of political changes at home and abroad, assessing the desirability of opening up new base locations, and the like. (For the purposes of this report the base structure data have been altered to permit publication in an unclassified form. A classified annex will be provided with the final report giving the actual data.)

3.0 MODEL STRUCTURE

3.1 Base Structure

In the base structure model the variables are base locations, and the levels are increasing increments of military construction, resulting in more and more capable bases. The milcon packages were selected from projects programmed for start in the next five fiscal years, but the groupings were selected on the basis of function rather then fiscal year of start or funding. Figure 3-1 shows the resultant structure.

3.2 Prepositioned Materiel

In this model the variables selected were classes of materiel to be prepositioned. The levels consist of amounts required to equip forces of increasing size, or amounts consumed by a division-sized force for increasing periods of time. Figure 3-2 shows the model structure.

3.3 Airlift/Sealift

The variables for this model are airlift and sealift, and the levels consist of incremental improvements to the base forces specifically assigned to increasing the responsiveness of those forces to RDJTF requirements. Figure 3-3 illustrates the structure of this model.

3.4 Support Architecture

The structure of the support architecture "super" DESIGN models differs from those described previously in that the

FAC II THURSDAY 5/28/1981 14:21

VARIABLE	1	2	3	4	5	6	7	8	9
1 MASIRAH /OM	SQ + A/C SHELTR/CAM	AIRFIELD IMPROVMTS	UTILITY IMPROVMTS	POL STORAGE	BASE SUPPORT	AIRFIELD SUPPORT	TROOP SUPPORT	MAIN RUNWAY	SECONDARY RUNWAY
2 SEEB/OM	SQ	EXPAND APRON	POL/H2O IMPROVEMEN	MUNITIONS HANDLING	GP WAREHOUSE				
3 THUMRAIT/OM	SQ	POL/H2O IMPROVEMEN	MUNITIONS STORAGE	BASE SUPPORT	GENERAL STORAGE				
4 MUSANDAM/OM	SQ	AIRFIELD IMPVTS							
5 MOMBASA/K	SQ	AIRFIELD IMPS	BASE SUPPORT	DREDGE PORT	UTILITIES UPGRADE	COMM/NAV AIDS			
6 MALINDI/K	SQ	LOX PLANT / HELO PAD	DREDGE/NAV AIDS						
7 BERBERA/S	SQ	CARGO TERM+A/F I	IMPROVE PORT	AIRFIELD BUILDINGS	UTILITIES UPGRADE				
8 MOGADISCIO/S	SQ	PAVEMENT UPGRADE	PREFAB WAREHOUSE						
9 DIEGO GARCIA	SQ	AIRFIELD IMPS+DRI/I	FACILITIES EXPANSION	POL UPGRADE	WATERFRONT FACILITY	UTILITY UPGRADE	DREDGING III	STORAGE/SERVICES	SUPPORT FAC UPGRAD
10 LAJES	SQ	UP POL STORAGE	IMPRV POL DISTRIB	BASE UPGRADE	UTILITIES UPGRADE	TROOP SERVICES			
11 RAS BANAS/E - ARMY	STATUS QUO	1 BDE ARMY STAGING	PORT CARGO FACILITY	2 BDE ARMY STAGING	BASE SUPPORT	DIVISION STAGING BS			
12 RAS BANAS/E -USAF	STATUS QUO	AIRFIELD IMPROVE I	AIRFIELD IMPROVE II	AIRFIELD IMPROVE II	APRON				
13 CAIRO EAST/E	STATUS QUO	POL STORAGE							

MODEL STRUCTURE

Figure 3-1

PREPO THURSDAY 5/28/1981 14:20

VARIABLE	1	2	3	4	5	6
1 EQUIP	NONE	3BDE	1 MAF+	1MAF + 1 ARMY DIV	1 MAF + 2 DIV	1 MAF + 4 DIV
2 AMMO	NONE	10 DAYS	30 DAYS	60 DAYS	90 DAYS	180 DAYS
3 SPARES	NONE	50SM + 10LG	100SM + 25LG	SM + 50LG	SM + 75LG	SM + LG
4 CONSUMABLES	NONE	10 DAYS	30 DAYS	60 DAYS	90 DAYS	180 DAYS
5 POL	NONE	5 DAYS	15 DAYS	30 DAYS	45 DAYS	90 DAYS
6 WATER	NONE	5 DAYS	10 DAYS	15 DAYS	20 DAYS	30 DAYS

MODEL STRUCTURE

Figure 3-2

LIFT THURSDAY 5/28/1981 14:20

VARIABLE	1	2	3	4	5	6	7
1 AIR-LIFT	NONE	RECONFIG CRAF PRGRA	+ CRAF MODS	+ 25 KC10'S	+ BUY 10 LO MIX CX'	BUY 10 HIGH MIX C	+ 15 KC10'S
2 SEA-LIFT	NONE	BUY 2 RORO'S	BUY 4 SL7'S	BUY 8 SL7'S, 1 L	CONVERT 4 SL7'S	CONVERT 8 SL7'S	+ RF ENHANCEMEN

MODEL STRUCTURE

Figure 3-2

variables are the three sub-models (base structure, prepositioned equipment, and lift). The levels are actually selected by the model software to provide relatively evenly spaced packages along the efficient curve (see Appendix A). Figures 3-4 through 3-10 show the levels selected, and Figure 3-11 summarizes their costs and assessed benefits. This last figure is analogous to the structure figures of the sub-models.

SUPPORT ARCHITECTURE THURSDAY 5/28/1981 15:25

SUBMODEL 1 PRE-POS

SUBMODEL 1 PRE-POS LEVEL 1

	VARIABLE	BENEFIT	COST	SUBLEVEL	
1	EQUIP	0	0	NONE	(1 OF 6)
2	AMMO	0	0	NONE	(1 OF 6)
3	SPARES	0	0	NONE	(1 OF 6)
4	CONSUMABLES	0	0	NONE	(1 OF 6)
5	POL	0	0	NONE	(1 OF 6)
6	WATER	0	0	NONE	(1 OF 6)
		0	0		

SUBMODEL 1 PRE-POS LEVEL 2

	VARIABLE	BENEFIT	COST	SUBLEVEL	
1	EQUIP	0	0	NONE	(1 OF 6)
2	AMMO	99	55	10 DAYS	(2 OF 6)
3	SPARES	0	0	NONE	(1 OF 6)
4	CONSUMABLES	85	50	30 DAYS	(3 OF 6)
5	POL	0	0	NONE	(1 OF 6)
6	WATER	23	16	5 DAYS	(2 OF 6)
		208	121		

SUBMODEL 1 PRE-POS LEVEL 3

	VARIABLE	BENEFIT	COST	SUBLEVEL	
1	EQUIP	0	0	NONE	(1 OF 6)
2	AMMO	196	166	30 DAYS	(3 OF 6)
3	SPARES	0	0	NONE	(1 OF 6)
4	CONSUMABLES	85	50	30 DAYS	(3 OF 6)
5	POL	54	55	5 DAYS	(2 OF 6)
6	WATER	66	67	20 DAYS	(5 OF 6)
		400	338		

SUBMODEL 1 PRE-POS LEVEL 4

	VARIABLE	BENEFIT	COST	SUBLEVEL	
1	EQUIP	241	600	3BDE	(2 OF 6)
2	AMMO	196	166	30 DAYS	(3 OF 6)
3	SPARES	0	0	NONE	(1 OF 6)
4	CONSUMABLES	85	50	30 DAYS	(3 OF 6)
5	POL	120	167	15 DAYS	(3 OF 6)
6	WATER	66	67	20 DAYS	(5 OF 6)
		707	1050		

Figure 3-4

SUPPORT ARCHITECTURE THURSDAY 5/28/1981 15:25

SUBMODEL 1 PRE-POS LEVEL 5

VARIABLE	BENEFIT	COST	SUBLEVEL	
1 EQUIP	292	1000	1 MAF+	(3 OF 6)
2 AMMO	196	166	30 DAYS	(3 OF 6)
3 SPARES	26	70	50SM + 10LG	(2 OF 6)
4 CONSUMABLES	85	50	30 DAYS	(3 OF 6)
5 POL	164	333	30 DAYS	(4 OF 6)
6 WATER	73	100	30 DAYS	(6 OF 6)
	835	1719		

SUBMODEL 1 PRE-POS LEVEL 6

VARIABLE	BENEFIT	COST	SUBLEVEL	
1 EQUIP	292	1000	1 MAF+	(3 OF 6)
2 AMMO	228	500	90 DAYS	(5 OF 6)
3 SPARES	33	160	100SM + 25LG	(3 OF 6)
4 CONSUMABLES	93	150	90 DAYS	(5 OF 6)
5 POL	197	1000	90 DAYS	(6 OF 6)
6 WATER	73	100	30 DAYS	(6 OF 6)
	916	2910		

SUBMODEL 1 PRE-POS LEVEL 7

VARIABLE	BENEFIT	COST	SUBLEVEL	
1 EQUIP	314	2000	1MAF + 1 ARMY DIV	(4 OF 6)
2 AMMO	228	500	90 DAYS	(5 OF 6)
3 SPARES	33	160	100SM + 25LG	(3 OF 6)
4 CONSUMABLES	93	150	90 DAYS	(5 OF 6)
5 POL	197	1000	90 DAYS	(6 OF 6)
6 WATER	73	100	30 DAYS	(6 OF 6)
	938	3910		

SUBMODEL 1 PRE-POS LEVEL 8

VARIABLE	BENEFIT	COST	SUBLEVEL	
1 EQUIP	365	5000	1 MAF + 4 DIV	(6 OF 6)
2 AMMO	228	500	90 DAYS	(5 OF 6)
3 SPARES	33	160	100SM + 25LG	(3 OF 6)
4 CONSUMABLES	93	150	90 DAYS	(5 OF 6)
5 POL	197	1000	90 DAYS	(6 OF 6)
6 WATER	73	100	30 DAYS	(6 OF 6)
	989	6910		

SUBMODEL 1 PRE-POS LEVEL 9

VARIABLE	BENEFIT	COST	SUBLEVEL	
1 EQUIP	365	5000	1 MAF + 4 DIV	(6 OF 6)
2 AMMO	234	1000	180 DAYS	(6 OF 6)
3 SPARES	36	500	SM + LG	(6 OF 6)
4 CONSUMABLES	95	300	180 DAYS	(6 OF 6)
5 POL	197	1000	90 DAYS	(6 OF 6)
6 WATER	73	100	30 DAYS	(6 OF 6)
	1000	7900		

Figure 3-5

SUBMODEL 2: LIFT

```
SUBMODEL 2 LIFT LEVEL 1
        VARIABLE      BENEFIT COST  SUBLEVEL
 1 AIR-LIFT                 0    0  NONE                (1 OF 7)
 2 SEA-LIFT                 0    0  NONE                (1 OF 7)
                            0    0

SUBMODEL 2 LIFT LEVEL 2
        VARIABLE      BENEFIT COST  SUBLEVEL
 1 AIR-LIFT                69   50  RECONFIG CRAF PRGRAM (2 OF 7)
 2 SEA-LIFT                69   50  BUY 2 RORO'S        (2 OF 7)
                          137  100

SUBMODEL 2 LIFT LEVEL 3
        VARIABLE      BENEFIT COST  SUBLEVEL
 1 AIR-LIFT               337  300  + CRAF MODS         (3 OF 7)
 2 SEA-LIFT                69   50  BUY 2 RORO'S        (2 OF 7)
                          406  350

SUBMODEL 2 LIFT LEVEL 4
        VARIABLE      BENEFIT COST  SUBLEVEL
 1 AIR-LIFT               625 1600  + 25 KC10'S         (4 OF 7)
 2 SEA-LIFT                69   50  BUY 2 RORO'S        (2 OF 7)
                          694 1650

SUBMODEL 2 LIFT LEVEL 5
        VARIABLE      BENEFIT COST  SUBLEVEL
 1 AIR-LIFT               625 1600  + 25 KC10'S         (4 OF 7)
 2 SEA-LIFT               166  900  BUY 8 SL7'S, 1 LASH (4 OF 7)
                          791 2500

SUBMODEL 2 LIFT LEVEL 6
        VARIABLE      BENEFIT COST  SUBLEVEL
 1 AIR-LIFT               669 2100  + BUY 10 LO MIX CX'S (5 OF 7)
 2 SEA-LIFT               166  900  BUY 8 SL7'S, 1 LASH (4 OF 7)
                          834 3000

SUBMODEL 2 LIFT LEVEL 7
        VARIABLE      BENEFIT COST  SUBLEVEL
 1 AIR-LIFT               669 2100  + BUY 10 LO MIX CX'S (5 OF 7)
 2 SEA-LIFT               245 2100  CONVERT 8 SL7'S     (6 OF 7)
                          914 4200
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Figure 3-6

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SUPPORT ARCHITECTURE      THURSDAY 5/28/1981 15:25

SUBMODEL 2 LIFT LEVEL 8
        VARIABLE       BENEFIT COST  SUBLEVEL
 1 AIR-LIFT                750 3400  + 15 KC10'S          (7 OF 7)
 2 SEA-LIFT                250 2200  + RF ENHANCEMENT     (7 OF 7)
                          1000 5600
```

Figure 3-7

SUBMODEL 3 FAC III

SUBMODEL 3 FAC III LEVEL 1

	VARIABLE	BENEFIT	COST	SUBLEVEL	
1	MASIRAH /OM	0	23.6	SQ + A/C SHELTR/CAMP	(1 OF 9)
2	SEEB/OM	0	.0	SQ	(1 OF 5)
3	THUMRAIT/OM	0	.0	SQ	(1 OF 5)
4	MUSANDAM/OM	8	.0	SQ	(1 OF 2)
5	MOMBASA/K	0	.0	SQ	(1 OF 6)
6	MALINDI/K	3	.0	SQ	(1 OF 3)
7	BERBERA/S	0	.0	SQ	(1 OF 5)
8	MOGADISCIO/S	0	.0	SQ	(1 OF 3)
9	DIEGO GARCIA	0	.0	SQ	(1 OF 9)
10	LAJES	0	.0	SQ	(1 OF 6)
11	RAS BANAS/E - ARMY	0	.0	STATUS QUO	(1 OF 6)
12	RAS BANAS/E -USAF	0	.0	STATUS QUO	(1 OF 5)
13	CAIRO EAST/E	0	.0	STATUS QUO	(1 OF 2)
		11	23.6		

SUBMODEL 3 FAC III LEVEL 2

	VARIABLE	BENEFIT	COST	SUBLEVEL	
1	MASIRAH /OM	0	23.6	SQ + A/C SHELTR/CAMP	(1 OF 9)
2	SEEB/OM	70	8.8	EXPAND APRON	(2 OF 5)
3	THUMRAIT/OM	0	.0	SQ	(1 OF 5)
4	MUSANDAM/OM	8	.0	SQ	(1 OF 2)
5	MOMBASA/K	20	2.6	AIRFIELD IMPS	(2 OF 6)
6	MALINDI/K	3	.0	SQ	(1 OF 3)
7	BERBERA/S	73	7.2	UTILITIES UPGRADE	(5 OF 5)
8	MOGADISCIO/S	12	.6	PREFAB WAREHOUSE	(3 OF 3)
9	DIEGO GARCIA	0	.0	SQ	(1 OF 9)
10	LAJES	0	.0	SQ	(1 OF 6)
11	RAS BANAS/E - ARMY	0	.0	STATUS QUO	(1 OF 6)
12	RAS BANAS/E -USAF	0	.0	STATUS QUO	(1 OF 5)
13	CAIRO EAST/E	19	5.5	POL STORAGE	(2 OF 2)
		205	48.3		

SUBMODEL 3 FAC III LEVEL 3

	VARIABLE	BENEFIT	COST	SUBLEVEL	
1	MASIRAH /OM	32	37.5	AIRFIELD IMPROVMTS	(2 OF 9)
2	SEEB/OM	80	17.4	POL/H2O IMPROVEMENTS	(3 OF 5)
3	THUMRAIT/OM	0	.0	SQ	(1 OF 5)
4	MUSANDAM/OM	8	.0	SQ	(1 OF 2)
5	MOMBASA/K	20	2.6	AIRFIELD IMPS	(2 OF 6)
6	MALINDI/K	3	.0	SQ	(1 OF 3)
7	BERBERA/S	73	7.2	UTILITIES UPGRADE	(5 OF 5)
8	MOGADISCIO/S	12	.6	PREFAB WAREHOUSE	(3 OF 3)
9	DIEGO GARCIA	156	84.6	AIRFIELD IMPS+DRI/II	(2 OF 9)
10	LAJES	0	.0	SQ	(1 OF 6)
11	RAS BANAS/E - ARMY	0	.0	STATUS QUO	(1 OF 6)
12	RAS BANAS/E -USAF	0	.0	STATUS QUO	(1 OF 5)
13	CAIRO EAST/E	19	5.5	POL STORAGE	(2 OF 2)
		410	155.4		

Figure 3-8

SUPPORT ARCHITECTURE THURSDAY 5/28/1981 15:26

SUBMODEL 3 FAC III LEVEL 4

	VARIABLE	BENEFIT	COST	SUBLEVEL	
1	MASIRAH /OM	32	38	AIRFIELD IMPROVMTS	(2 OF 9)
2	SEEB/OM	88	17	POL/H2O IMPROVEMENTS	(3 OF 5)
3	THUMRAIT/OM	0	0	SQ	(1 OF 5)
4	MUSANDAM/OM	8	0	SQ	(1 OF 2)
5	MOMBASA/K	58	26	COMM/NAV AIDS	(6 OF 6)
6	MALINDI/K	3	0	SQ	(1 OF 3)
7	BERBERA/S	73	7	UTILITIES UPGRADE	(5 OF 5)
8	MOGADISCIO/S	12	1	PREFAB WAREHOUSE	(3 OF 3)
9	DIEGO GARCIA	156	85	AIRFIELD IMPS+DRI/II	(2 OF 9)
10	LAJES	85	54	UP POL STORAGE	(2 OF 6)
11	RAS BANAS/E - ARMY	0	0	STATUS QUO	(1 OF 6)
12	RAS BANAS/E -USAF	0	0	STATUS QUO	(1 OF 5)
13	CAIRO EAST/E	19	6	POL STORAGE	(2 OF 2)
		533	233		

SUBMODEL 3 FAC III LEVEL 5

	VARIABLE	BENEFIT	COST	SUBLEVEL	
1	MASIRAH /OM	41	45.7	UTILITY IMPROVMTS	(3 OF 9)
2	SEEB/OM	104	29.2	GP WAREHOUSE	(5 OF 5)
3	THUMRAIT/OM	29	31.8	GENERAL STORAGE	(5 OF 5)
4	MUSANDAM/OM	8	.0	SQ	(1 OF 2)
5	MOMBASA/K	58	26.1	COMM/NAV AIDS	(6 OF 6)
6	MALINDI/K	3	.0	SQ	(1 OF 3)
7	BERBERA/S	73	7.2	UTILITIES UPGRADE	(5 OF 5)
8	MOGADISCIO/S	12	.6	PREFAB WAREHOUSE	(3 OF 3)
9	DIEGO GARCIA	156	84.6	AIRFIELD IMPS+DRI/II	(2 OF 9)
10	LAJES	154	100.8	BASE UPGRADE	(4 OF 6)
11	RAS BANAS/E - ARMY	0	.0	STATUS QUO	(1 OF 6)
12	RAS BANAS/E -USAF	0	.0	STATUS QUO	(1 OF 5)
13	CAIRO EAST/E	19	5.5	POL STORAGE	(2 OF 2)
		657	331.5		

SUBMODEL 3 FAC III LEVEL 6

	VARIABLE	BENEFIT	COST	SUBLEVEL	
1	MASIRAH /OM	41	45.7	UTILITY IMPROVMTS	(3 OF 9)
2	SEEB/OM	104	29.2	GP WAREHOUSE	(5 OF 5)
3	THUMRAIT/OM	29	31.8	GENERAL STORAGE	(5 OF 5)
4	MUSANDAM/OM	8	.0	SQ	(1 OF 2)
5	MOMBASA/K	58	26.1	COMM/NAV AIDS	(6 OF 6)
6	MALINDI/K	3	.0	SQ	(1 OF 3)
7	BERBERA/S	73	7.2	UTILITIES UPGRADE	(5 OF 5)
8	MOGADISCIO/S	12	.6	PREFAB WAREHOUSE	(3 OF 3)
9	DIEGO GARCIA	282	223.6	UTILITY UPGRADE	(6 OF 9)
10	LAJES	154	100.8	BASE UPGRADE	(4 OF 6)
11	RAS BANAS/E - ARMY	0	.0	STATUS QUO	(1 OF 6)
12	RAS BANAS/E -USAF	0	.0	STATUS QUO	(1 OF 5)
13	CAIRO EAST/E	19	5.5	POL STORAGE	(2 OF 2)
		783	470.5		

Figure 3-9

SUBMODEL 3 FAC III LEVEL 7

	VARIABLE	BENEFIT COST	SUBLEVEL	
1	MASIRAH /OM	41 45.7	UTILITY IMPROVMTS	(3 OF 9)
2	SEEB/OM	104 29.2	GP WAREHOUSE	(5 OF 5)
3	THUMRAIT/OM	29 31.8	GENERAL STORAGE	(5 OF 5)
4	MUSANDAM/OM	8 .0	SQ	(1 OF 2)
5	MOMBASA/K	58 26.1	COMM/NAV AIDS	(6 OF 6)
6	MALINDI/K	3 .0	SQ	(1 OF 3)
7	BERBERA/S	73 7.2	UTILITIES UPGRADE	(5 OF 5)
8	MOGADISCIO/S	12 .6	PREFAB WAREHOUSE	(3 OF 3)
9	DIEGO GARCIA	307253.3	STORAGE/SERVICES	(8 OF 9)
10	LAJES	160109.6	UTILITIES UPGRADE	(5 OF 6)
11	RAS BANAS/E - ARMY	16 24.6	1 BDE ARMY STAGING	(2 OF 6)
12	RAS BANAS/E -USAF	53 81.1	AIRFIELD IMPROVE II	(3 OF 5)
13	CAIRO EAST/E	19 5.5	POL STORAGE	(2 OF 2)
		883614.7		

SUBMODEL 3 FAC III LEVEL 8

	VARIABLE	BENEFIT COST	SUBLEVEL	
1	MASIRAH /OM	41 45.7	UTILITY IMPROVMTS	(3 OF 9)
2	SEEB/OM	104 29.2	GP WAREHOUSE	(5 OF 5)
3	THUMRAIT/OM	29 31.8	GENERAL STORAGE	(5 OF 5)
4	MUSANDAM/OM	8 .0	SQ	(1 OF 2)
5	MOMBASA/K	58 26.1	COMM/NAV AIDS	(6 OF 6)
6	MALINDI/K	3 .0	SQ	(1 OF 3)
7	BERBERA/S	73 7.2	UTILITIES UPGRADE	(5 OF 5)
8	MOGADISCIO/S	12 .6	PREFAB WAREHOUSE	(3 OF 3)
9	DIEGO GARCIA	307253.3	STORAGE/SERVICES	(8 OF 9)
10	LAJES	160109.6	UTILITIES UPGRADE	(5 OF 6)
11	RAS BANAS/E - ARMY	53107.1	BASE SUPPORT	(5 OF 6)
12	RAS BANAS/E -USAF	88178.0	APRON	(5 OF 5)
13	CAIRO EAST/E	19 5.5	POL STORAGE	(2 OF 2)
		956794.1		

SUBMODEL 3 FAC III LEVEL 9

	VARIABLE	BENEFIT COST	SUBLEVEL	
1	MASIRAH /OM	63109.4	SECONDARY RUNWAY	(9 OF 9)
2	SEEB/OM	104 29.2	GP WAREHOUSE	(5 OF 5)
3	THUMRAIT/OM	29 31.8	GENERAL STORAGE	(5 OF 5)
4	MUSANDAM/OM	8 .0	SQ	(1 OF 2)
5	MOMBASA/K	58 26.1	COMM/NAV AIDS	(6 OF 6)
6	MALINDI/K	3 .0	SQ	(1 OF 3)
7	BERBERA/S	73 7.2	UTILITIES UPGRADE	(5 OF 5)
8	MOGADISCIO/S	12 .6	PREFAB WAREHOUSE	(3 OF 3)
9	DIEGO GARCIA	313274.1	SUPPORT FAC UPGRADE	(9 OF 9)
10	LAJES	163126.2	TROOP SERVICES	(6 OF 6)
11	RAS BANAS/E - ARMY	66152.4	DIVISION STAGING BS	(6 OF 6)
12	RAS BANAS/E -USAF	88178.0	APRON	(5 OF 5)
13	CAIRO EAST/E	19 5.5	POL STORAGE	(2 OF 2)
		1000940.5		

Figure 3-10

SUPPORT ARCHITECTURE THURSDAY 5/28/1981 15 26

ASSESSED VALUES

VARIABLE	LEVEL 1	2	3	4	5	6	7	8	9	WT
1 PRE-POS	0	21	40	71	84	92	94	99	100	100
	0	121	338	1050	1719	2910	3910	6910	7900	
2 LIFT	0	14	41	69	79	83	91	100		50
	0	100	350	1650	2500	3000	4200	5600		
3 FAC III	1	20	41	53	66	78	88	96	100	70
	24	48	155	233	331	470	615	794	940	

Figure 3-11

4.0 MODEL INPUTS

4.1 Base Structure

Figures 4-1 through 4-4 show the inputs to the base structure model in terms of costs ($ million) and relative benefits. They also show the relative importance of each criterion ("across criteria weights") and the relative importance of making the full range of change in each variable within the various criteria. For example, the "within criterion" weight for variable 1, Masirah, under the "EFF" (military effectiveness) criterion is 21. The same weight for variable 9, Diego Garcia is 100. This indicates that building all the nine levels of milcon at Diego Garcia contributes about five times as much to the effectiveness of the RDJTF as building the entire nine-level package at Masirah. The columns headed "Host," "Israel," and "Domest" indicate the relative political effect on making the change as it affects the RDJTF. Here 100 represents maximum relative satisfaction and 0 represents minimum relative satisfaction.

4.2 Prepositioned Materiel

Costs, benefits and importance weights are assigned to prepositioned materiel as indicated in Figures 4-5 and 4-6. Note that benefits are assessed against "small" and "large" conflicts. These are totalled in proportion to their "across criteria" weights. This mechanism allows various hedging strategies to be built into the model. In this example the weights are 100 for a "small" conflict and 25 for a "large" conflict, indicating that the likelihood and importance of

FAC III THURSDAY 5/28/1981 15:09

ASSESSED VALUES

VARIABLE 1: MASIRAH /OM

		COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1	SQ + A/C SHELTR/CAMP	23.6	0	0	100	100	0
2	AIRFIELD IMPROVMTS	37.5	30	60	80	80	50
3	UTILITY IMPROVMTS	45.7	40	90	60	60	64
4	POL STORAGE	57.0	50	100	40	40	69
5	BASE SUPPORT	74.0	65	100	20	20	74
6	AIRFIELD SUPPORT	82.5	75	100	0	0	74
7	TROOP SUPPORT	86.7	85	100	0	0	85
8	MAIN RUNWAY	101.2	95	100	0	0	95
9	SECONDARY RUNWAY	109.4	100	100	0	0	100
	WITHIN CRITERION WEIGHTS		21	100	55	50	
	ACROSS CRITERIA WEIGHTS		100	10	10	10	

VARIABLE 2: SEEB/OM

		COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1	SQ	.0	0	20	100	100	0
2	EXPAND APRON	8.8	60	80	80	80	68
3	POL/H2O IMPROVEMENTS	17.4	75	100	70	70	85
4	MUNITIONS HANDLING	25.3	95	0	0	0	95
5	GP WAREHOUSE	29.2	100	0	0	0	100
	WITHIN CRITERION WEIGHTS		36	25	10	10	
	ACROSS CRITERIA WEIGHTS		100	10	10	10	

VARIABLE 3: THUMRAIT/OM

		COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1	SQ	.0	0	100	100	100	0
2	POL/H2O IMPROVEMENTS	12.8	50	0	0	0	26
3	MUNITIONS STORAGE	20.5	75	0	0	0	63
4	BASE SUPPORT	27.9	90	0	0	0	85
5	GENERAL STORAGE	31.8	100	0	0	0	100
	WITHIN CRITERION WEIGHTS		14	25	10	10	
	ACROSS CRITERIA WEIGHTS		100	10	10	10	

VARIABLE 4: MUSANDAM/OM

		COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1	SQ	.0	0	100	100	100	100
2	AIRFIELD IMPVTS	2.4	100	0	0	0	0
	WITHIN CRITERION WEIGHTS		1	20	7	10	
	ACROSS CRITERIA WEIGHTS		100	10	10	10	

Figure 4-1

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VARIABLE 5: MOMBASA/K

	COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1 SQ	.0	0	100	0	100	0
2 AIRFIELD IMPS	2.6	35	50	100	50	34
3 BASE SUPPORT	4.4	45	0	100	0	39
4 DREDGE PORT	22.3	90	0	100	0	89
5 UTILITIES UPGRADE	24.6	95	0	100	0	94
6 COMM/NAV AIDS	26.1	100	0	100	0	100
WITHIN CRITERION WEIGHTS		21	20	3	5	
ACROSS CRITERIA WEIGHTS		100	10	10	10	

VARIABLE 6: MALINDI/K

	COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1 SQ	.0	0	100	0	100	100
2 LOX PLANT / HELO PAD	.7	25	0	100	0	0
3 DREDGE/NAVAIDS	14.3	100	0	100	0	79
WITHIN CRITERION WEIGHTS		1	10	3	5	
ACROSS CRITERIA WEIGHTS		100	10	10	10	

VARIABLE 7: BERBERA/S

	COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1 SQ	.0	0	0	40	100	0
2 CARGO TERM+A/F IMPRV	2.4	40	100	60	0	30
3 IMPROVE PORT	4.0	70	100	100	0	69
4 AIRFIELD BUILDINGS	6.6	95	100	0	0	94
5 UTILITIES UPGRADE	7.2	100	100	0	0	100
WITHIN CRITERION WEIGHTS		29	3	13	50	
ACROSS CRITERIA WEIGHTS		100	10	10	10	

VARIABLE 8: MOGADISCIO/S

	COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1 SQ	.0	0	0	0	100	0
2 PAVEMENT UPGRADE	.3	65	90	100	0	62
3 PREFAB WAREHOUSE	.6	100	100	100	0	100
WITHIN CRITERION WEIGHTS		4	5	3	10	
ACROSS CRITERIA WEIGHTS		100	10	10	10	

Figure 4-2

FAC III THURSDAY 5/28/1981 15:09

VARIABLE 9: DIEGO GARCIA

	COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1 SQ	.0	0	0	0	100	0
2 AIRFIELD IMPS+DRI/II	84.6	50	100	20	0	50
3 FACILITIES EXPANSION	165.1	65	100	40	0	65
4 POL UPGRADE	184.5	75	100	60	0	75
5 WATERFRONT FACILITY	207.5	85	100	80	0	85
6 UTILITY UPGRADE	223.6	90	100	100	0	90
7 DREDGING III	244.3	95	100	100	0	95
8 STORAGE/SERVICES	253.3	98	100	100	0	98
9 SUPPORT FAC UPGRADE	274.1	100	100	100	0	100
WITHIN CRITERION WEIGHTS		100	5	10	1	
ACROSS CRITERIA WEIGHTS		100	10	10	10	

VARIABLE 10: LAJES

	COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1 SQ	.0	0	100	0	100	0
2 UP POL STORAGE	54.1	55	0	40	0	52
3 IMPRV POL DISTRIB	95.7	90	0	80	0	88
4 BASE UPGRADE	100.8	93	0	100	0	94
5 UTILITIES UPGRADE	109.6	98	0	100	0	98
6 TROOP SERVICES	126.2	100	0	100	0	100
WITHIN CRITERION WEIGHTS		43	2	100	1	
ACROSS CRITERIA WEIGHTS		100	10	10	10	

VARIABLE 11: RAS BANAS/E - ARMY

	COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1 STATUS QUO	.0	0	0	100	100	0
2 1 BDE ARMY STAGING	24.6	30	100	0	0	25
3 PORT CARGO FACILITY	56.5	45	100	0	0	50
4 2 BDE ARMY STAGING	87.9	70	50	0	0	68
5 BASE SUPPORT	107.1	80	40	0	0	80
6 DIVISION STAGING BS	152.4	100	10	0	0	100
WITHIN CRITERION WEIGHTS		36	100	55	100	
ACROSS CRITERIA WEIGHTS		100	10	10	10	

VARIABLE 12: RAS BANAS/E -USAF

	COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1 STATUS QUO	.0	0	0	100	100	0
2 AIRFIELD IMPROVE I	47.2	40	90	0	0	31
3 AIRFIELD IMPROVE II	81.1	60	100	0	0	60
4 AIRFIELD IMPROVE III	137.2	75	90	0	0	75
5 APRON	178.0	100	70	0	0	100
WITHIN CRITERION WEIGHTS		36	100	65	80	
ACROSS CRITERIA WEIGHTS		100	10	10	10	

Figure 4-3

FAC III   THURSDAY 5/28/1981 15:09

VARIABLE 13 CAIRO EAST/E

		COST	EFF	HOST	ISRAEL	DOMEST	TOTAL
1	STATUS QUO	.0	0	0	100	100	0
2	POL STORAGE	5.5	100	100	0	0	100
	WITHIN CRITERION WEIGHTS		7	10	10	10	
	ACROSS CRITERIA WEIGHTS		100	10	10	10	

Figure 4-4

PREPO THURSDAY 5/28/1981 14 26

ASSESSED VALUES

VARIABLE 1: EQUIP

		COST	SMALL	LARGE	TOTAL
1	NONE	0	0	0	0
2	3BDE	600	80	10	66
3	1 MAF+	1000	95	20	80
4	1MAF + 1 ARMY DIV	2000	100	30	86
5	1 MAF + 2 DIV	3000	100	50	90
6	1 MAF + 4 DIV	5000	100	100	100
	WITHIN CRITERION WEIGHTS		100	100	
	ACROSS CRITERIA WEIGHTS		100	25	

VARIABLE 2: AMMO

		COST	SMALL	LARGE	TOTAL
1	NONE	0	0	0	0
2	10 DAYS	55	50	20	42
3	30 DAYS	166	95	50	84
4	60 DAYS	333	100	70	92
5	90 DAYS	500	100	90	97
6	180 DAYS	1000	100	100	100
	WITHIN CRITERION WEIGHTS		60	80	
	ACROSS CRITERIA WEIGHTS		100	25	

VARIABLE 3: SPARES

		COST	SMALL	LARGE	TOTAL
1	NONE	0	0	0	0
2	50SM + 10LG	70	80	30	70
3	100SM + 25LG	160	100	50	90
4	SM + 50LG	270	100	70	94
5	SM + 75LG	380	100	90	98
6	SM + LG	500	100	100	100
	WITHIN CRITERION WEIGHTS		10	10	
	ACROSS CRITERIA WEIGHTS		100	25	

VARIABLE 4: CONSUMABLES

		COST	SMALL	LARGE	TOTAL
1	NONE	0	0	0	0
2	10 DAYS	16	50	10	47
3	30 DAYS	50	95	25	90
4	60 DAYS	100	99	50	95
5	90 DAYS	150	100	80	98
6	180 DAYS	300	100	100	100
	WITHIN CRITERION WEIGHTS		30	10	
	ACROSS CRITERIA WEIGHTS		100	25	

Figure 4-5

PREPO THURSDAY 5/28/1981 14:26

VARIABLE 5: POL

		COST	SMALL	LARGE	TOTAL
1	NONE	0	0	0	0
2	5 DAYS	55	30	20	27
3	15 DAYS	167	70	35	61
4	30 DAYS	333	95	50	83
5	45 DAYS	500	99	80	94
6	90 DAYS	1000	100	100	100
	WITHIN CRITERION WEIGHTS		50	70	
	ACROSS CRITERIA WEIGHTS		100	25	

VARIABLE 6: WATER

		COST	SMALL	LARGE	TOTAL
1	NONE	0	0	0	0
2	5 DAYS	16	35	20	32
3	10 DAYS	33	60	50	58
4	15 DAYS	50	70	70	70
5	20 DAYS	67	90	90	90
6	30 DAYS	100	100	100	100
	WITHIN CRITERION WEIGHTS		20	20	
	ACROSS CRITERIA WEIGHTS		100	25	

Figure 4-6

the former are rated about four times that of the latter. However, even though the "large" war is substantially discounted, it still has some weight in the composite total benefit number.

4.3 Airlift/Sealift

Figure 4-7 shows the assessed cost and benefit numbers for incremental airlift and sealift programs.

LIFT THURSDAY 5/28/1981 14:33

ASSESSED VALUES

VARIABLE 1: AIR-LIFT

		COST	SMALL	LARGE	TOTAL
1	NONE	0	0	0	0
2	RECONFIG CRAF PRGRAM	50	10	5	9
3	+ CRAF MODS	300	50	20	45
4	+ 25 KC10'S	1600	90	50	83
5	+ BUY 10 LO MIX CX'S	2100	93	70	89
6	BUY 10 HIGH MIX CX'S	2600	96	80	93
7	+ 15 KC10'S	3400	100	100	100
	WITHIN CRITERION WEIGHTS		100	100	
	ACROSS CRITERIA WEIGHTS		100	20	

VARIABLE 2: SEA-LIFT

		COST	SMALL	LARGE	TOTAL
1	NONE	0	0	0	0
2	BUY 2 RORO'S	50	30	20	27
3	BUY 4 SL7'S	450	50	30	45
4	BUY 8 SL7'S, 1 LASH	900	75	40	66
5	CONVERT 4 SL7'S	1500	85	70	81
6	CONVERT 8 SL7'S	2100	98	98	98
7	+ RF ENHANCEMENT	2200	100	100	100
	WITHIN CRITERION WEIGHTS		30	50	
	ACROSS CRITERIA WEIGHTS		100	20	

Figure 4-7

5.0 MODEL OUTPUTS

5.1 Base Structure

As explained in Appendix A, the base structure model searches among all possible combinations of location and milcon alternatives (in this case several billion) and selects "efficient" packages; that is, packages such that, for the cost, no other combinations yield better effectiveness. The list of such packages, in increasing order of benefit-to-cost ratio, is shown in Figures 5-1 and 5-2. It can be seen that this represents a priority list and provides an initial indication, at least, of how one might respond to program cuts or increases.

Another very useful output of the model is a comparison of the proposed package to more efficient packages in the same region. For purposes of illustration a proposed package has been selected, corresponding very roughly to the FY 1981 program. The model plots the efficient packages in a cost/benefit space, shows where the proposed package falls in the space, and selects for comparison packages that give about equal benefit for less cost, and more benefit for the same cost. This is shown in Figure 5-2. Finally, the model maps the cheaper, better, and proposed packages in a space corresponding to the basic model structure indicating potential changes in the proposed packages to produce a more optimal mix. This is shown in Figure 5-3.

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LIST OF EFFICIENT PACKAGES

ALL VARIABLES SET AT LEVEL 1
BENEFIT COST
11 24

CHANGE 8: MOGADISCIO/S
FROM 1: SQ
TO 2: PAVEMENT UPGRADE

BENEFIT COST
19 24

CHANGE 8: MOGADISCIO/S
FROM 2: PAVEMENT UPGRADE
TO 3: PREFAB WAREHOUSE

BENEFIT COST
23 24

CHANGE 7: BERBERA/S
FROM 1: SQ
TO 3: IMPROVE PORT

BENEFIT COST
74 28

CHANGE 2: SEEB/OM
FROM 1: SQ
TO 2: EXPAND APRON

BENEFIT COST
144 37

CHANGE 5: MOMBASA/K
FROM 1: SQ
TO 2: AIRFIELD IMPS

BENEFIT COST
164 40

CHANGE 7: BERBERA/S
FROM 3: IMPROVE PORT
TO 5: UTILITIES UPGRADE

BENEFIT COST
186 43

CHANGE 13: CAIRO EAST/E
FROM 1: STATUS QUO
TO 2: POL STORAGE

BENEFIT COST
205 48

CHANGE 1: MASIRAH /OM
FROM 1: SQ + A/C SHELTR/CAMP
TO 2: AIRFIELD IMPROVMTS

BENEFIT COST
236 62

CHANGE 2: SEEB/OM
FROM 2: EXPAND APRON
TO 3: POL/H2O IMPROVEMENTS

BENEFIT COST
254 71

CHANGE 9: DIEGO GARCIA
FROM 1: SQ
TO 2: AIRFIELD IMPS+DRI/II

BENEFIT COST
410 155

CHANGE 5: MOMBASA/K
FROM 2: AIRFIELD IMPS
TO 6: COMM/NAV AIDS

BENEFIT COST
449 179

CHANGE 10: LAJES
FROM 1: SQ
TO 2: UP POL STORAGE

BENEFIT COST
533 233

CHANGE 10: LAJES
FROM 2: UP POL STORAGE
TO 4: BASE UPGRADE

BENEFIT COST
602 280

CHANGE 2: SEEB/OM
FROM 3: POL/H2O IMPROVEMENTS
TO 5: GP WAREHOUSE

BENEFIT COST
618 292

CHANGE 1: MASIRAH /OM
FROM 2: AIRFIELD IMPROVMTS
TO 3: UTILITY IMPROVMTS

BENEFIT COST
627 300

Figure 5-1

FAC III THURSDAY 5/28/1981 14 59

LIST OF EFFICIENT PACKAGES

CHANGE 3: THUMRAIT/OM
FROM 1: SQ
TO 5: GENERAL STORAGE

BENEFIT	COST
657	331

CHANGE 9: DIEGO GARCIA
FROM 2: AIRFIELD IMPS+DRI/II
TO 6: UTILITY UPGRADE

BENEFIT	COST
783	470

CHANGE 9: DIEGO GARCIA
FROM 6: UTILITY UPGRADE
TO 8: STORAGE/SERVICES

BENEFIT	COST
807	500

CHANGE 10: LAJES
FROM 4: BASE UPGRADE
TO 5: UTILITIES UPGRADE

BENEFIT	COST
814	509

CHANGE 11: RAS BANAS/E - ARMY
FROM 1: STATUS QUO
TO 2: 1 BDE ARMY STAGING

BENEFIT	COST
830	534

CHANGE 12: RAS BANAS/E -USAF
FROM 1: STATUS QUO
TO 3: AIRFIELD IMPROVE II

BENEFIT	COST
883	615

CHANGE 11: RAS BANAS/E - ARMY
FROM 2: 1 BDE ARMY STAGING
TO 3: PORT CARGO FACILITY

BENEFIT	COST
900	647

CHANGE 11: RAS BANAS/E - ARMY
FROM 3: PORT CARGO FACILITY
TO 5: BASE SUPPORT

BENEFIT	COST
920	697

CHANGE 12: RAS BANAS/E -USAF
FROM 3: AIRFIELD IMPROVE II
TO 5: APRON

BENEFIT	COST
956	794

CHANGE 1: MASIRAH /OM
FROM 3: UTILITY IMPROVMTS
TO 9: SECONDARY RUNWAY

BENEFIT	COST
978	858

CHANGE 9: DIEGO GARCIA
FROM 8: STORAGE/SERVICES
TO 9: SUPPORT FAC UPGRADE

BENEFIT	COST
984	879

CHANGE 11: RAS BANAS/E - ARMY
FROM 5: BASE SUPPORT
TO 6: DIVISION STAGING BS

BENEFIT	COST
997	924

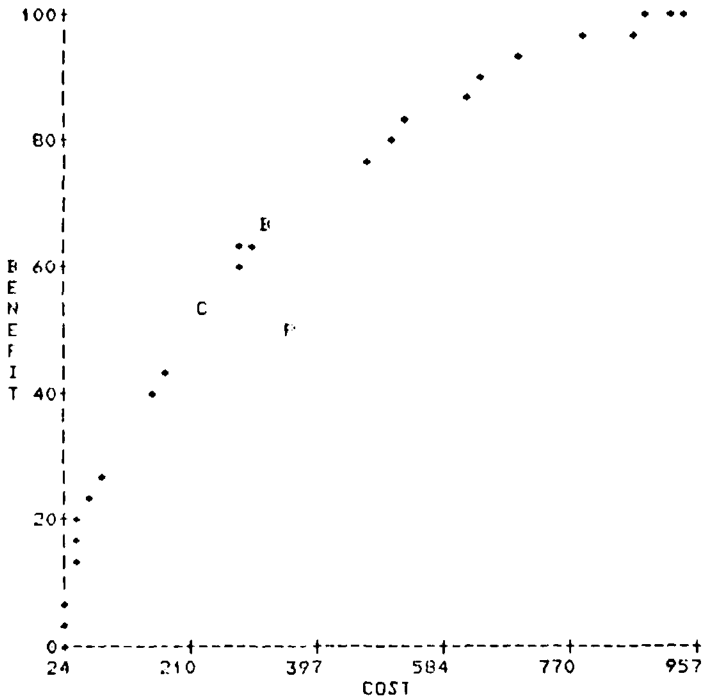
CHANGE 10: LAJES
FROM 5: UTILITIES UPGRADE
TO 6: TROOP SERVICES

BENEFIT	COST
1000	940

Figure 5-2

FAC III THURSDAY 5/28/1981 14:59

PROPOSED PACKAGE



VARIABLE	LEVEL 1	2	3	4	5	6	7	8	9
1 MASIRAH /OM		C	B				F		
2 SEEB/OM	F		C		B				
3 THUMRAIT/OM	CF				B				
4 MUSANDAM/OM	CB	F							
5 MOMBASA/K			F			CB			
6 MALINDI/K	CFB								
7 BERBERA/S					CFB				
8 MOGADISCIO/S			CFB						
9 DIEGO GARCIA		CB			F				
10 LAJES		CF		B					
11 RAS BANAS/E - ARMY	CFB								
12 RAS BANAS/E -USAF	CFB								
13 CAIRO EAST/E	F	CB							

Figure 5-3

5.2 Prepositioned Materiel

In a manner similar to that described for the base structure, the prepositioned materiel model also produces a list of efficient packages, a cost/benefit curve, and a mapping of proposed, better and cheaper packages on the model structure. Figures 5-4 through 5-7 display these elements.

5.3 Airlift/Sealift

Figures 5-8 and 5-9 show output from the airlift/sealift model similar to that previously described for the other two basic models.

5.4 Support Architecture

Merging of the three basic or sub-models with a "super" DESIGN model, as described in Section 3.4 produces outputs for the entire support architecture similar to that for each sub-model. Figures 5-10, 5-11, and 5-12 show the results of this process. Note that the "proposed" package gives some 39.2% of the available total benefit for $1,218 billion, or 8.4% of the total cost. The model, directed to search in the region of 70% of the total benefit, has selected a package that gives 69.5%, at a cost of $2,015 billion, or 14% of the total cost. Thus, a relatively small dollar increment secures a relatively large increment of benefit. The cost/benefit curve also suggests sharply diminishing marginal returns in the region of $3-4 billion.

LIST OF EFFICIENT PACKAGES

ALL VARIABLES SET AT LEVEL 1
BENEFIT COST
0 0

CHANGE 2: AMMO
FROM 1: NONE
TO 2: 10 DAYS

BENEFIT COST
144 71

CHANGE 4: CONSUMABLES
FROM 2: 10 DAYS
TO 3: 30 DAYS

BENEFIT COST
208 121

CHANGE 5: FOL
FROM 1: NONE
TO 2: 5 DAYS

BENEFIT COST
281 193

CHANGE 6: WATER
FROM 3: 10 DAYS
TO 5: 20 DAYS

BENEFIT COST
400 338

CHANGE 1: EQUIP
FROM 1: NONE
TO 2: 3PDL

BENEFIT COST
707 1050

CHANGE 5: FOL
FROM 3: 15 DAYS
TO 4: 30 DAYS

BENEFIT COST
777 1286

CHANGE 1: EQUIP
FROM 2: 3PDL
TO 3: 1 MAF+

BENEFIT COST
835 1719

CHANGE 4: CONSUMABLES
FROM 1: NONE
TO 2: 10 DAYS

BENEFIT COST
45 16

CHANGE 6: WATER
FROM 1: NONE
TO 2: 5 DAYS

BENEFIT COST
167 87

CHANGE 6: WATER
FROM 2: 5 DAYS
TO 3: 10 DAYS

BENEFIT COST
227 138

CHANGE 2: AMMO
FROM 2: 10 DAYS
TO 3: 30 DAYS

BENEFIT COST
377 304

CHANGE 5: FOL
FROM 2: 5 DAYS
TO 3: 15 DAYS

BENEFIT COST
466 450

CHANGE 3: SPARES
FROM 1: NONE
TO 2: 50SM + 10LL

BENEFIT COST
733 1120

CHANGE 6: WATER
FROM 5: 20 DAYS
TO 6: 30 DAYS

BENEFIT COST
784 1319

CHANGE 5: FOL
FROM 4: 30 DAYS
TO 5: 45 DAYS

BENEFIT COST
857 1886

Figure 5-4

PREFO THURSDAY 5/28/1981 14:27

LIST OF EFFICIENT PACKAGES

CHANGE 2: AMMO
FROM 3: 30 DAYS
TO 4: 60 DAYS

BENEFIT	COST
877	2053

CHANGE 3: SPARES
FROM 2: 50SM + 10LG
TO 3: 100SM + 25LG

BENEFIT	COST
890	2193

CHANGE 4: CONSUMABLES
FROM 4: 60 DAYS
TO 5: 90 DAYS

BENEFIT	COST
904	2410

CHANGE 1: EQUIP
FROM 3: 1 MAF+
TO 4: 1MAF + 1 ARMY DIV

BENEFIT	COST
938	3910

CHANGE 3: SPARES
FROM 3: 100SM + 25LG
TO 5: SM + 75LG

BENEFIT	COST
992	7130

CHANGE 4: CONSUMABLES
FROM 5: 90 DAYS
TO 6: 180 DAYS

BENEFIT	COST
999	7780

CHANGE 4: CONSUMABLES
FROM 3: 30 DAYS
TO 4: 60 DAYS

BENEFIT	COST
882	2103

CHANGE 2: AMMO
FROM 4: 60 DAYS
TO 5: 90 DAYS

BENEFIT	COST
901	2360

CHANGE 5: POL
FROM 5: 45 DAYS
TO 6: 90 DAYS

BENEFIT	COST
916	2910

CHANGE 1: EQUIP
FROM 4: 1MAF + 1 ARMY DIV
TO 6: 1 MAF + 4 DIV

BENEFIT	COST
989	6910

CHANGE 2: AMMO
FROM 5: 90 DAYS
TO 6: 180 DAYS

BENEFIT	COST
998	7630

CHANGE 3: SPARES
FROM 5: SM + 75LG
TO 6: SM + LG

BENEFIT	COST
1000	7900

Figure 5-5

PREPO THURSDAY 5/28/1981 14:27

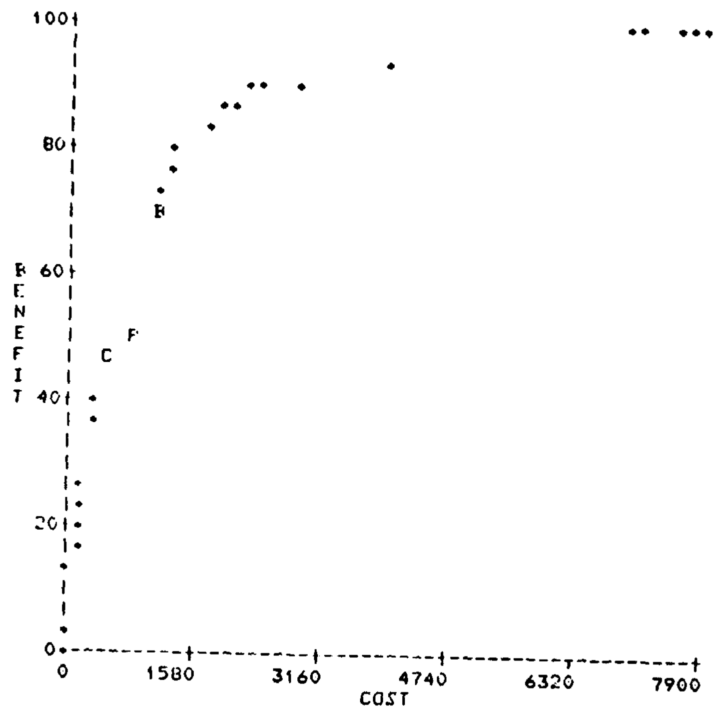
PROPOSED PACKAGE

VARIABLE	BENEFIT	WTS	COST	LEVEL	
1 EQUIP	241	365	600	3RDC	(2 OF 6)
2 AMMO	99	234	55	10 DAYS	(2 OF 6)
3 SPARES	0	36	0	NONE	(1 OF 6)
4 CONSUMABLES	0	95	0	NONE	(1 OF 6)
5 POL	120	197	167	15 DAYS	(3 OF 6)
6 WATER	42	73	33	10 DAYS	(3 OF 6)
	503		855		

Figure 5-6

PREPO THURSDAY 5/28/1981 14:27

PROPOSED PACKAGE



VARIABLE	LEVEL 1	2	3	4	5	6
1 EQUIP	C	PB				
2 AMMO		P	CB			
3 SPARES	CPB					
4 CONSUMABLES	P		CB			
5 POL			CPB			
6 WATER			P		CB	

Figure 5-7

LIFT THURSDAY 5/28/1981 14.33

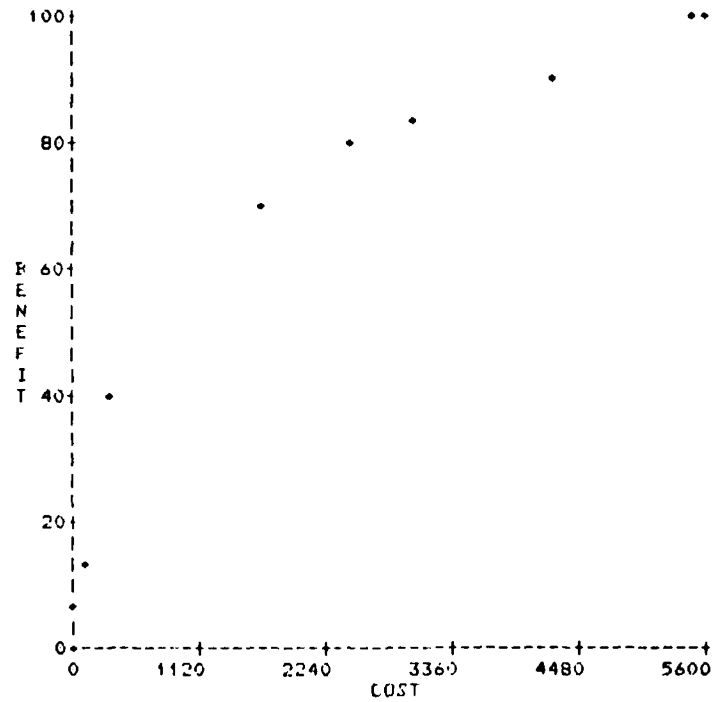
LIST OF EFFICIENT PACKAGES

```
ALL VARIABLES SET AT LEVEL 1
      BENEFIT        COST
         0             0

CHANGE  2: SEA-LIFT
   FROM 1: NONE
     TO 2: BUY 2 RORO'S

     BENEFIT        COST
       137            100

CHANGE  1: AIR-LIFT
   FROM 3: + CRAF MODS
     TO 4: + 25 KC10'S

     BENEFIT        COST
       694           1650

CHANGE  1: AIR-LIFT
   FROM 4: + 25 KC10'S
     TO 5: + BUY 10 LO MIX CX'S

     BENEFIT        COST
       834           3000

CHANGE  1: AIR-LIFT
   FROM 5: + BUY 10 LO MIX CX'S
     TO 7: + 15 KC10'S

     BENEFIT        COST
       995           5500

CHANGE  1: AIR-LIFT
   FROM 1: NONE
     TO 2: RECONFIG CRAF PRGRAM

     BENEFIT        COST
        69             50

CHANGE  1: AIR-LIFT
   FROM 2: RECONFIG CRAF PRGRAM
     TO 3: + CRAF MODS

     BENEFIT        COST
       406            350

CHANGE  2: SEA-LIFT
   FROM 2: BUY 2 RORO'S
     TO 4: BUY 8 SL7'S, 1 LASH

     BENEFIT        COST
       791           2500

CHANGE  2: SEA-LIFT
   FROM 4: BUY 8 SL7'S, 1 LASH
     TO 6: CONVERT 8 SL7'S

     BENEFIT        COST
       914           4200

CHANGE  2: SEA-LIFT
   FROM 6: CONVERT 8 SL7'S
     TO 7: + RF ENHANCEMENT

     BENEFIT        COST
      1000           5600
```

Figure 5-8

LIFT THURSDAY 5/28/1981 14:33

PROPOSED PACKAGE



VARIABLE	LEVEL 1	2	3	4	5	6	7
1 AIR-LIFT	CFB						
2 SEA-LIFT	CFB						

Figure 5-9

SUPPORT ARCHITECTURE THURSDAY 5/28/1981 15:26

LIST OF EFFICIENT PACKAGES

ALL VARIABLES SET AT LEVEL 1
BENEFIT COST
4 24

CHANGE VARIABLE 1: PRE-POS
FROM LEVEL 1 TO LEVEL 2

BENEFIT COST
160 169

CHANGE VARIABLE 3 FAC III
FROM LEVEL 3 TO LEVEL 4

BENEFIT COST
264 354

CHANGE VARIABLE 3 FAC III
FROM LEVEL 4 TO LEVEL 5

BENEFIT COST
391 667

CHANGE VARIABLE 3 FAC III
FROM LEVEL 5 TO LEVEL 6

BENEFIT COST
462 908

CHANGE VARIABLE 3 FAC III
FROM LEVEL 6 TO LEVEL 7

BENEFIT COST
555 1303

CHANGE VARIABLE 3: FAC III
FROM LEVEL 7 TO LEVEL 8

BENEFIT COST
718 2194

CHANGE VARIABLE 1: PRE-POS
FROM LEVEL 4 TO LEVEL 5

BENEFIT COST
790 3009

CHANGE VARIABLE 1: PRE-POS
FROM LEVEL 5 TO LEVEL 6

BENEFIT COST
892 5500

CHANGE VARIABLE 3: FAC III
FROM LEVEL 1 TO LEVEL 2

BENEFIT COST
65 48

CHANGE VARIABLE 3: FAC III
FROM LEVEL 2 TO LEVEL 3

BENEFIT COST
225 276

CHANGE VARIABLE 1: PRE-POS
FROM LEVEL 2 TO LEVEL 3

BENEFIT COST
352 571

CHANGE VARIABLE 2: LIFT
FROM LEVEL 1 TO LEVEL 2

BENEFIT COST
422 769

CHANGE VARIABLE 2: LIFT
FROM LEVEL 2 TO LEVEL 3

BENEFIT COST
523 1158

CHANGE VARIABLE 1: PRE-POS
FROM LEVEL 3 TO LEVEL 4

BENEFIT COST
695 2015

CHANGE VARIABLE 3: FAC III
FROM LEVEL 8 TO LEVEL 9

BENEFIT COST
732 2340

CHANGE VARIABLE 2: LIFT
FROM LEVEL 3 TO LEVEL 4

BENEFIT COST
856 4309

CHANGE VARIABLE 2: LIFT
FROM LEVEL 4 TO LEVEL 5

BENEFIT COST
914 6350

Figure 5-10

SUPPORT ARCHITECTURE   THURSDAY 5/28/1981 15:26

LIST OF EFFICIENT PACKAGES

CHANGE VARIABLE 2: LIFT
FROM LEVEL 5 TO LEVEL 6

BENEFIT	COST
924	6850

CHANGE VARIABLE 2: LIFT
FROM LEVEL 7 TO LEVEL 8

BENEFIT	COST
962	9450

CHANGE VARIABLE 1 PRE-POS
FROM LEVEL 7 TO LEVEL 8

BENEFIT	COST
995	13450

CHANGE VARIABLE 2: LIFT
FROM LEVEL 6 TO LEVEL 7

BENEFIT	COST
942	8050

CHANGE VARIABLE 1: PRE-POS
FROM LEVEL 6 TO LEVEL 7

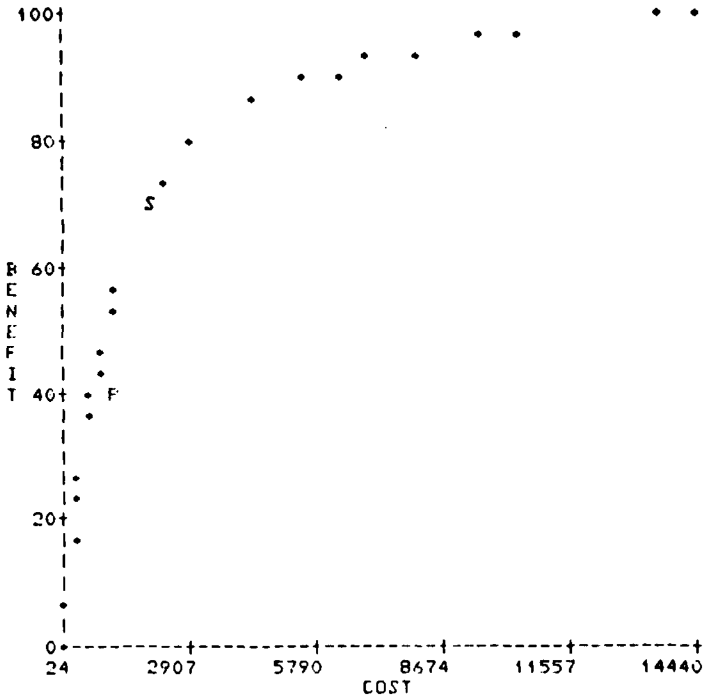
BENEFIT	COST
972	10450

CHANGE VARIABLE 1: PRE-POS
FROM LEVEL 8 TO LEVEL 9

BENEFIT	COST
1000	14440

Figure 5-11

SUPPORT ARCHITECTURE   THURSDAY 5/28/1981 15.26



VARIABLE	SELECTED BENEFIT	SELECTED COST	PROPOSED BENEFIT	PROPOSED COST	MAXIMUM BENEFIT	MAXIMUM COST
1 FFE-POS	321	1050	228	855	455	7900
2 LIFT	92	350	0	0	227	5600
3 FAC III	281	615	164	363	318	940
	695	2015	392	1218	1000	14440

Figure 5-12

6.0 CONCLUSION

6.1 Findings and Conclusions

The work so far indicates that the models and techniques developed by DDI are potentially very useful to the RDJTF. Analysis of the models, especially the base structure model, has raised several provocative issues of policy and priority. An account of these will be provided in the classified annex to the final report.

6.2 Implications for Further Research

There are at least four areas in which further exploratory work appears useful:

1. Derivation of real world cost and benefit data for the prepositioned equipment and airlift/sealift models.

2. Exploration of alternative base locations and milcon options beyond those contained in the DoD program.

3. Assessment of the political dimensions of the base structure model by knowledgeable people outside RDJTF staff (i.e., State or NSC personnel).

4. Tracking and assessing RDJTF staff use of the models in exploring alternatives and adapting to real world changes.

APPENDIX A

DESIGN

A. DESIGN

A.1 Resource Allocation

A.1.1 General approach - Decisions and Designs, Inc. (DDI) has developed a methodological approach to resource allocation based on benefit-cost analysis. The modeling software used to implement this approach is called "DESIGN." DESIGN's basic building block is a "variable"; a DESIGN variable is one of the projects/programs competing for limited resources. Each of the competing variables is itself defined in terms of "levels" that describe increasingly costly options for it; one level must be selected by the decision maker for each variable. Finally, each level is described in terms of its cost (resource use) and benefits relative to other levels. A fully defined collection of DESIGN variables that compete for the same resource is called a DESIGN "model." In addition to the foregoing structure definitions, any resource allocation decision, that is, any choice of one level for each variable in the model, is called a "package" or a "design"; it is from this that the methodology gets its name.

In terms of these definitions, the DESIGN methodology and software have these functions during the working meetings:

(1) To organize, display, and update the working group's judgements about the relative costs and benefits of each level of each variable in the model.

(2) To display the relative overall cost and benefit of any one design compared to other designs.

(3) To compute and display an approximation to the "efficient frontier" of designs for the model, i.e., those key packages among all possible packages that provide maximum benefit for the amount of resource they use. These designs are the key options for the group to consider, but they are difficult to find without the computer's assistance. Figure A-1 shows a hypothetical benefit-cost curve, which indicates pictorially the benefit of efficient designs at different levels of cost.

(4) To display the variable and levels that comprise the best package for any given level of overall resource expenditure.

(5) To compare different designs proposed by the decision makers with more efficient designs that either cost less and provide the same overall benefit or provide more benefit for the same cost.

(6) To perform sensitivity analysis showing the decision makers how the overall results would change as a result of modifying the benefits and costs assigned to the levels on the variables in the DESIGN model.

This technical approach to resource allocation problems is designed to bring forth the decision makers' expertise and priorities so as to influence their decision in an effective and efficient manner. It captures the essence of the working group's collective judgement about resource allocation opportunities, helping it to find the most attractive ones.

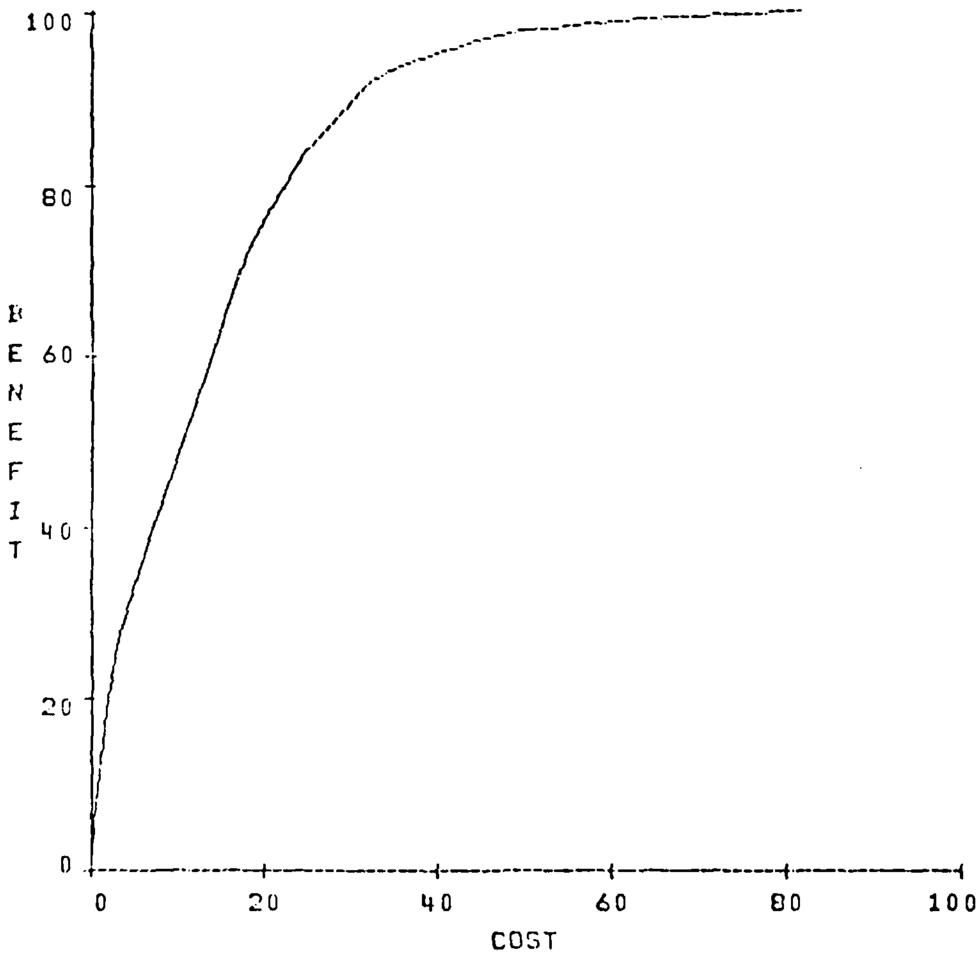


Figure A-1
BENEFIT/COST CURVE

This is not an approach that DDI uses unilaterally to study and recommend decisions; rather, it is oriented towards the collection and use of the high-level professional judgements of the client.

A.1.2 Procedural steps - The implementation of DDI's resource allocation approach using the DESIGN software has the following seven steps:

(1) Identify variables over which resources can be allocated - Variables over which resources can be distributed are identified. An attempt is made to characterize the problem using variables that can be independently manipulated. That is differing levels of resources can be allocated independently to each of the variables.

(2) Identify levels of the variables that vary from "baseline" to "gold-plated" - The "baseline" level involves a minimal realistic resource allocation with correspondingly minimal benefit. The "gold-plated" level involves maximal resource allocation with, hopefully, maximal benefit. The levels of the variables from "baseline" to "gold" involve increasing commitments of resources with resultant increased level of capability and usually increased level of benefit to the organization.

(3) Assess costs - In the DESIGN software, there is one type of limited resource to be allocated to the variables. This resource is called "cost." A cost is assigned to each level of each variable such

that the first level is the least expensive level, successive levels are increasingly more expensive, and the last level is the most expensive level on that variable.

(4) Assess benefits (intra-variable) - The levels of each variable are assigned scores to reflect their relative benefit. Since incremental benefit is being considered, Level 1 is assigned a score of 0 and the highest level is assigned a score of 100. Intermediate levels are assigned values by comparing their improvement over Level 1 relative to the total improvement from Level 1 to the highest level.

(5) Assess importance weights (inter-variable benefits)- The variables are given importance weights by having the decision maker(s) assess the relative improvement or benefit of going from "baseline" to "gold" on each of the variables. This step rescales the 100-point benefit ranges associated with each variable onto a common benefit scale by direct comparison of the benefits associated with these 100-point ranges. The procedure uses these comparisons to allocate 1000 total points among the variables. For example, one variable may be assessed to have 200 points associated with its baseline-to-gold range, while another variable has 100 points associated with its baseline-to-gold range. This indicates that the former variable is twice as "important" as the latter, thereby yielding twice the overall benefit. The calculated benefit value for any level of a variable equals the weight of the variable multiplied by the score on that level.

(6) Identify most cost-beneficial allocations of resources - The set of most cost-beneficial allocations of resources is identified using the costs and benefits already assessed. These allocations form a set that has the property called "efficiency": any allocation not in the set is inferior either in a cost or benefit sense (or both) to at least one allocation in the set.

(7) Exercise the model - Proposed allocations are compared to the set of optimal allocations. Sensitivity of allocations to model inputs are examined until the experts involved are satisfied with the model inputs and the resultant model allocations.

When there are too many variables to be considered in one model, the DESIGN software can be used to reduce the effective number of variables that the group must consider at once. This is accomplished by creating a hierarchical design model composed of independent submodels. This is done as follows: (1) the variables are divided into submodels; (2) each submodel is developed and analyzed separately to determine its set of efficient designs; (3) a new variable is created to represent each submodel, choosing a representative few of the submodel's efficient designs to be levels for the new variable; and (4) the new variables representing the submodels are analyzed together to determine a composite set of efficient designs for the whole model. This four-step process is too complex to describe in detail here; let it suffice to say that it has the advantage in practice of bringing the size of the allocation problem down to a manageable level.

A.2 Description of Computer Model and Outputs

In order to facilitate the numerical calculations and the graphical display of assessed values, results, and rationale, DDI uses a proprietary software package called "DESIGN." The DESIGN software incorporates into a computer model all of the elicited information concerning the specified variables and their levels, the costs and benefits associated with each level of each variable, and the verbal rationale underlying the assessed scores, weights, and costs. DESIGN allows for convenient calculation and display of these assessments and results in a variety of formats. This section described the DESIGN outputs available and acts as a guide to their interpretation.

A.2.1 Model structure: variables and levels - The first sort of output display available is simply on overall summary of the design options being evaluated, the decision variables, and the possible levels for each variable. Figure A-2 shows an example of the model structure display, using a hypothetical factory design problem for illustrative purposes.

The names of the decision variables are listed in the left-hand column of the display. To the right of each variable name, two or more boxes will appear, each containing the name (possibly abbreviated) of a level for that variable. As a general rule, the levels will appear in order of increasing cost. Thus, for example, the most expensive level of the three "waste removal" options would be "pneumatic removal."

SAMPLE MODEL (FACTORY DESIGN)   TUESDAY 7/15/1980 9:53

VARIABLE	1	2	3	4
1 PLANT-WIDE CONTROLS	LOCAL AUTOMATION	PROCESS COMPUTER	COMPLETE AUTOMATION	
2 STORAGE AND DELIVERY	RAIL/TRUCK DELIVERY	DRIVE-IN RACK SYSTE	AUTOMATIC STACK/RTRV	
3 PRIMARY RECEIVING	TRUCK/FORK LIFT	CONVEYER RECEIPT	RECEVE,CND TION,GRADE	
4 SECONDARY LAYOUT	COMBINE IN ONE DEPT	ONE DEPT PER LINE	FOUR SEPARATE D	
5 WASTE REMOVAL	REMOVE BY FORKLIFT	DRIVERLESS TRACTORS	PNEUMATIC REMOVAL	
6 RECLAMATION	MANUAL UNLOADING	AUTOMATED HANDLING		
7 SHIPPING	MANUAL REMV,PALLT	AUTO REC,SRT,UN	AUTO REC,SRT,UN	ALL AUTO
8 SUPPLIES	ALL MANUAL	SEMI-AUTO STORE RETR	AUTO STORE, RET	AUTO STORE,RTRV

Figure A-2

ILLUSTRATIVE "MODEL STRUCTURE" PRINTOUT

ASSESSED VALUES

VARIABLE 1: PLANT-WIDE CONTROLS

	COST	DSPL	FLEX	OPS	QUAL	TOTAL
1 LOCAL AUTOMATION	3.5	0	0	0	0	0
2 PROCESS COMPUTER	4.5	0	0	80	80	80
3 COMPLETE AUTOMATION	6.5	0	0	100	100	100
WITHIN CRITERION WEIGHTS		0	0	100	10	
ACROSS CRITERIA WEIGHTS		50	82	62	100	

VARIABLE 2: STORAGE AND DELIVERY

	COST	DSPL	FLEX	OPS	QUAL	TOTAL
1 RAIL/TRUCK DELIVERY	1	0	100	0	0	7
2 DRIVE-IN RACK SYSTEM	3	10	35	60	0	0
3 AUTOMATIC STACK/RTRV	11	100	0	100	0	100
WITHIN CRITERION WEIGHTS		10	5	5	0	
ACROSS CRITERIA WEIGHTS		50	82	62	100	

VARIABLE 3: PRIMARY RECEIVING

	COST	DSPL	FLEX	OPS	QUAL	TOTAL
1 TRUCK/FORKLIFT	.1	0	0	0	0	0
2 CONVEYER RECEIPT	2.5	80	0	0	0	19
3 RECEVE,CNDTION,GRADE	4.9	100	100	0	0	100
WITHIN CRITERION WEIGHTS		10	20	0	0	
ACROSS CRITERIA WEIGHTS		50	82	62	100	

VARIABLE 4: SECONDARY LAYOUT

	COST	DSPL	FLEX	OPS	QUAL	TOTAL
1 COMBINE IN ONE DEPT	2.5	0	0	0	0	0
2 ONE DEPT PER LINE	3.0	0	70	60	0	62
3 FOUR SEPARATE DEPTS	4.0	0	100	100	0	100
WITHIN CRITERION WEIGHTS		0	20	100	0	
ACROSS CRITERIA WEIGHTS		50	82	62	100	

Figure A-3

ILLUSTRATIVE "ASSESSED VALUES" PRINTOUT

VARIABLE 5: WASTE REMOVAL

		COST	DSPL	FLEX	OPS	QUAL	TOTAL
1	REMOVE BY FORKLIFT	.3	25	100	100	100	100
2	DRIVERLESS TRACTORS	.3	0	50	50	100	38
3	PNEUMATIC REMOVAL	1.2	100	0	0	0	0
	WITHIN CRITERION WEIGHTS		8	5	15	2	
	ACROSS CRITERIA WEIGHTS		50	82	62	100	

VARIABLE 6: RECLAMATION

		COST	DSPL	FLEX	OPS	QUAL	TOTAL
1	MANUAL UNLOADING	2.0	0	0	0	0	0
2	AUTOMATED HANDLING	3.0	100	0	0	0	100
	WITHIN CRITERION WEIGHTS		3	0	0	0	
	ACROSS CRITERIA WEIGHTS		50	82	62	100	

VARIABLE 7: SHIPPING

		COST	DSPL	FLEX	OPS	QUAL	TOTAL
1	MANUAL REMV,PALLT,LD	.3	0	100	0	0	0
2	AUTO REC,SRT,UNITIZE	2.0	30	60	30	0	29
3	AUTO REC,SRT,UNT,STR	3.0	45	80	100	0	61
4	ALL AUTO	5.0	100	0	100	0	100
	WITHIN CRITERION WEIGHTS		20	1	5	0	
	ACROSS CRITERIA WEIGHTS		50	82	62	100	

VARIABLE 8: SUPPLIES

		COST	DSPL	FLEX	OPS	QUAL	TOTAL
1	ALL MANUAL	.5	0	100	0	0	0
2	SEMI-AUTO STORE RETR	1.0	30	80	75	60	63
3	AUTO STORE, RETRIEVE	1.5	60	70	100	100	100
4	AUTO STORE,RTRV,DIST	5.0	100	0	100	100	74
	WITHIN CRITERION WEIGHTS		30	20	20	5	
	ACROSS CRITERIA WEIGHTS		50	82	62	100	

Figure A-3 (Con't)

ILLUSTRATIVE "ASSESSED VALUES" PRINTOUT

A.2.2 Assessed values - The display of assessed values (illustrated in Figure A-3) consists of one table for each of the variables in the model. For each variable, the heading identifies its name and number. The left-hand column lists the possible levels associated with the name variable; the column immediately to its right shows the cost associated with that level (although the displayed costs may be rounded off, the actual assessed costs are accurately retained in the computer's internal representation). Usually, costs are expressed in millions of dollars, unless otherwise noted in the text.

To the right of the cost column will appear one or more columns corresponding to the various components of benefit associated with a given level. In the current illustration, there are four components, DSPL, FLEX, OPS, and QUAL. The numbers under each of these headings indicate the assessed performance of each level with respect to the corresponding component of benefit. (Frequently, benefit will be treated as a single quantity and represented by a heading such as BENFT or BEN.)

Beneath the assessed benefit scores for each component there will be two rows entitled "within criterion weights" and "across criteria weights." The "within criterion weights" represents the relative contribution of the best-rated level of that variable to the overall best possible performance on the utility component corresponding to the column indicated. For example, the "within criterion weight" for Variable 2 (Storage and Display on the DSPL criterion is 10, which indicates that the value of Level 3 (Automatic Stack/Retrieve) accounts for 10 percent of the possible impact on the DSPL criterion. The "across criteria weights" indicates the overall contribution of the maximum performance on each criterion to total benefit (roughly speaking, the "importance" of each criterion with respect to the others).

Finally, the rightmost column indicates a TOTAL benefit score for each level on the given variable. This total score represents a weighted average of the component criterion scores (with weights proportional to the product of the "within" and "across" weights), rescaled in such a manner that the level with the lowest overall benefit gets a score of 0, the level with the highest overall benefit gets a score of 100, and the remaining levels are rescored so as to maintain the original proportional differences. Note that when only a single benefit criterion has been used, the TOTAL column will exactly duplicate the numbers in the BENFT column.

A.2.3 Normalized values - Figure A-4 illustrates a summary display of the variables and their levels, with the total costs and benefits associated with each level. In this case, however, the benefit associated with each level is "normalized" to represent its proportional contribution to a total benefit score of 1000 points. For example, Level 2 on Variable 1 (Plant-wide Controls) would account for 257 out of a possible 1000 benefit points. In a similar manner, costs are normalized so that the difference in cost between the cheapest combination of levels and the most expensive corresponds to 1000 "cost points" and each level which exceeds the minimum cost on any variable receives a proportion of those points based upon the amount by which its cost exceeds the least expensive level (i.e., normalized costs represent the increment over the minimum-level cost on each variable).

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NORMALIZED VALUES

VARIABLE	BENEFIT LEVEL 1	2	3	4	WEIGHT	COST LEVEL 1	2	3	4
1 PLANT-WIDE CONTROLS	0	257	322		322	0	33	99	
2 STORAGE AND DELIVERY	1	0	19		19	0	66	329	
3 PRIMARY RECEIVING	0	18	96		96	0	79	158	
4 SECONDARY LAYOUT	0	218	350		350	0	16	49	
5 WASTE REMOVAL	55	21	0		55	0	0	30	
6 RECLAMATION	0	7			7	0	33		
7 SHIPPING	0	16	33	55	55	0	56	89	155
8 SUPPLIES	0	60	96	72	96	0	16	33	148

Figure A-4

ILLUSTRATIVE "NORMALIZED VALUES" PRINTOUT

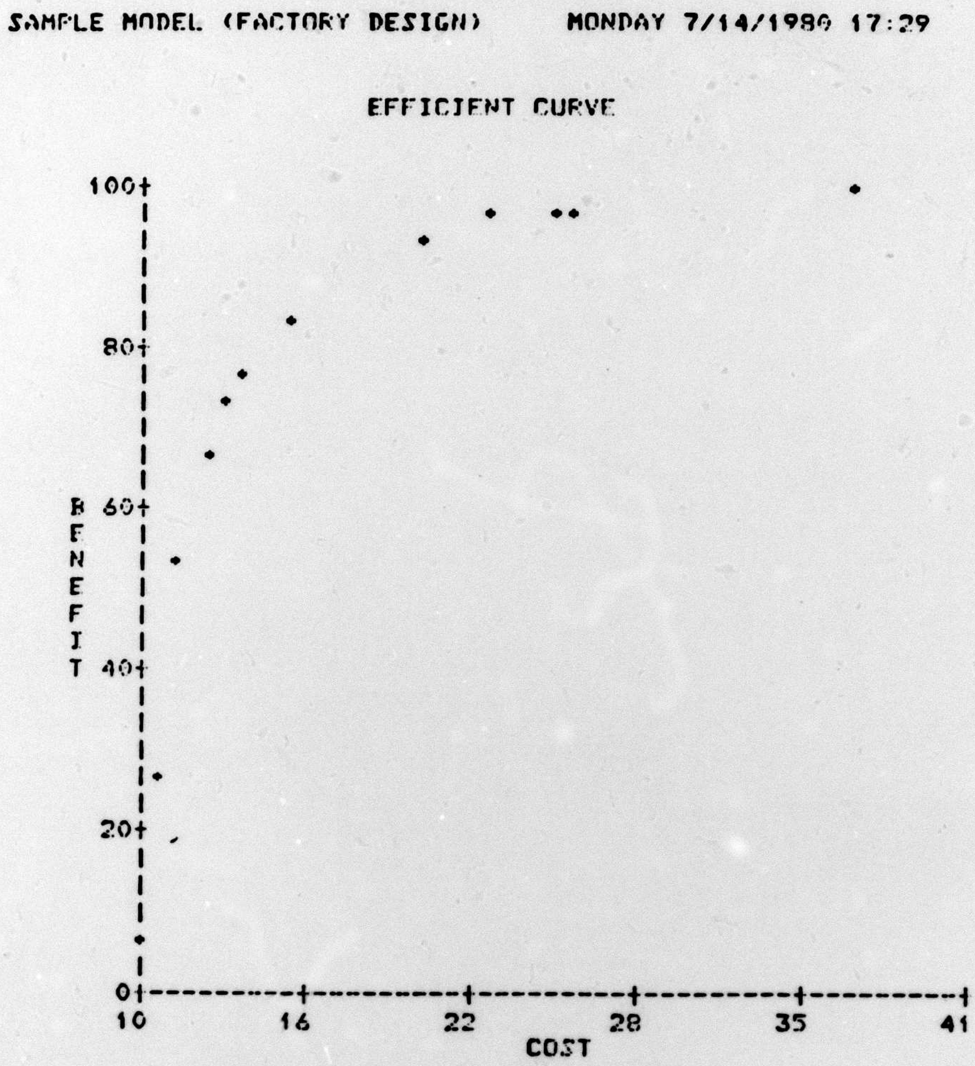

Figure A-5

ILLUSTRATIVE PLOT OF "EFFICIENT CURVE"

LIST OF EFFICIENT PACKAGES

ALL VARIABLES SET AT LEVEL 1

BENEFIT	COST
57	10

CHANGE 1: PLANT-WIDE CONTROLS
FROM 1: LOCAL AUTOMATION
TO 2: PROCESS COMPUTER

BENEFIT	COST
532	12

CHANGE 8: SUPPLIES
FROM 1: ALL MANUAL
TO 2: SEMI-AUTO STORE RETR

BENEFIT	COST
725	13

CHANGE 1: PLANT-WIDE CONTROLS
FROM 2: PROCESS COMPUTER
TO 3: COMPLETE AUTOMATION

BENEFIT	COST
825	16

CHANGE 7: SHIPPING
FROM 1: MANUAL REMV,PALLT,LD
TO 3: AUTO REC,SRT,UNT,STR

BENEFIT	COST
954	23

CHANGE 6: RECLAMATION
FROM 1: MANUAL UNLOADING
TO 2: AUTOMATED HANDLING

BENEFIT	COST
982	26

CHANGE 4: SECONDARY LAYOUT
FROM 1: COMBINE IN ONE DEPT
TO 2: ONE DEPT PER LINE

BENEFIT	COST
274	11

CHANGE 4: SECONDARY LAYOUT
FROM 2: ONE DEPT PER LINE
TO 3: FOUR SEPARATE DEPTS

BENEFIT	COST
665	13

CHANGE 8: SUPPLIES
FROM 2: SEMI-AUTO STORE RETR
TO 3: AUTO STORE, RETRIEVE

BENEFIT	COST
761	14

CHANGE 3: PRIMARY RECEIVING
FROM 1: TRUCK/FORKLIFT
TO 3: RECEVE,CNDTION,GRADE

BENEFIT	COST
921	20

CHANGE 7: SHIPPING
FROM 3: AUTO REC,SRT,UNT,STR
TO 4: ALL AUTO

BENEFIT	COST
975	25

CHANGE 2: STORAGE AND DELIVERY
FROM 1: RAIL/TRUCK DELIVERY
TO 3: AUTOMATIC STACK/RTRV

BENEFIT	COST
1000	36

Figure A-6

ILLUSTRATIVE "LIST OF EFFICIENT PACKAGES" DISPLAY

A.2.4 Efficient curve and list of efficient packages Figures A-5 illustrates a graphic plot of those packages which represent the maximally efficient combinations of levels. For any point on the efficient curve, an increase in benefit can be achieved only by increasing cost, and a decrease in cost can be achieved only by sacrificing some benefit.

Figure A-6 contains a list of the specific packages corresponding to the efficient curve. By setting all of the variables at Level 1 (the cheapest option), a minimum cost and a baseline benefit can be determined (in the illustrative example, the baseline benefit is 57 points, at a cost of $10 million). The next-cheapest efficient package can be reached by changing Variable 4 (Secondary Layout) from Level 1 to Level 2, thus raising the overall benefit score to 274 and the cost to $11 million. Reading from right to left, the successive changes indicate the increments corresponding to adjacent points on the efficient curve.

A.2.5 Proposed packages - Figure A-7 illustrates a specific package proposed for the illustrative problem. For each variable, the normalized benefit associated with the proposed level is displayed (with the sum of the benefits at the bottom). For comparison, the maximum achievable benefit on that variable is displayed in the WTS column. These are followed by the cost associated with the proposed level, the name of the proposed level, and its identifying number (e.g., for Variable 6, "Reclamation", the proposed level, "Manual Unloading," is Level 1 of two possible levels).

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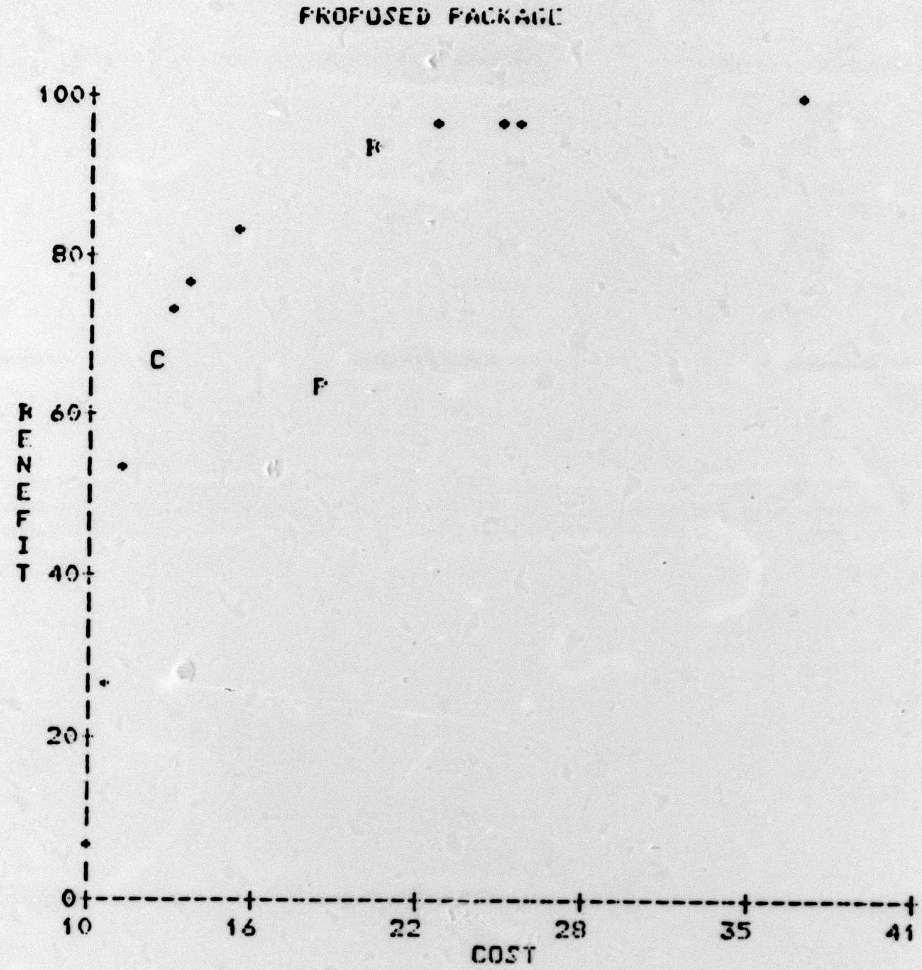
PROPOSED PACKAGE

	VARIABLE	BENEFIT	WTS	COST	LEVEL	
1	PLANT-WIDE CONTROLS	257	322	5	PROCESS COMPUTER	(2 OF 3)
2	STORAGE AND DELIVERY	0	19	3	DRIVE-IN RACK SYSTEM	(2 OF 3)
3	PRIMARY RECEIVING	18	96	3	CONVEYER RECEIPT	(2 OF 3)
4	SECONDARY LAYOUT	218	350	3	ONE DEPT PER LINE	(2 OF 3)
5	WASTE REMOVAL	21	55	0	DRIVERLESS TRACTORS	(2 OF 3)
6	RECLAMATION	0	7	2	MANUAL UNLOADING	(1 OF 2)
7	SHIPPING	16	55	2	AUTO REC,SRT,UNITIZE	(2 OF 4)
8	SUPPLIES	96	96	2	AUTO STORE, RETRIEVE	(3 OF 4)
		626		19		

Figure A-7

ILLUSTRATIVE "PROPOSED PACKAGE" DISPLAY



VARIABLE	LEVEL 1	2	3	4
1 PLANT-WIDE CONTROLS		CP	B	
2 STORAGE AND DELIVERY	CB	P		
3 PRIMARY RECEIVING	C	P	B	
4 SECONDARY LAYOUT		P	CB	
5 WASTE REMOVAL	CB	P		
6 RECLAMATION	CPB			
7 SHIPPING	CB	P		
8 SUPPLIES	C		PB	

Figure A-8

ILLUSTRATIVE PLOT OF "PROPOSED", "CHEAPER" , AND "BETTER" PACKAGES

Figure A-8 reproduces the efficient curve shown in Figure A-5, with three points highlighted (P) represents the cost and benefit associated with the proposed package; (C) represents a "cheaper" package on the efficient curve, whereby cost savings can be achieved without significantly lowering overall benefit levels; and (B) represents a "better" package on the efficient curve, whereby greater benefits can be achieved without significantly increasing costs. Beneath the plot of the curve is a table indicating the levels corresponding to the three illustrated packages. For example, on Variable 1 ("Plant-wide Controls") both packages (C) and (P) select Level 2, while the (B) package opts for the more expensive Level 3.