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A METHODOLOGY FOR EVALUATION OF AMMUNITION PACKAGING/CONTAINERI--ETC(U)
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A METHODOLOGY FOR EVALUATION OF AMMUNITION PACKAGING/CONTAINERIZATION ALTERNATIVES ON A LIFE CYCLE BASIS

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BY

THOMAS H. SHORT

OCTOBER 1979

DECISION MODELS DIRECTORATE

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A METHODOLOGY FOR EVALUATION OF AMMUNITION PACKAGING/CONTAINERIZATION ALTERNATIVES ON A LIFE CYCLE BASIS

FOREWORD

There is a need within the conventional ammunition community for the capability of evaluating alternative ammunition packaging and containerization configurations on a life cycle cost basis. To meet this need, an ammunition packaging/containerization methodology was developed by the Joint Conventional Ammunition Program Decision Models Directorate (JCAP-DM), now the ARRCOM Decision Models Directorate (DRSAR-DM), under the auspices of the Joint Conventional Ammunition Program Coordinating Group (JCAP-CG). The methodology has been completely developed, tested, and successfully demonstrated. This document provides information about this methodology and outlines the concepts, purposes, and appropriate uses.

Configuration management of the methodology is retained by the ARRCOM Decision Models Directorate (DRSAR-DM) which serves as the Single Manager for Conventional Ammunition (SMCA) Office of Primary Responsibility for models. Proposals for modification of the methodology and inquiries with respect to application should be addressed to: Commander, US Army Armament Materiel Readiness Command, ATTN: DRSAR-DM, Mr. Bernard C. Witherspoon, Rock Island, IL 61299. Telephone inquiries should be addressed to: Chief, Acquisition & Inventory Systems Division, AUTOVON 793-5980/6635.

SUMMARY

This report describes the structure and application of a life cycle cost methodology for evaluating ammunition packaging and containerization alternatives. The methodology was developed by the Joint Conventional Ammunition Program Decision Models Directorate (JCAP-DM), now the ARRCOM Decision Models Directorate (DRSAR-DM), at the direction of the Joint Conventional Ammunition Program Operating Group (JCAP-OG). The study was accomplished in two parts. Phase I, completed in February 1976, provided a review and assessment of relevant cost methodologies and data availability. Development of the methodology described herein occurred during Phase II.

The JCAP Packaging Task Group consisting of packaging and preservation specialists from each Service provided detailed directions regarding specifications and sources of operational data. Task Group members also provided essential assistance and feedback during the testing and demonstration phases of development.

The methodology provides a viable and consistent framework for evaluation of ammunition/containerization on a life cycle cost basis. Utility of the methodology is demonstrated by the evaluation of packaging configurations for the 2.75-Inch Rocket. Results of this demonstration are provided in Appendix E.

ACKNOWLEDGEMENTS

The contributions of the following individuals to the development, modification, application, and documentation of this methodology are gratefully acknowledged.

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1. INTRODUCTION

The ammunition packaging/containerization methodology is sufficiently flexible to permit evaluation of a wide variety of packaging/containerization configurations with diverse characteristics, and to allow users in the engineering and packaging communities to develop and evaluate their own packaging configurations.

Packaging and containerization are used herein in general terms. They include the package, pack, pallet, unit load, container, intermodal container, and other items used to preserve, protect, and facilitate handling during distribution and storage. A complete definition of relevant terms is provided in Appendix F.

2. METHODOLOGY

a. Development

The methodology uses network simulation analysis to determine a baseline total life cycle cost. Life cycle costs include costs to develop packaging and distribute ammunition, and salvage or reuse packaging for specified pack alternatives. The methodology has the following features:

(1) Initial costs to develop and establish a specified pack are included. These costs include research and development, new equipment, and documentation.

(2) Costs incurred throughout the ammunition distribution system are treated on an "averaged" basis. The methodology is not a simulation which can follow an individual pack or container throughout its life.

(3) Reuse of packaging is accounted for by the estimated fraction of the total ammunition production which uses new packaging.

(4) The acquisition and transportation costs are combined with repair and return costs to obtain a weighted cost.

(5) The distribution network, including percentages of ammunition going to different locations, is determined for the item. Costs are then obtained for activities throughout the network. Costs should be requested for the same fiscal year for all network activities.

(6) The total cost for each path (total path cost) and the probability of taking each path (path probability) is calculated. The expected path cost is the product of the total path cost and the path probability. The total expected distribution cost is the sum of the individual expected path costs.

(7) Activity costs are requested in the form which is logically related to pack efficiency parameters, where this is possible. For example, ocean shipping costs are on a "measurement ton" (MT) basis. (40 cu ft = 1 MT) and so are related to pack volumetric efficiency. All activity costs are converted to dollars per round within the program. The total distribution cost is calculated in dollars per round.

b. Scope.

The methodology includes all costs incurred by pack configuration, from development to disposal or reuse. Impacts of damage and loss, discounting, and inflation are considered. The alternatives evaluated are assumed to satisfy all constraints for specified distribution paths. Data required for analysis is described in Appendix A. However, it is not necessary that a specific application of the methodology use all the cost elements described in Appendix A. Figure 1 is a detailed flow through a distribution network. The methodology allows the user to network any specific application as defined and shaped by the available data.

c. Application.

The methodology centers around a computer program, written in FORTRAN, which evaluates a network structure. The computer program does not change. By varying the network structure within the guidelines given in 2a above the user can achieve considerable flexibility. This flexibility allows the user to readily tailor the methodology to conform to his/her particular application and available related data.

Two examples are provided in the Appendices to illustrate the methodology's adaptability to a wide variety of applications. The example in Appendix B illustrates a simple hypothetical application, while Appendix E contains an actual application to the 2.75 inch rocket.

Depending on the complexity of the problem under investigation, it may be helpful to prepare a questionnaire to facilitate collection of data essential to packaging cost analysis. The life cycle costing network of Figure 1 may be used as a starting point in developing a questionnaire.

During packaging analysis for the 105mm HEAT-T M456A1 (completed) and the 2.75 inch rocket (Appendix E) it was found that collection of detailed data, as shown in Figure 1, was not practical since much of the data was not readily available.

3. PROCEDURES

a. Input Data.

(1) Costs can be expressed in dollars per round, per load, per short ton, per measurement ton, or per square foot. If the actual cost units are used more information about the distribution system can be obtained.

(2) Appendix A contains a detailed discussion of the data applicable to packaging/containerization cost analysis.

(3) The actual format for computer input is in Table 1.

b. Output Analysis.

(1) Sample outputs are in Figure 2, 3, and 4. Figure 2 output is a summary of the input after minor arithmetic calculations: The "Unit Load Parameters" are echoed from the input and conversions are made to provide per round quantities for the unit load. These quantities can be used as figures of merit in comparing the competing alternatives. The distribution table is also shown in Figure 2. The activity information given in Figure 2 is nearly the same information entered on the computer input card. After being converted to dollars per round, the cost coefficients are placed in columns, indicating parameter dependency.

(2) Detailed path information, as shown in Figure 3 can be provided by the program. Each print group in Figure 3 contains a path identification number. Following this path identifier, nodes in the path are listed in the sequence encountered in the path. The line below the path number and node list contains the path activities in sequence. The third line contains the path probability, the path cost, and the expected path cost. The path cost vector and expected path cost vector show the cost dependencies of the total and expected path costs. These costs are each in dollars per round. The cost dependency sequence for these vectors is the same as in Figure 2; per round, per unit load, per short ton, per measurement ton, and per square foot. If the network is complex, printout of all paths is time consuming. The printout of detailed path information can be omitted. (See Table 1.)

(3) Analysis results are provided in Figure 4. The expected total cost is the sum of the expected path costs. The average cost is the sum of the "path cost" (from Figure 3) divided by the number of paths. The "cost percent vector" shows the relative cost dependence of the expected total cost. The "expected total cost vector" is the sum of the individual expected cost vectors. The costs for startup equipment, publication, and design appear on the next line. The distribution cost is the product of the expected cost per round and the number of rounds. The bottom line contains the number of rounds applicable to the computer run and the total cost; the sum of development and distrib ution costs. A detailed discussion of analysis procedures is provided for the 2.75 inch rocket in Appendix E.

(4) A sample input deck for computer processing at ARRCOM is listed in Appendix C. The computer source program is listed in Appendix D.

PACKAGING/CONTAINERIZATION LIFE CYCLE COSTING NETWORK

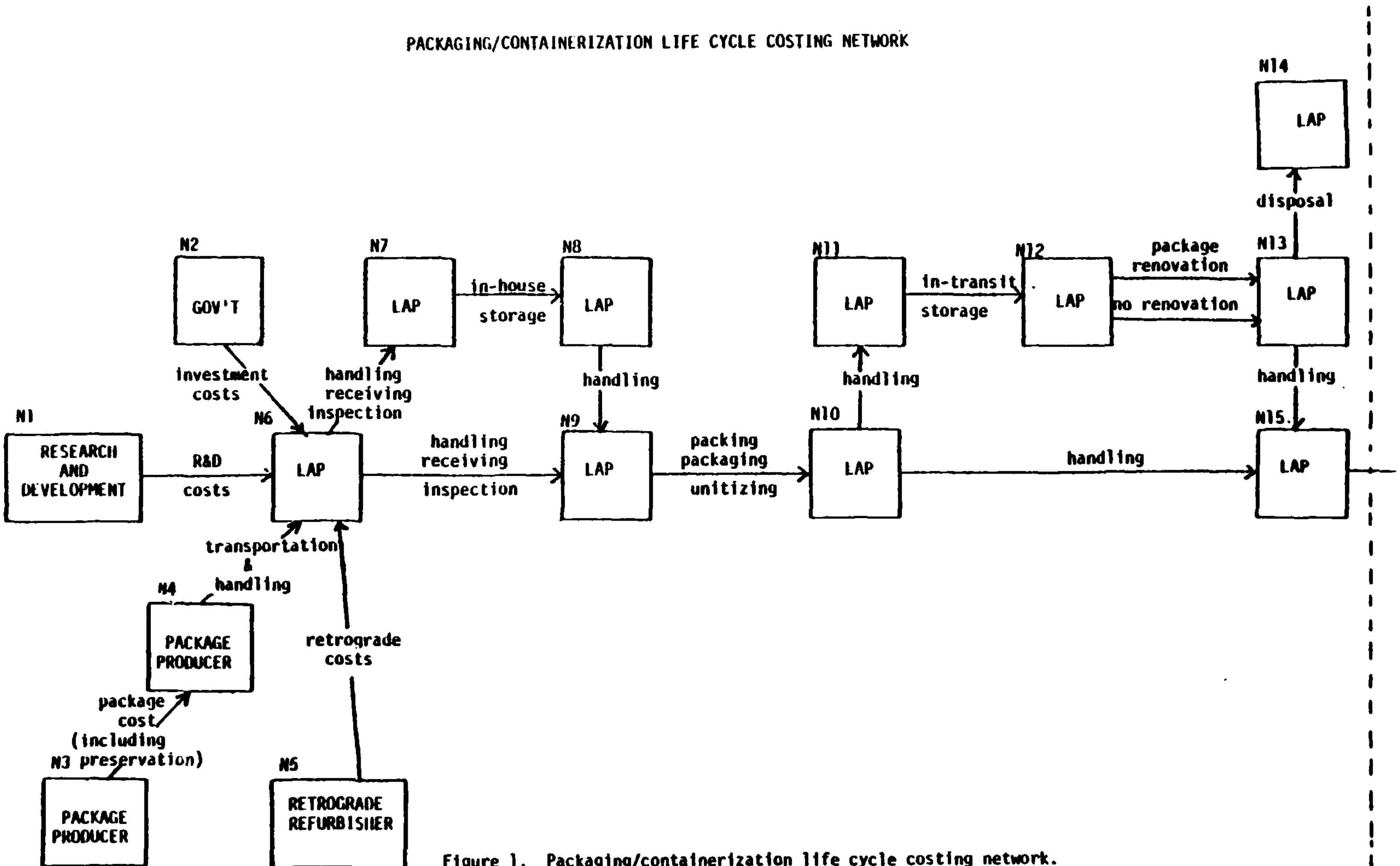

Figure 1. Packaging/containerization life cycle costing network.

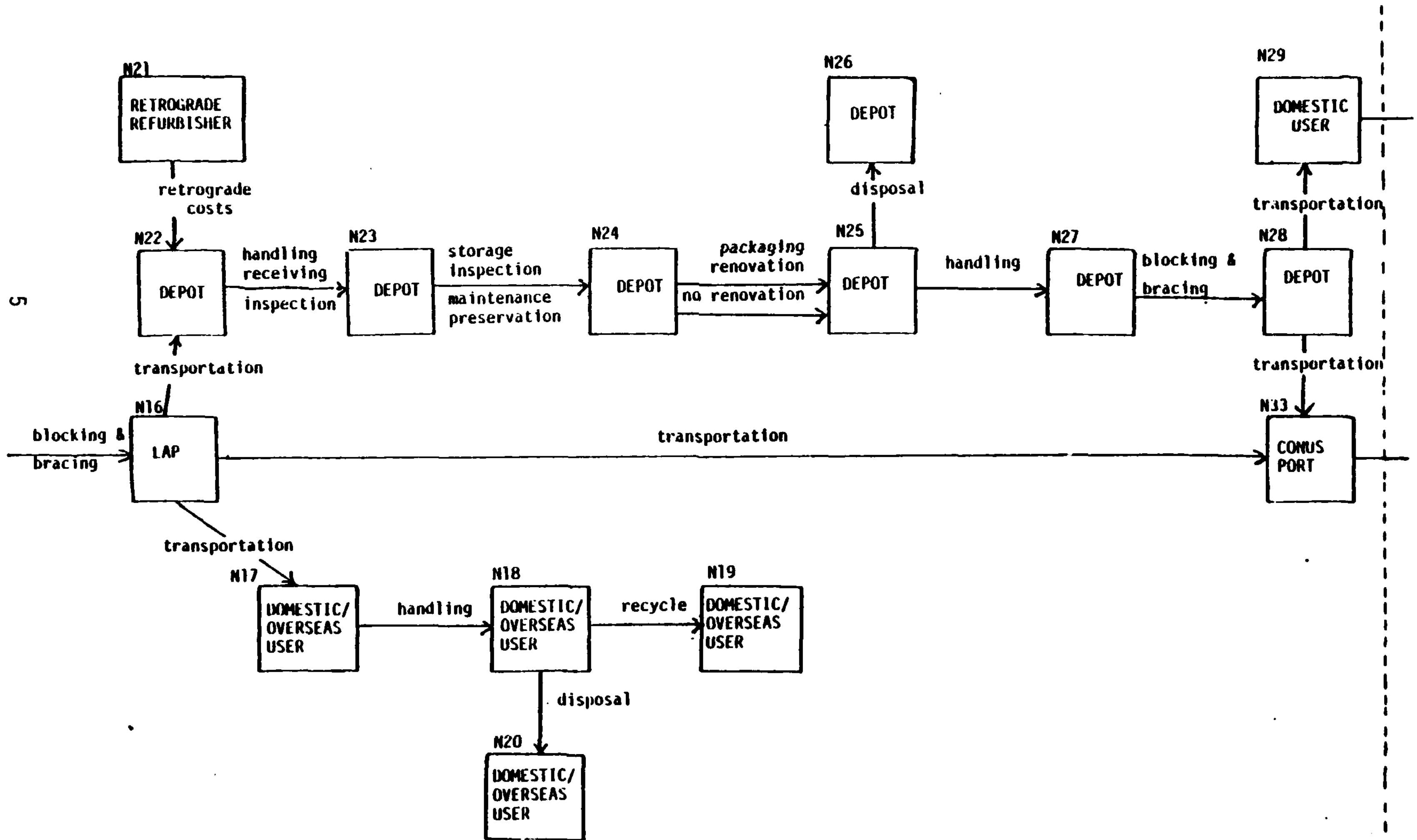

Figure 1. Packaging/containerization life cycle costing network. (cont'd)

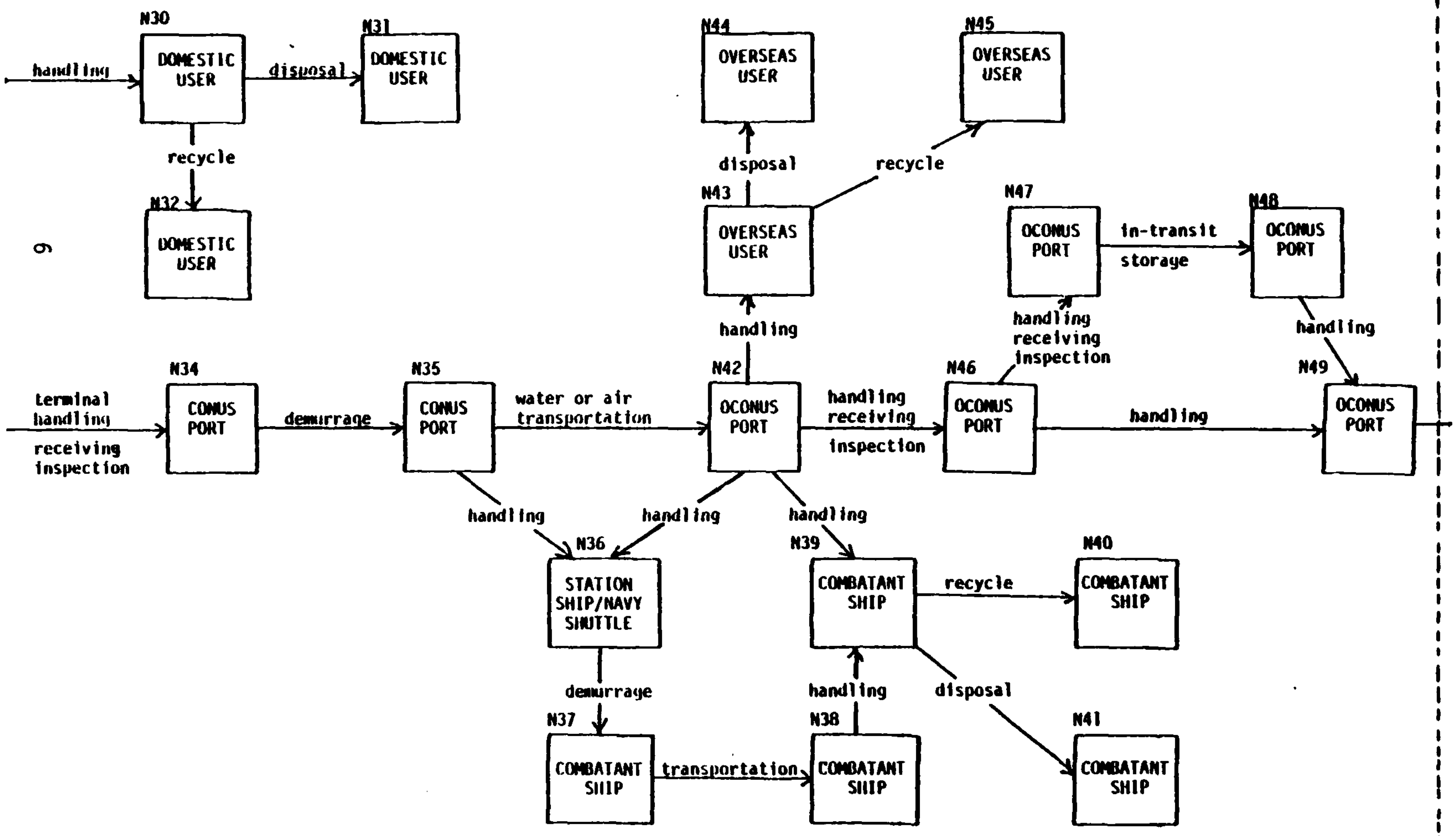

Figure 1. Packaging/containerization life cycle costing network. (cont'd)

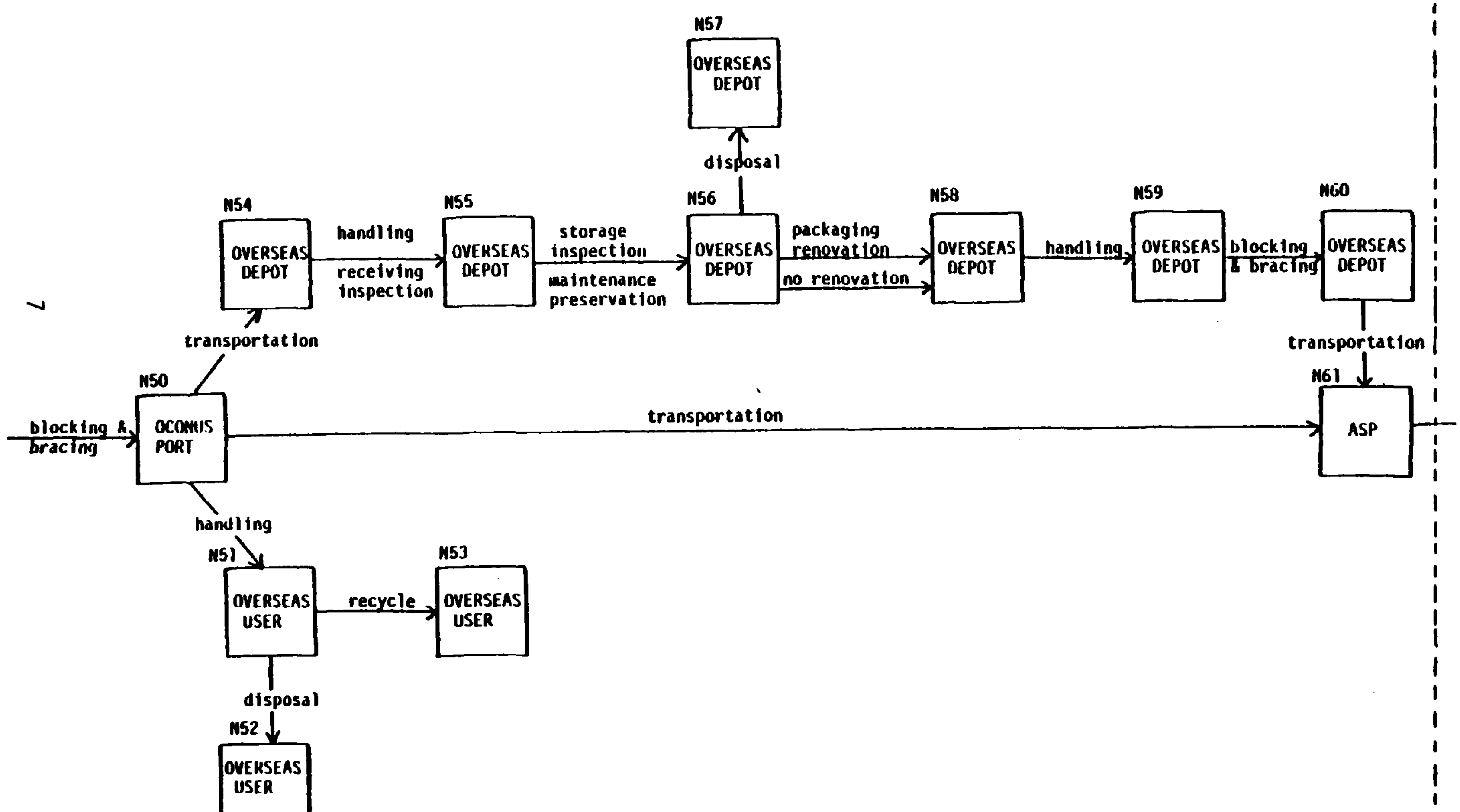

Figure 1. Packaging/containerization life cycle costing network. (cont'd)

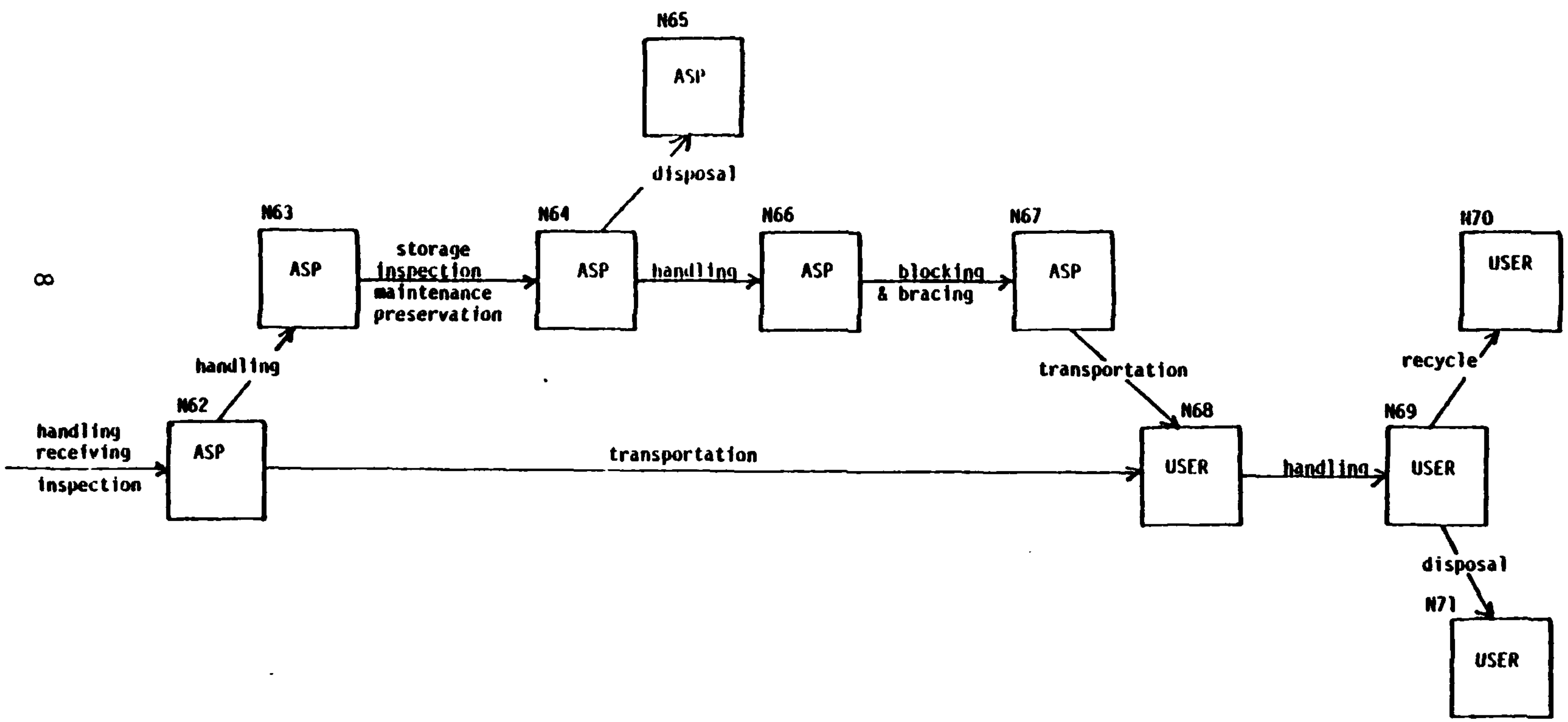

Figure 1. Packaging/containerization life cycle costing network. (cont'd)

DEVELOPMENT AND DISTRIBUTION COSTS FOR ALTERNATIVE 2, 2.75 IN ROCKET PKG REUSE FACTOR 4
COSTS ARE CALCULATED IN $/RD.

UNIT LOAD PARAMETERS
50 ROUNDS, 1552. POUNDS, 5.24 FEET LONG, 3.31 FEET WIDE, 1.98 FEET HIGH
0.02000 UNIT LOAD/RD, 0.01552 STON/RD, 0.01718 MTON/RD, 0.34712 SQ FT/RD

DISTRIBUTION TABLE

ACTIVITY	FROM	TO	PROBABILITY	COST DEPENDENCIES;COEFFICIENTS IN $/RD RD	UL	ST	MT	SQ-FT	
50	50	51	0.9300	1.6000	0.0	0.0	0.0	0.0	PROCURE CNTR
51	51	60	1.0000	0.0	1.5000	0.0	0.0	0.0	PROCURE 2 BOXES FOR UL
52	50	59	0.0728	0.0	2.3743	0.0	0.0	0.0	CONSOL RTN, EUR
53	50	59	0.0672	0.0	2.2931	0.0	0.0	0.0	CONSOL RTN, PAC
54	50	59	0.0150	0.0	0.6370	0.0	0.0	0.0	CONSOL RTN, RUCKER
55	50	59	0.0150	0.0	0.4778	0.0	0.0	0.0	CONSOL RTN, HOOD
57	59	60	0.8000	0.0	0.0	0.0	0.0	0.0	NO DAMAGE
59	59	60	0.2000	0.0	2.1000	0.0	0.0	0.0	RPR BOXES,RPLC CNTRS

Figure 2. Input Data Echo

```
                                        PATH ANALYSIS

          EACH PATH COMPUTED IS NUMBERED SEQUENTIALLY.  THE PATH NUMBER IS FOLLOWED BY THE NODE PATH, AND ITS CORRESPONDING
ARC PATH.  THE COST OF THE PATH AND THE EXPECTED COSTS OF THE PATH ARE CALCULATED IN $/RD.


  1  50- 51- 60-
       50  51
          PATH PROBABILITY: 0.830000     PATH COST: $   3.10000     EXPECTED COST OF PATH: $   2.57300
        PATH COST VECTOR (    1.50000   1.50000   0.0       0.0       0.0     )
    EXPECTED COST VECTOR (    1.32800   1.24500   0.0       0.0       0.0     )

  2  50- 59- 60-
       52  57
          PATH PROBABILITY: 0.059240     PATH COST: $   2.37428     EXPECTED COST OF PATH: $   0.13828
        PATH COST VECTOR (    0.0       2.37428   0.0       0.0       0.0     )
    EXPECTED COST VECTOR (    0.0       0.13828   0.0       0.0       0.0     )

  3  50- 59- 60-
       52  59
          PATH PROBABILITY: 0.014560     PATH COST: $   4.47428     EXPECTED COST OF PATH: $   0.06515
        PATH COST VECTOR (    0.0       4.47428   0.0       0.0       0.0     )
    EXPECTED COST VECTOR (    0.0       0.06515   0.0       0.0       0.0     )

  4  50- 59- 60-
       53  57
          PATH PROBABILITY: 0.053760     PATH COST: $   2.29312     EXPECTED COST OF PATH: $   0.12328
        PATH COST VECTOR (    0.0       2.29312   0.0       0.0       0.0     )
    EXPECTED COST VECTOR (    0.0       0.12328   0.0       0.0       0.0     )

  5  50- 59- 60-
       53  59
          PATH PROBABILITY: 0.013440     PATH COST: $   4.39312     EXPECTED COST OF PATH: $   0.05904
        PATH COST VECTOR (    0.0       4.39312   0.0       0.0       0.0     )
    EXPECTED COST VECTOR (    0.0       0.05904   0.0       0.0       0.0     )

  6  50- 59- 60-
       54  57
          PATH PROBABILITY: 0.012000     PATH COST: $   0.63700     EXPECTED COST OF PATH: $   0.00764
        PATH COST VECTOR (    0.0       0.63700   0.0       0.0       0.0     )
    EXPECTED COST VECTOR (    0.0       0.00764   0.0       0.0       0.0     )

  7  50- 59- 60-
       54  59
          PATH PROBABILITY: 0.003000     PATH COST: $   2.73700     EXPECTED COST OF PATH: $   0.00821
        PATH COST VECTOR (    0.0       2.73700   0.0       0.0       0.0     )
    EXPECTED COST VECTOR (    0.0       0.00821   0.0       0.0       0.0     )

  8  50- 59- 60-
       55  57
          PATH PROBABILITY: 0.012000     PATH COST: $   0.47776     EXPECTED COST OF PATH: $   0.00573
        PATH COST VECTOR (    0.0       0.47776   0.0       0.0       0.0     )
    EXPECTED COST VECTOR (    0.0       0.00573   0.0       0.0       0.0     )

  9  50- 59- 60-
       55  59
          PATH PROBABILITY: 0.003000     PATH COST: $   2.57776     EXPECTED COST OF PATH: $   0.00773
        PATH COST VECTOR (    0.0       2.57776   0.0       0.0       0.0     )
    EXPECTED COST VECTOR (    0.0       0.00773   0.0       0.0       0.0     )
```

Figure 3. Detailed Path Information

```
DEVELOPMENT AND DISTRIBUTION COSTS FOR ALTERNATIVE   2, 2.75 IN ROCKET PKG REUSE FACTOR 4
                                COSTS ARE CALCULATED IN $/RD.
                                      FINAL STATISTICS

         TOTAL EXPECTED COST OF ALL PATHS $   2.98806/RD
         AVERAGE COST FOR ALL PATHS $   2.56270/RD

        COSTS, IN $/RD, DUE TO:(  PER RD     PER UL     PER ST     PER MT     PER SQ-FT)
          COST PERCENT VECTOR:(   0.44444    0.55556    0.0        0.0        0.0      )
   TOTAL EXPECTED COST  VECTOR:(   1.32800    1.66006    0.0        0.0        0.0      )

         EQUIPMENT,PUBLICATION,AND DESIGN COSTS ARE RESPECTIVELY,:  0.050  0.002  0.115  $MILLIONS.

         THE TOTAL COST FOR DEVELOPEMENT AND DISTRIBUTION OF  411.  THOUSAND ROUNDS IS $    1.395  MILLIONS
```


Figure 4. Cost Results

TABLE 1. INPUT DATA DESCRIPTION

Input data cards are described in sequence used in data deck for computer runs.

CARD NO	CARD DESCRIPTION	CARD COLUMNS	DATA ELEMENT	FORMAT
1	Descriptor of alternative	9, 10	Identifying number	I2
		15 - 20	Number of rounds, K	F6.0
		21 - 60	Description	10A4
2	Fixed costs	1 - 10	Equipment costs, $M	F10.4
		11 - 20	Publication, $M	F10.4
		21 - 30	Design & development, $M	F10.4
3	Switch to print all paths	5	1 to print, 0 to omit	I1
4	Pack parameters	3 - 10	Rounds per pack	I8
		16 - 21	Pack shipping weight in pounds	F6.0
		27 - 34	One horizontal dimension, feet	F8.2
		35 - 42	Other horizontal dimension, feet	F8.2
		43 - 50	Height, feet	F8.2
5 . . .	Activity cards	3 - 5	Activity number	I3
		8 - 10	Node preceding activity	I3
		13 - 15	Node succeeding activity	I3
		18 - 24	Probability of leaving preceding node on this activity path	F7.6
		27 - 36	Cost coefficient for activity	F10.5
		39 - 43	Type of cost coefficient (1.0 is $ per round 2.0 is $ per unit load, 3.0 is $ per short ton, 4.0 is $ per measurement ton, 5.0 is $ per square foot)	F5.1
		44 - 67	Activity description	

APPENDIX A

INPUT DATA

APPENDIX A. INPUT DATA

1. To provide a complete description of all packaging/containerization alternatives to be considered (including the alternative in current use, if one exists) the following data elements are required.

a. Identity of item or component packaged.

b. Stock and drawing numbers and other information describing each configuration.

c. Dimensions, weight (net and tare) and the number of rounds in the unit pack, exterior pack, and unitized load.

2. To provide a cost and sensitivity analysis of packaging costs per round over the package or ammunition life, a best estimate and an upper and lower limit for the following data elements are essential. If no sensitivity analysis is needed, a single estimate (or average) may be used throughout.

a. Total quantity of item to be produced.

b. Economic life for each packaging/containerization alternative and the associated end item.

c. The fraction of reusable containers which will be reused.

d. The fraction of the reused containers that will be repaired along with the associated repair cost per container for each trip.

e. Interest or discount rates, if the cost analysis is required to reflect inflation.

3. To evaluate packaging alternatives, the entire life cycle must be considered. The methodology used combines costs of transportation with costs at plants, depots, ports and other intermediate handling points, and with user costs. The paths of ammunition flow and the quantity of ammunition (or fraction of the total production) traveling each path must be provided for each alternative. This should be provided in a distribution network. The level of detail is determined by the level of detail of available data. Several plants, depots and multiple users may be identified for the cost analysis in a particular application. Retrograde paths must be clearly identified for reusable packages/containers.

4. The cost and time required to distribute the item through the network or a portion of the network can be analyzed. In order to accomplish this, the cost and time to perform each operation or movement of ammunition must be specified. Inflation and discounting require time estimates for activities. Costs are separated into three categories. They are distribution network costs, initial investment costs and recurring costs.

a. Distribution network costs. Typically, a palletized or containerized package goes through the distribution network. In order to compare packaging economics, a complete supply network is used to describe all interrelated activities and events. Costing should be comprehensive, considering the costs from the time of initial acquisition of the package or container throughout its life, including disposal. To accurately evaluate packaging alternatives, all cost information should be provided on a per round basis for distribution of the item. It will usually be adequate to limit the data collection effort by selection of one or two typical paths. The data for model input is keyed to activities in the distribution network. The following data must be provided for each packaging/containerization alternative:

(1) Package manufacturer(s)

(a) Development costs

(b) Package costs

(c) Fraction of total from each source to each LAP plant

(2) Transportation to LAP plant(s) (cost and fraction of total for each path)

(3) LAP plant(s) (include only costs due to packaging/containerization change(s), for each alternative)

(a) Production

(b) Preservation

(c) Packaging

(d) Packing

(e) Palletization

(f) Handling (including blocking and bracing)

(4) Transportation to CONUS depot(s) and ports (cost and fraction of total for each path)

(5) CONUS depot(s) (cost from Joint Interservice Support Agreement)

(a) Receipt at depot

(b) Maintenance and renovation, based on average life

(c) Storage (consider storage density and inspection)

(d) Outloading

(6) Transportation to CONUS port(s)

(7) CONUS port(s)

(a) Terminal handling

(b) Shiploading (including dunnage)

(8) Ocean transport

(a) Consider cube utilization on ship

(b) Consider ship demurrage even though none is planned (use historical data)

(9) Overseas port(s)

(a) Unloading of ship

(b) Terminal handling

(c) Outloading

(10) Transport to overseas depot(s)

(11) Overseas depot (costs as in (5))

(a) Receipt at depot

(b) Maintenance/renovation

(c) Storage

(d) Outloading

(12) Transport to Ammunition Supply Point(s) (ASP)

(13) ASP(s)

(a) Receipt

(b) Handling

(14) Transport to user(s)

(15) User(s) (salvage/disposal costs)

(16) Transportation, repair/refurbishment of reusables

b. Initial investment costs are those costs which accrue in establishing the use of a new packaging/containerization alternative throughout the ammunition logistics system. This includes documentation, equipment, and initial personnel changes where any of these are required. These costs should be identified by location and activity, using the distribution network as a guide. Initial investment costs include:

(1) All fixed costs for equipment, publications, etc.

(2) All fixed costs for the package (research and development for package design, etc.).

(3) Cost to fill the logistics pipeline (where time data is not provided and alternatives include significantly different pipelines, e.g., airlift vs. ocean shipment).

c. Recurring costs are those costs which do not accrue in the same way as distribution costs, including:

(1) Cost recurring after specified quantity of rounds, for some fraction of total production (provide quantity and fraction). For example, for replacement of worn-out special equipment for an alternative.

(2) Cost recurring periodically after specified time (provide time). For example, for replacement of special equipment for an alternative due to corrosion or other time-related factors.

(3) The interest on cost of materiel in the pipeline (where time data is not provided and alternatives include significantly different pipelines as in 4b(3) above).

APPENDIX B

SAMPLE PROBLEM

APPENDIX B. SAMPLE PROBLEM

1. Problem Definition.

a. The purpose of the study is to calculate the total cost associated with the use of ammunition pack, including initial purchase cost, transportation costs, and disposal or recycle costs.

b. An ammunition pack holds 40 rounds of ammunition, weighs 60 pounds, and measures 3 x 2.5 x 2 ft.

c. The pack is purchased from the producer at $20/unit load.

d. The pack is shipped from an Army Ammunition Plant (AAP) to two users. User 1 receives 60% of the packs, of which 10% are recycled and 90% are destroyed. User 2 receives 40% of the packs, recycles 20% of those received and disposes of 80%.

e. The total number of rounds shipped is 400,000 rounds.

f. Shipping costs from the AAP to the users is given in $/unit load. Costs from user to disposal are given in $/short ton and costs from user to recycle are given in $/round.

g. The network diagram for this distribution is given in Figure B1.

2. Problem Solution.

a. A listing of the input data, corresponding to the information which appears on the network diagram (Figure B1), prepared for computer processing is in Figure B2.

b. Figure B3 is the computer echo of the input data with all costs converted to $/round.

c. Individual path information, which can be requested at the users option, is listed in Figure B4.

d. Final statistics, with costs in $/round, showing total expected costs of all paths, average cost for all paths, cost percent vector, total expected cost vector, equipment costs, publication costs, design costs and the total costs for development and distribution is shown in Figure B5.

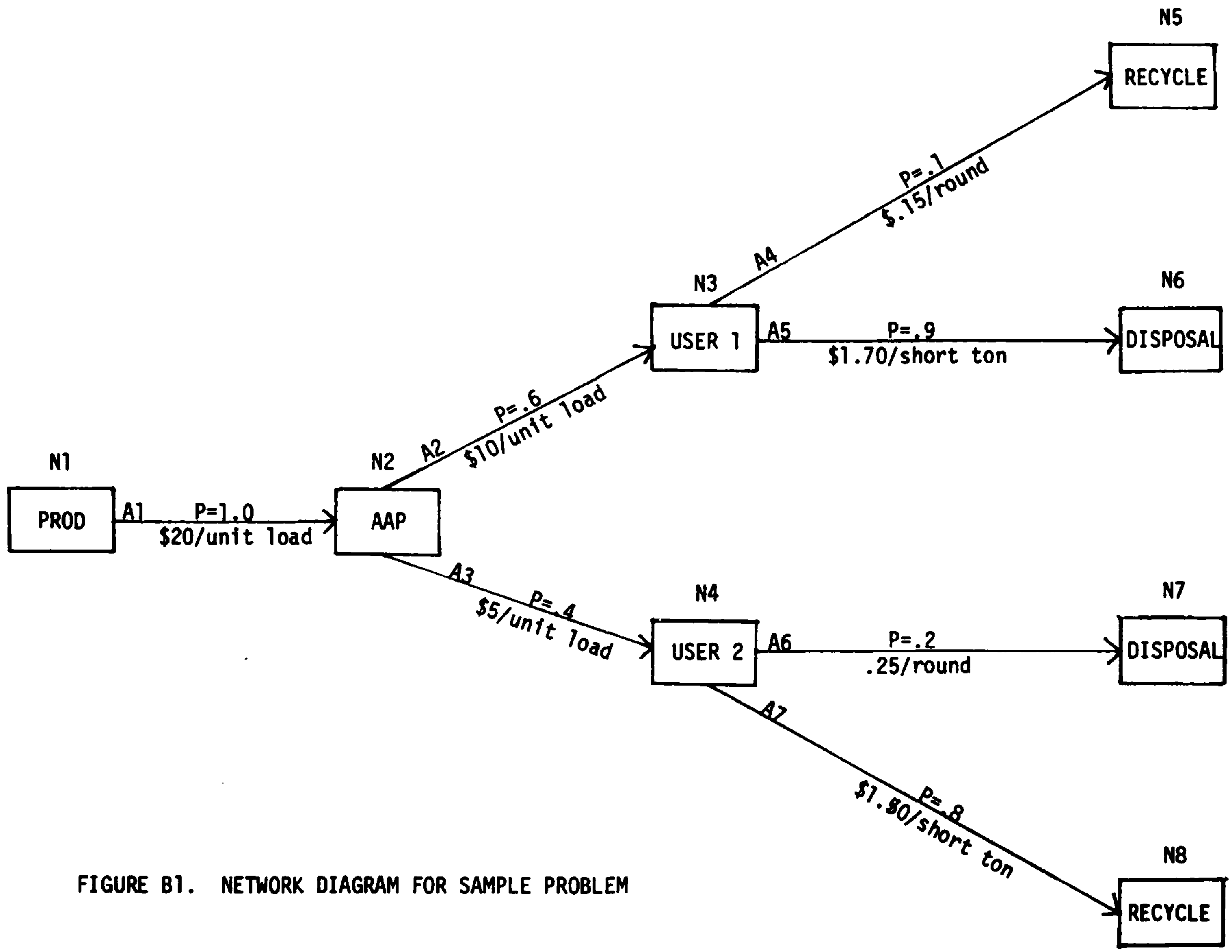

FIGURE B1. NETWORK DIAGRAM FOR SAMPLE PROBLEM

```
//R0179QTS JOB (3IRG,A2R8,65010179,JCAP),'SHORT',CLASS=F,TIME=1
//GO EXEC PGM=APC,REGION=100K
//STEPLIB DD DSN=JCOMNVH.LOAD,DISP=SHR
//GO.FT06F001 DD SYSOUT=A
//GO.FT05F001 DD *
        1     400.   SAMPLE APPLICATION OF APC METHODOLOGY
0.0         0.0         0.0
     1
         40      500.0        3.0       2.5        2.0
     1   1    2  1.0         20.0              2.0  PURCHASE PACK
     2   2    3  0.6         10.0              2.0  SHIP TO USER1
     3   2    4  0.4          5.0              2.0  SHIP TO USER2
     4   3    5  0.1          .15              1.0  RECYCLE FROM USER1
     5   3    6  0.9         1.70              3.0  DISPOSAL FROM USER1
     6   4    7  0.8         1.50              3.0  DISPOSAL FROM USER2
     7   4    8  0.2          .25              1.0  RECYCLE FROM USER2
```

FIGURE B2. INPUT DATA FOR SAMPLE PROBLEM

DEVELOPMENT AND DISTRIBUTION COSTS FOR ALTERNATIVE 1,SAMPLE APPLICATION OF APC METHODOLOGY
COSTS ARE CALCULATED IN $/RD.

UNIT LOAD PARAMETERS

40 ROUNDS,	600.	POUNDS,	3.00	FEET LONG,	2.50	FEET WIDE,	2.00	FEET HIGH
0.02500	UNIT LOAD/RD,	0.00750	STON/RD,	0.00937	MTON/RD,	0.18750	SQ FT/RD	

DISTRIBUTION TABLE

ACTIVITY	FROM	TO	PROBABILITY	COST DEPENDENCIES;COEFFICIENTS IN $/RD RD	UL	ST	MT	SQ-FT	
1	1	2	1.0000	0.0	0.5000	0.0	0.0	0.0	PURCHASE PACK
2	2	3	0.6000	0.0	0.2500	0.0	0.0	0.0	SHIP TO USER1
3	2	4	0.4000	0.0	0.1250	0.0	0.0	0.0	SHIP TO USER2
4	3	5	0.1000	0.1500	0.0	0.0	0.0	0.0	RECYCLE FROM USER1
5	3	6	0.9000	0.0	0.0	0.0127	0.0	0.0	DISPOSAL FROM USER1
5	4	7	0.8000	0.0	0.0	0.0112	0.0	0.0	DISPOSAL FROM USER2
7	4	8	0.2000	0.2500	0.0	0.0	0.0	0.0	RECYCLE FROM USER2

FIGURE B3. DATA INPUT ECHO FOR SAMPLE PROBLEM

```
                                PATH ANALYSIS

          EACH PATH COMPUTED IS NUMBERED SEQUENTIALLY.  THE PATH NUMBER IS FOLLOWED BY THE NODE PATH, AND ITS CORRESPONDING
ARC PATH.  THE COST OF THE PATH AND THE EXPECTED COSTS OF THE PATH ARE CALCULATED IN $/RD.


 1   1-  2-  3-  5-
       1   2   4
         PATH PROBABILITY: 0.060000     PATH COST: $    0.90000     EXPECTED COST OF PATH: $   0.05400
       PATH COST VECTOR (   0.15000   0.75000   0.0       0.0       0.0     )
   EXPECTED COST VECTOR (   0.00900   0.04500   0.0       0.0       0.0     )

 2   1-  2-  3-  6-
       1   2   5
         PATH PROBABILITY: 0.540000     PATH COST: $    0.76275     EXPECTED COST OF PATH: $   0.41188
       PATH COST VECTOR (   0.0       0.75000   0.01275   0.0       0.0     )
   EXPECTED COST VECTOR (   0.0       0.40500   0.00688   0.0       0.0     )

 3   1-  2-  4-  7-
       1   3   5
         PATH PROBABILITY: 0.320000     PATH COST: $    0.63625     EXPECTED COST OF PATH: $   0.20360
       PATH COST VECTOR (   0.0       0.62500   0.01125   0.0       0.0     )
   EXPECTED COST VECTOR (   0.0       0.20000   0.00360   0.0       0.0     )

 4   1-  2-  4-  8-
       1   3   7
         PATH PROBABILITY: 0.080000     PATH COST: $    0.87500     EXPECTED COST OF PATH: $   0.07000
       PATH COST VECTOR (   0.25000   0.62500   0.0       0.0       0.0     )
   EXPECTED COST VECTOR (   0.02000   0.05000   0.0       0.0       0.0     )
```


FIGURE B4. INDIVIDUAL PATH ANALYSIS FOR SAMPLE PROBLEM

```
DEVELOPMENT AND DISTRIBUTION COSTS FOR ALTERNATIVE   1,SAMPLE APPLICATION OF APC METHODOLOGY
                              COSTS ARE CALCULATED IN $/RD.
                                    FINAL STATISTICS

      TOTAL EXPECTED COST OF ALL PATHS $   0.73948/RD
      AVERAGE COST FOR ALL PATHS $   0.79350/RD

     COSTS, IN $/RD, DUE TO:(  PER RD     PER UL     PER ST     PER MT    PER SQ-FT)
       COST PERCENT VECTOR:(    0.03922    0.94660    0.01418    0.0        0.0     )
  TOTAL EXPECTED COST  VECTOR:(    0.02900    0.70000    0.01048    0.0        0.0     )

      EQUIPMENT,PUBLICATION,AND DESIGN COSTS ARE RESPECTIVELY,:  0.0     0.0     0.0     $MILLIONS.

      THE TOTAL COST FOR DEVELOPEMENT AND DISTRIBUTION OF  400.  THOUSAND ROUNDS IS $    0.296  MILLIONS
```

FIGURE B5. DEVELOPMENT AND DISTRIBUTION COSTS FOR SAMPLE PROBLEM

APPENDIX C

INPUT DECK SETUP

APPENDIX C

```
//R0179QTS JOB (3IRG,A2R3,68010179,JCAP),'SHORT',CLASS=F,TIME=1
//GO EXEC PGM=APC,REGION=100K
//STEPLIB DD DSN=JCDMNVH.LOAD,DISP=SHR
//GO.FT06F001 DD SYSOUT=A
//GO.FT05F001 DD *
        3     411.    2.75 IN ROCKET DISTRIB OF 38 RD PACK
   .05     .002        .115
   0
        38        982.        4.9167  3.0208   2.0208
   1     1     2  1.          1.50205       1.   PROCURE/RETURN%REPAIR
   2     2     3  1.          .10           1.   PACK%UNITIZE
   3     3     4  .05         .314          1.   LOAD TRUCK
   4     3     5  .95         .215          1.   LOAD RAILCAR
   5     5     6  .2274       1.03          1.   LAP TO SIERRA
   6     5     7  .3516       .61           1.   LAP TO ANNISTON
   7     5     8  .0526       .81           1.   LAP TO BLUEGRASS
   8     5     9  .0526       .23           1.   LAP TO RED RIVER
   9     5    10  .1263       1.15          1.   LAP TO CONCORD
  10     5    11  .1359       .95           1.   LAP TO SUNNY POINT
  11     4    12  .5          .77           1.   LAP TO FT HOOD
  12     4    13  .5          .96           1.   LAP TO FT RUCKER
  13     5    14  .0263       .79           1.   LAP TO FT CAMPBELL
  14     5    15  .0263       .97           1.   LAP TO FT BRAGG
  15     6    16  1.          44.84         2.   SIERRA RECEIVE AND SHIP
  16     7    17  1.          12.56         2.   ANNISTON RECEIVE AND SHIP
  17     8    18  1.          72.45         2.   BLUEGRASS RECEIVE AND SHIP
  18     9    19  1.          35.39         2.   RED RIVER RECEIVE AND SHIP
  19    16    20  1.          .66           1.   SIERRA STORAGE
  20    17    21  1.          .56           1.   ANNISTON STORAGE
  21    18    22  1.          .56           1.   BLUEGRASS STORAGE
  22    19    23  1.          .56           1.   RED RIVER STORAGE
  23    20    10  1.          .21           1.   SIERRA TO CONCORD
  24    21    11  .7006       .59           1.   ANNISTON TO SUNNY POINT
  25    21    15  .1497       .53           1.   ANNISTON TO FT BRAGG
  26    21    13  .1497       .32           1.   ANNISTON TO FT RUCKER
  27    22    14  1.          .41           1.   BLUEGRASS TO CAMPBELL
  28    23    12  1.          .95           1.   RED RIVER TO FT HOOD
  29    10    24  1.          36.54         4.   CONCORD HANDLING
  30    24    25  1.          82.28         4.   CONCORD TO CHINHAE
```

APPENDIX C (cont'd)

31	25	26	1.	19.33	4.	CHINHAE HANDLING
32	26	27	.9	15.29	4.	CHINHAE TO YONGSAN
33	27	28	1.	.73	1.	YONGSAN HANDLING STORAGE
34	28	29	.9	.99	4.	YONGSAN TO VIJONGBJ
35	26	29	.1	16.27	4.	CHINHAE TO VIJONGBJ
36	29	30	1.	.45	1.	VIJONGBJ HANDLING
37	28	31	.1	.99	4.	YONGSAN TO USERS
38	30	31	1.	.5	4.	VIJONGBJ TO USERS
39	31	32	1.	.09	1.	USERS HANDLING ,UNPACK
40	11	33	1.	23.14	4.	SUNNY POINT HANDLING
41	33	34	1.	59.13	4.	SUNNY POINT TO NORDENHAM
42	34	35	1.	24.15	4.	NORDENHAM HANDLING
43	35	36	.9	21.07	4.	NORDENHAM TO MIESAU
44	36	37	1.	.73	1.	MIESAU HANDLING STORAGE
45	37	38	.9	16.04	4.	MIESAU TO GRAFENWOEHR
46	35	38	.1	23.95	4.	NORDENHAM TO GRAFENWOEHR
47	38	39	1.	.45	1.	GRAFENWOEHR HANDLING
48	37	40	.1	16.04	4.	MIESAU TO USERS
49	39	40	1.	8.02	4.	GRAFENWOEHR TO USERS
50	40	41	1.	.09	1.	USERS HANDLING AND UNPACK
51	12	42	1.	.09	1.	FT HOOD HANDLING %UNPACK
52	13	43	1.	.09	1.	FT RUCKER HANDLING,UNPACK
53	14	44	1.	.09	1.	FT CAMPBELL HANDLING,UNPACK
54	15	45	1.	.09	1.	FT BRAGG HANDLING,UNPACK

APPENDIX D

COMPUTER PROGRAM SOURCE LISTING

APPENDIX D

```
C      A  EQUALO MATRIX OF ARCS AND NODES   A(I,J)
C      B  EQUALS MATRIX OF ARCS OF A PATH    B(M)
C      C  EQUALS MATRIX OF NODES OF A PATH    C(M)
       DIMENSION A(999,3),B(200),C(200)
       DIMENSION  PACK(5), AA(999,6), D(200), TCST(5), ECST(5), TECST(5)
       DIMENSION AECST(5), PERCNT(5) ,NAME(10),ACTIV(999,6)
       DIMENSION FXDCST(3)
       INTEGER A,B,C,D
       READ (5,1000)IALT,TOTRND ,NAME
 1000  FORMAT(8X,I2,4X,F6.0,10A4)
       READ(5,2009) FXDCST
 2009  FORMAT(3F10.4)
       READ(5,1999)KEY
 1999  FORMAT(4X,I1)
       WRITE(6,1001)IALT,NAME
 1001  FORMAT(1H1,52HDEVELOPMENT AND DISTRIBUTION COSTS FOR ALTERNATIVE
      C, I2,1H,,10A4,/30X,30H COSTS ARE CALCULATED IN $/RD.)
       READ(5,1002) NRND,WTLB,WIDE,DEEP,HIGH
 1002  FORMAT(2X,I8,5X,F5.0,5X,3F8.2)
C   DIMENSIONS MUST BE IN FEET   FOR UNIT LOAD
       PACK(1) = 1.
       PACK(2) = 1./FLOAT(NRND)
       PACK(3) = PACK(2)*WTLB/2000.
       PACK(4) = (WIDE*DEEP*HIGH)*PACK(2)/40.
       PACK(5) = WIDE*DEEP*PACK(2)
       WRITE(6,1003)NRND,WTLB,WIDE,DEEP,HIGH
 1003  FORMAT(/,20X,20HUNIT LOAD PARAMETERS/,2X,I8,9H  ROUNDS,,3X,F6.0,
      19H  POUNDS,,3X,F8.2,12H  FEET LONG,,3X,F8.2,12H  FEET WIDE,,3X,
      2F8.2,11H  FEET HIGH)
       WRITE(6,1004)(PACK(I),I=2,5)
 1004  FORMAT(5X,F8.5,15H  UNIT LOAD/RD,F9.5,3X,10H  STON/RD,F9.5,3X,
      110H  MTON/RD,,F9.5,3X,10H  SQ FT/RD)
       M=2
       TOTCOS  = 0.0
       WRITE(6,19)
```

APPENDIX D (cont'd)

```
19 FORMAT(1H0,40X,18HDISTRIBUTION TABLE,//,
  145X                                  ,42H    COST DEPENDENCIES;COEFFIC
  3IENTS IN $/RD ,/,10H  ACTIVITY ,2X,4HFROM,4X,
  2 2HTO,6X,11HPROBABILITY,6X,4H  RD,6X,4H  UL,6X,4H  ST,6X,4H  MT,
  44X,7H  SQ-FT,/)
   DO 99 I=1,5
   TECST(I)=0.0
   AECST(I)=0.0
99 CONTINUE
   TECOST=0.0
   DO 1 I=1,999
   READ(5,2,END=3)(A(I,J),J=1,3),(AA(I,K),K=1,2),X,(ACTIV(I,K),K=1,6)
 2 FORMAT(3(2X,I3),2X,F7.5,2X,F10.5,2X,F5.1,6A4)
   IX =IFIX(X+.001)
   XTEMP =AA(I,2)
   AA(I,2) =0.
   AA(I,3) =0.
   AA(I,4) =0.
   AA(I,5) =0.
   AA(I,6) =0.
   AA(I,IX+1)=XTEMP*PACK(IX)
 1 WRITE(6,20) (A(I,J),J=1,3),(AA(I,K),K=1,6),(ACTIV(I,L),L=1,6)
20 FORMAT(5X,3(I3,4X),5X,F5.4,5X,5F10.4,6A4)
 3 NARCS=I-1
   DO 25 I=1,NARCS
   PROB=0.0
   DO 24 J=1,NARCS
   IF (A(I,2) .EQ. A(J,2)) PROB=PROB+AA(J,1)
24 CONTINUE
   IF (PROB .GE. 1.001001) GO TO 30
   IF (PROB .LE. 0.999   ) GO TO 30
25 CONTINUE
   NPATHS=0
   DO 5 I=1,NARCS
   DO 4 J=1,NARCS
   IF (A(I,2) .EQ. A(J,3)) GO TO 5
```

APPENDIX D (cont'd)

```
    4 CONTINUE
      GO TO 6
    5 CONTINUE
    6 B(2)=I
      D(2)=A(I,1)
      C(1)=A(I,2)
      C(2)=A(I,3)
      IF (KEY.EQ. 0) GO TO 2000
      WRITE(6,22)
   22 FORMAT(1H1,40X,13HPATH ANALYSIS,//,10X,
     1 55HEACH PATH COMPUTED IS NUMBERED SEQUENTIALLY.  THE PATH ,
     2 38HNUMBER IS FOLLOWED BY THE NODE PATH, AND ITS CORRESPONDING/1X,
     3 35HARC PATH.  THE COST OF THE PATH AND ,
     454HTHE EXPECTED COSTS OF THE PATH ARE CALCULATED IN $/KD.,//)
      GO TO 7
 2000 CONTINUE
      WRITE (6,2001)KEY
 2001 FORMAT(//,10X,7H'KEY'=  ,I2,3X,20HPATHS NOT PRINTED     )
    7 N=B(M)
      DO 8 I=1,NARCS
      IF (A(N,3) .EQ. A(I,2)) GO TO 10
    8 CONTINUE
C     NO MORE NODES IN THIS PATH-------- FOUND TERMINAL NODE
      NPATHS=NPATHS+1
      IF (KEY.EQ. 0) GO TO 2002
      WRITE(6,9) NPATHS,(C(J),J=1,M)
    9 FORMAT(1H0,I3,1X,30(I3,1H-))
      WRITE(6,15) (D(J),J=2,M)
   15 FORMAT(7X,30(I3,1X))
 2002 CONTINUE
      TCOST=0.0
      ECOST=0.0
      DO 101 I=1,5
      TCST(I)=0.0
      ECST(I)=0.0
  101 CONTINUE
```

APPENDIX D (cont'd)

```
      PPROB=1.0
      DO 17 L=2,M
      K=B(L)
      PPROB=PPROB*AA(K,1)
      DO 102 I=1,5
      TCST(I) = TCST(I)+ AA(K,I+1)
  102 CONTINUE
   17 CONTINUE
      DO 103 I=1,5
      ECST(I) =TCST(I)*PPROB
      ECOST = ECOST +ECST(I)
      TCOST = TCOST +TCST(I)
      TECST(I)=TECST(I)+ECST(I)
  103 CONTINUE
      IF (KEY.EQ. 0) GO TO 2004
      WRITE(6,18)PPROB,TCOST,ECOST
   18 FORMAT(11X,18HPATH PROBABILITY: ,F8.6,5X,12HPATH COST: $,F10.5,5X,
     124HEXPECTED COST OF PATH: $,F10.5)
      WRITE(6,1006) TCST,ECST
 1006 FORMAT(9X,18HPATH COST VECTOR (,5F10.5,1H)/,5X,22HEXPECTED COST VE
     CCTOR (,5F10.5,1H))
 2004 CONTINUE
      TOTCOS  = TOTCOS  + TCOST
      TECOST=TECOST+ECOST
      GO TO 11
   10 M=M+1
      B(M)=I
      D(M)=A(I,1)
      C(M)=A(I,3)
      IF (M .GT. NARCS+1) GO TO 32
      GO TO 7
   11 N=B(M)
      MM=N+1
      DO 12 J=MM,NARCS
      IF (A(N,2) .EQ. A(J,2)) GO TO 13
   12 CONTINUE
```

APPENDIX D (cont'd)

```
      M=M-1
      IF (M .EQ. 1) GO TO 14
      GO TO 11
   13 B(M)=J
      D(M)=A(J,1)
      C(M)=A(J,3)
      GO TO 7
   30 WRITE(5,31) A(1,2),PROB
   31 FORMAT(5X,31HERROR - PROBABILITIES FROM NODE ,I5,
     1 19H DO NOT ADD TO 1.0,,1X,10HSUM EQUALS,F10.6)
      GO TO 100
   32 WRITE(5,33) M
   33 FORMAT(5X,32HERROR - NUMBER OF ARCS IN PATH ,I4,3H > ,
     1 29HTOTAL NUMBER OF ARCS(LOOPING))
      GO TO 100
   14 CONTINUE
      DO 105 I=1,5
      PERCNT(I)=TECST(I)/TECOST
  105 CONTINUE
      ACOST  =  TOTCOS /NPATHS
      WRITE(6,1001)IALT,NAME
      WRITE(6,21) TECOST,ACOST
   21 FORMAT(      40X,16HFINAL STATISTICS,
     1  //,10X,34HTOTAL EXPECTED COST OF ALL PATHS $,F10.5,3H/RD,/
     2 10X,28HAVERAGE COST FOR ALL PATHS $ ,F10.5,3H/RD,/)
      WRITE(6,1007)       PERCNT,TECST
 1007 FORMAT(09X,80HCOSTS, IN $/RD, DUE TO:(  PER RD    PER UL    PER ST
     C     PER MT   PER SQ-FT)                  /,11X,22H COST PERCENT
     A                                          VECTOR:(,5F10.5,
     CVECTOR:(,5F10.5,1H),/,4X,29HTOTAL EXPECTED COST  VECTOR:(,5F10.5,
     21H))
      TECOST =TECOST * TOTRND/1000
      WRITE(6,2010)FXDCST
 2010 FORMAT(//,10X,57HEQUIPMENT,PUBLICATION,AND DESIGN COSTS ARE RESPEC
     CTIVELY,:  ,3F7.3,12H  $MILLIONS.)
      DO 2011 I=1,3
      TECOST=TECOST+FXDCST(I)
```

APPENDIX D (cont'd)

```
 2011 CONTINUE
      WRITE(6,1008) TOTRND,TECOST
 1008 FORMAT(///,10X,51HTHE TOTAL COST FOR DEVELOPEMENT AND DISTRIBUTION
     C OF,F6.0,22H  THOUSAND ROUNDS IS $,F9.3,11H  MILLIONS )
  100 STOP
      END
```

APPENDIX E

DEMONSTRATION OF AMMUNITION PACK LIFE CYCLE COST METHODOLOGY USING THE 2.75 INCH ROCKET

APPENDIX E. DEMONSTRATION OF AMMUNITION PACK LIFE CYCLE METHODOLOGY USING THE 2.75 INCH ROCKET

1. Packaging Alternatives.

There are three pack configurations under consideration: a 38 round pack, a 50 round pack and a 60 round pack. The pack procurement/reuse analysis involves a separate network for each of the three pack alternatives, hence, three separate computer runs.

2. Methodology Application.

The analysis is simplified by separating the packaging costing into two parts, procurement/reuse analysis and distribution analysis. This allows the procurement vs reuse tradeoff to be made separately. Only cost-effective procurement and reuse policies will then be used in subsequent analysis.

3. Data Constraints.

Network structures were constrained by data availability.

Specifically:

a. No data was available on damage and loss of packaging and ammunition throughout the distribution system.

b. Salvage and disposal costs were not available.

c. No recurring costs were identified.

d. Network activity times with estimated variations were not available, i.e., times for each activity.

e. Discounting and inflation of costs were not included in the methodology since determination of when costs were accrued could not be made.

f. Cost ranges to provide estimated variability of costs for activities were not obtained.

g. In analysis of distribution, costs and percentage splits along alternative paths were averaged over the (three-year) period for which the cost evaluation was made. The resulting model closely followed the network picture for development and distribution of the particular ammunition pack being studied. (See Appendix E, Figures E7-E11.)

4. Analysis of Procurement and Packaging Reuse.

a. Activity Costs for Procurement/Reuse. Costs to return and repair the fiber container and box are compared to procurement costs for the container and box. Return is planned for locations where return plus repair costs are less than 90% of procurement costs.

(1) For the container, using packaging reuse costs from Table E1:

(a) Container procurement cost is $1.60/rd.

(b) The highest container return cost (Europe) is $.865/rd.

(c) Because repair of a damaged container is not economical, damaged containers are replaced. If 20% of the containers returned are found to be damaged, the overall cost of container procurement vs reuse can be compared simply by considering return of 10 containers as follows:

Procurement

Total Cost = Cost to Replace 10 Containers

= $1.60/rd x 10 rd = $16.00

Reuse

Total Cost = (Cost of Return 10 containers) + Cost to replace 2 containers)

= $.865/rd x 10 rd + $1.60/rd x 2 rd = $11.85

Since a reuse policy has 74% of the cost of a no reuse policy for the theater with highest return costs, reuse is planned for all theaters and users where transportation permits return (there is no transportation for reuse of packaging from Fts Bragg and Campbell).

(2) Box procurement cost is $37.50/25 rd, return from Europe is $42.417/25 rd, and repair is $12.50/25 rd. Comparing costs for 10 boxes:

Procurement

Total Cost = Cost to replace 10 boxes

= $37.50/box 10 boxes

= $375.00

Reuse

Total Cost = (Cost to return 10 boxes) + (cost to repair 2 boxes)

= ($42.417/box 10 boxes) + ($12.50/box 2 boxes)

= $449.17

Reuse of boxes returned from Europe is more costly than procurement; return of boxes from Europe is not planned. Similarly, return of boxes from the Pacific Theater is not cost-effective. Reuse of boxes from Fts Rucker and Hood is less than 90% of procurement cost and so reuse is planned for these two locations. Lack of transportation excludes return from Fts Bragg and Campbell.

(3) Based on this analysis procedure, Figure E9 summarizes container and box return alternatives and relevant costs for the 50-round pack. For example, the cost equivalent to $37.50/25 rd for procurement of boxes gives a cost of $1.50/rd. Procurement and return costs for the three alternatives are given in Figures E7 to E11.

b. Activity Probabilities for Procurement/Reuse.

(1) Different shipment quantities are sent to each user and different quantities of pack material are returned from each user. The economic decisions that are made in planning reuse affect the relative frequencies of procurement vs return; these frequencies or probabilities must be calculated.

(2) Ammunition distribution in the network was specified as the following: 20% through CONUS depot to CONUS users (it is assumed that each user receives equal quantities), 45% through CONUS depots and through CONUS ports to overseas users (it is assumed 23.4% goes to Europe and 21.6% goes to Pacific), 10% direct to CONUS users (equal user quantities are assumed), and 25% direct to CONUS port for overseas users (13% to Europe and 12% to Pacific are assumed). The fraction

of containers and boxes returned for reuse was specified as 5% for the 50-round pack. This fraction is assumed to be an average value that can be used to calculate procurement quantities averaged over all years of the analysis. It is informative to compare distribution and reuse for users and areas where return is cost-effective. This comparison is made in the following chart:

AREA/USER	FRACTION OF TOTAL	AREA/USER	FRACTION (at 5%) RETURNED	NUMBER OF ROUNDS FOR WHICH BOXES RETURNED
Europe	(.234+.13)	149604	.0182	7480
Pacific	(.216+12)	138096	.0168	6905
Ft Rucker	(.05+.025)	30825	.00375	1541
Ft Hood	(.05+.025)	30825	.00375	1541
TOTAL	.85	349350	.0425	17467

(Fts Bragg & Campbell account for 15% of the distribution, but have no return capabilities and are therefore omitted from the chart)

Using information from this table, 1-.0425 (.9575) of the total or 411,000 - 17467 (393533 rounds) must be procurred. The fractions are used as model input to specify the probability for activities 11-15 of Figure E9. In Figure E9 activities 17 and 19, probabilities are the estimates of relative frequency of no container damage and container damage, respectively. The probabilities for activities 21, 24, and 25 are calculated in the same way as for activities 11 - 15; return of boxes from Europe and Pacific theaters was shown in paragraph 1b to be too costly so that only Ft Rucker and Ft Hood box returns are available for shipment of new rounds. Activities 27 and 29 are similar to 17 and 19 above. Note that for each node the sum of the probabilities for all activities leaving the node is 1.

(3) Each possible path going from node 10 to node 30 of Figure E9 describes an alternative way to obtain packaging. For example, the path consisting of activities 13, 19, 24, and 27 represents a container returned from the Pacific that was found to be damaged and was replaced, and boxes returned from Ft. Rucker that required no repair. The probability

of taking this path is the product of the individual activity probabilities (.0168 x .2 x .0037 x .8 or .000010). The per round cost is the sum of the activity costs (.7050/rd + 1.6000/rd + .3590/rd + 0, or 2.664/rd). The expected cost of the 50-round pack alternative with separate return of container and box is $3.06651/rd; the total cost for 411000 rounds is $1.260 millions.

(4) Results of such reuse analyses are provided in Table E8. This Table shows "as stated" or the base costs (reuse percentages, 20% of containers, pallets, etc., requiring repair, and 411,000 rounds) and the sensitivity of each alternative to parameter variations from "as stated" values.

5. Total Costs

a. Activity Costs.

The results of the preliminary procurement/reuse analysis for the 2.75 inch rocket are put into the distribution network (Figure E12) as per-round costs for Activity 1. Figures E1-E3 show the input data, input data echo and analysis results, respectively, for the procurement/reuse analysis of the 38 round pack. Figures E4-E6 show the input data, input data echo and analysis results, respectively, for the distribution analysis using the results from the 38 round pack procurement/reuse analysis.

b. Results

Results from distribution network costing are shown in Figures E13, E14, and E15. These results are for separate return of pack components, where return is cost-effective. Note that the procurement/reuse analysis (Table E2) revealed insignificant differences in separate return vs "consolidated" return (containers in boxes). The total costs to develop, establish, and distribute each of the pack alternatives are in Table E4. The 38-round pack is lowest in cost principally because of the lower procurement costs. Procurement for the 60-round pack totals $4.00/round, for the 50-round pack totals $3.10/round, and for the 38-round pack procurement totals $1.69/round.

c. Cost Sensitivity

If the relative magnitudes of procurement costs stay about the same, the 38-round pack will remain lowest in cost. Sensitivity of total costs to reuse, quantity, and repair rate is shown in Table E5 and in Figures E16, E17, and E18. For production quantities above about 200,000 rounds the 38-round pack cost is lowest in cost for the variation in reuse, quantity and repair rates studied. Total cost ranking is not sensitive to these variables.

6. Conclusions.

The proposed 38-round pack is the least-cost pack; the cost ranking does not change for large changes in reuse percentage, production quantity, and percentage repair. The principal cost benefit is gained from much lower procurement costs for the 38-round pack components than for the alternatives. Radical cost differential cost changes would be required to change the relative ranking of the alternatives.

7. Recommendations.

Projected costs for each alternative should be reviewed to determine whether development, procurement, or distribution costs have changed so significantly that the proposed 38-round pack is no longer the least-cost alternative.

TABLE E1. PACKAGING REUSE COSTS 2.75 INCH ROCKET

Activity	60-round pack Cost ($)	50-round pack Cost ($)	38-round pack Cost ($)
Procure Container	1.60/rd	1.60/rd	
Reuse Container (repair unecon.)			
Return from Europe	.865/rd	.865/rd	
Return from Pacific	.705/rd	.705/rd	
Return from Ft Rucker	.220/rd	.220/rd	
Return from Ft Hood	.178/rd	.178/rd	
Procure Box, or Drum	8.40/4 rd	37.50/25 rd	22.83/19 rd ship 3.209/19 rd
Reuse Box or Drum			
Repair (avg cost for those repaired)	.80/4rd	12.50/25 rd	6.25/19 rd
Return from Europe	7.324/4 rd	42.417/ 25 rd	19.444/19 rd
Return from Pacific	5.855/4 rd	33.847/25 rd	15.757/19 rd
Return from Ft Rucker	1.428/4 rd	8.976/25 rd	1.978/19 rd
Return from Ft Hood	1.064/4 rd	6.688/25 rd	1.450/19 rd
Procure Skid or Pallet	18.00/60 rd		9.50/38 rd ship 2.706/ 38 rd
Reuse Skid or Pallet			
Repair (avg cost for those repaired)	7.20/60 rd		3.80/38 rd
Return from Europe	24.588/60 rd		19.241/38 rd
Return from Pacific	21.806/60 rd		17.945/38 rd
Return from Ft Rucker	4.537/60 rd		3.600/38 rd
Return from Ft Hood	3.699/60 rd		2.956/38 rd
Consolidated return (containers in box or drum)			
10,000 lb from Europe	9.944/4 rd	59.351/25 rd	
10,000 lb from Pacific	9.704/4 rd	57.328/25 rd	
10,000 lb from Ft Rucker	2.546/4 rd	15.925/25 rd	
10,000 lb from Ft Hood	1.909/4 rd	11.944/25 rd	
Procurement costs Equivalent to Consolidated Return	14.80/4 rd	77.50/25 rd	26.04/19 rd

TABLE E1. PACKAGING REUSE COSTS 2.75 INCH ROCKET (cont'd)

Activity	60-round pack Cost ($)	50-round pack Cost ($)	38-round pack Cost ($)
Single Item Return Costs, Equivalent to Consolidated Return			
Return from Europe	10.784/4 rd	64.042/25 rd	19.414/19 rd
Return from Pacific	8.675/4 rd	51.472/25 rd	15.757/19 rd
Return from Ft Rucker	2.308/4 rd	14.476/25 rd	1.978/19 rd
Return from Ft Hood	1.776/4 rd	11.138/25 rd	1.459/19 rd

TABLE E2. 2.75 IN ROCKET PROCUREMENT/PKG REUSE COST SENSITIVITY

Sensitivity to Varying Reuse Factor (20% Repair, 411K Rounds)

% Reuse	60-Round Pack Sep Return	60-Round Pack Consol Ret	50-Round Pack Sep Return	50-Round Pack Consol Ret	38-Round Pack Sep Return
0	$1644K	$1644K	$1274K	$1274K	$695K
as stated	$1622K	$1622K	$1260K	$1263K	$658K
4 x as stated	$1556K	$1558K	$1219K	$1228K	$548K

Sensitivity to Varying Quantity of Ammunition (Reuse "as stated," % Repair 20%)

# Rounds	60-Round Sep Return	50-Round Sep Return	38-Round Sep Return
0	0	0	0
as stated	$1622K	$1260K	$658K
1000K	$3947K	$3067K	$1602K

Sensitivity to Varying % Repair (Reuse "as stated", 411K Rounds)

% Repair	60-Round Sep Return	50-Round Sep Return	38-Round Sep Return
0%	$1616K	$1254K	$654K
as stated	$1622K	$1260K	$658K
50%	$1632K	$1269K	$665K

TABLE E3. 2.75 INCH ROCKET PACKAGING & DISTRIBUTION COST SUMMARY
($/rd unless otherwise stated)

	Activity	Probability	60 round pack	50 round pack	38 round pack
1.	Procure/Return & Repair	1.0	3.94668	3.06651	1.60205
2.	Pack & Unitize	1.0	.17	.16	.10
3.	Load Truck	.05	.076	.133	.314
4.	Load Railcar	.95	.080	.113	.216
5.	LAP to Sierra	.2274	1.34	1.26	1.08
6.	LAP to Anniston	.3516	.88	.75	.61
7.	LAP to Blue Grass	.0526	1.03	.99	.81
8.	LAP to Red River	.0526	.29	.28	.23
9.	LAP to Concord (½ in-transit at Sierra)	.1263	(1.35+1.52)/2	(1.27+1.43)/2	(1.09+1.22)/2
10.	LAP to Sunny Point (½ in-transit at Anniston)	.1368	(1.08+1.34)/2	(1.05+1.29)/2	(.85+1.05)/2
11.	LAP to Ft Hood (Truck)	.5	.98	.29	.77
12.	LAP to Ft Rucker (Truck)	.5	1.22	1.14	.96
13.	LAP to Ft Campbell (½ in-transit at Blue Grass)	.0263	(.80+1.19)/2	(.77+1.15)/2	(.63+.94)/2
14.	LAP to Ft Bragg (½ in-transit at Anniston)	.0263	(1.15+1.30)/2	(.99+1.26)/2	(.91+1.02)/2
15.	Sierra Receive & Ship	1.0		(35.05+9.79)per unit load	
16.	Anniston Receive & Ship	1.0		(5.19+7.37)per unit load	
17.	Blue Grass Receive & Ship	1.0		(19.46+53.00)per unit load	
18.	Red River Receive & Ship	1.0		(16.69+18.70)per unit load	
19.	Sierra Storage	1.0	.69	.86	.66
20.	Anniston Storage	1.0	.69	.86	.66

TABLE E3. 2.75 INCH ROCKET PACKAGING & DISTRIBUTION COST SUMMARY (contd)
($/rd unless otherwise stated)

	Activity	Probability	60 round pack	50 round pack	38 round pack
21.	Blue Grass Storage	1.0	.69	.86	.66
22.	Red River Storage	1.0	.69	.86	.66
23.	Sierra to Concord	1.0	.28	.25	.21
24.	Anniston to Sunny Point	.7006	.75	.72	.59
25.	Anniston to Ft Bragg	.1497	.68	.65	.53
26.	Anniston to Ft Rucker	.1497	1.05	.99	.82
27.	Blue Grass to Campbell	1.0	.53	.51	.41
28.	Red River to Ft Hood	1.0	1.23	1.14	.95
29.	Concord Handling	1.0		36.54/MT (for all)	
30.	Concord to Chinhae	1.0		82.28/MT " "	
31.	Chinhae Handling	1.0		19.33/MT " "	
32.	Chinhae to Yongsan	.9		15.29/MT " "	
33.	Yongsan Handling & Storage	1.0	.55	.64	.73
34.	Yongsan to Vijongbu	.9		.99/MT " "	
35.	Chinhae to Vijongbu	.1		16.27/MT " "	
36.	Vijongbu Handling	1.	.32	.37	.46
37.	Yongsan to Users	.1		.99/MT " "	
38.	Vijongbu to Users	1.0		.50/MT " "	
39.	Users Handling & Unpack	1.0	.18	.16	.09
40.	Sunny Point Handling	1.0		23.14/MT " "	
41.	Sunny Point to Nordenham	1.0		59.13/MT " "	
42.	Nordenham Handling	1.0		24.15/MT " "	

TABLE E3. 2.75 INCH ROCKET PACKAGING & DISTRIBUTION COST SUMMARY (contd)
($/rd unless otherwise stated)

Activity	Probability	60 round pack	50 round pack	38 round pack
43. Nordenham to Miesau	.9		21.07/MT (for all)	
44. Miesau Handling & Storage	1.0	.55	.64	.73
45. Miesau to Grafenwoehr	.9		16.04/MT " "	
46. Nordenham to Grafenwoehr	.1		23.95/MT " "	
47. *Grafenwoehr Handling*	1.	.32	.37	.46
48. Miesau to Users	.1		16.04/MT " "	
49. Grafenwoehr to Users	1.		8.02/MT " "	
50. Users Handling & Unpack	1.	.18	.16	.09
51. " " "	"	"	"	"
52. " " "	"	"	"	"
53. " " "	"	"	"	"
54. " " "	"	"	"	"

Fixed Costs to Implement Pack:	60 round pack	50 round pack	38 round pack
Equipment	0	0	$50,000
Publications	0	0	$ 2,000
Design	0	0	$115,000

TABLE E4. TOTAL DEVELOPMENT AND DISTRIBUTION COSTS FOR 2.75 INCH ROCKET PACK ALTERNATIVES

	60-Round (Current Pack; cost in $ Thousands)	50-Round (Current Pack; cost in $ Thousands)	38-Round (New Drum Pack; cost in $ Thousands)
Procurement/Reuse	1622	1260	658
Develop/Distribute (exclude proc/reuse)	2328	2152	2370
Total Costs	3950	3412	3028

TABLE E5. SENSITIVITY OF TOTAL (DEVELOPMENT, PROCUREMENT/REUSE, AND DISTRIBUTION) PACK COSTS TO VARYING REUSE, QUANTITY, AND REPAIR RATE

	60-Round (Current Pack; cost in $ Thousands)	50-Round (Current Pack; cost in $ Thousands	38-Round (New Drum Pack; cost in $ Thousands)
No Reuse	3972	3426	3065
4 x Base % Reuse	3884	3371	2918
0 Rounds	0	0	167
1 Million Rounds	9610	8303	7129
0 % Repair	3944	3406	3024
50% Repair	3960	3421	3035

```
//R0179@TS JOB (31RG,A2RB,68010179,JCAP),'SHORT',CLASS=F,TIME=1
//GO EXEC PGM=APC,REGION=100K
//STEPLIB DD DSN=JCDMNVH.LOAD,DISP=SHR
//GO.FT05F001 DD SYSOUT=A
//GO.FT05F001 DD *
         3    411.    2.75 IN ROCKET DISTRIB OF 38 RD PACK
  .05     .002       .115
  I
        38       982.       4.9167  3.0208  2.0208
  11    10   20    .83       52.078        2.    PROCURE 2 DRUMS FOR UL
  12    10   19    .0728     38.828        2.    RTN 2 DRUMS,EUR
  13    10   19    .0672     31.514        2.    RTN 2 DRUMS,PAC
  14    10   19    .0150      3.956        2.    RTN 2 DRUMS,RUCKER
  15    10   19    .0150      2.918        2.    RTN 2 DRUMS,HOOD
  17    19   20    .8          0.0         2.    NO DRUM DAMAGE
  19    19   20    .2        12.5          2.    RPR DRUM
  21    20   30    .9970     12.206        2.    PROCURE PALLET
  24    20   29    .0015      3.6          2.    RTN PALLET,RUCKER
  25    20   29    .0015      2.956        2.    RTN PALLET,HOOD
  27    29   30    .8          0.0         2.    NO PALLET DAMAGE
  29    29   30    .2          3.8         2.    RPR PALLET
```

Figure E1. Procurement/Reuse Input Data, 38 Round Pack, 2.75 Inch Rocket

DEVELOPMENT AND DISTRIBUTION COSTS FOR ALTERNATIVE 3, 2.75 IN ROCKET DISTRIB OF 38 RD PACK
COSTS ARE CALCULATED IN $/RD.

UNIT LOAD PARAMETERS

38 ROUNDS,	992. POUNDS,	4.92 FEET LONG,	3.02 FEET WIDE,	2.02 FEET HIGH	
0.02632 UNIT LOAD/RD,	0.01292 STON/RD,	0.01975 MTON/RD,	0.39085 SQ FT/RD		

DISTRIBUTION TABLE

ACTIVITY	FROM	TO	PROBABILITY	RD	UL	ST	MT	SQ-FT	
				COST DEPENDENCIES;COEFFICIENTS IN $/RD					
11	10	20	0.8300	0.0	1.3705	0.0	0.0	0.0	PROCURE 2 DRUMS FOR UL
12	10	19	0.0728	0.0	1.0218	0.0	0.0	0.0	RTN 2 DRUMS,EUR
13	10	19	0.0672	0.0	0.8293	0.0	0.0	0.0	RTN 2 DRUMS,PAC
14	10	19	0.0150	0.0	0.1041	0.0	0.0	0.0	RTN 2 DRUMS,RUCKER
15	10	19	0.0150	0.0	0.0768	0.0	0.0	0.0	RTN 2 DRUMS,HOOD
17	19	20	0.8000	0.0	0.0	0.0	0.0	0.0	NO DRUM DAMAGE
19	19	20	0.2000	0.0	0.3269	0.0	0.0	0.0	RPR DRUM
21	20	30	0.9970	0.0	0.3212	0.0	0.0	0.0	PROCURE PALLET
24	20	29	0.0015	0.0	0.0947	0.0	0.0	0.0	RTN PALLET,RUCKER
25	20	29	0.0015	0.0	0.0778	0.0	0.0	0.0	RTN PALLET,HOOD
27	29	30	0.8000	0.0	0.0	0.0	0.0	0.0	NO PALLET DAMAGE
29	29	30	0.2000	0.0	0.1000	0.0	0.0	0.0	RPR PALLET

Figure E2. Procurement/Reuse Input Data Echo, 2.75 Inch Rocket

```
DEVELOPMENT AND DISTRIBUTION COSTS FOR ALTERNATIVE   3, 2.75 IN ROCKET DISTRIB OF 38 RD PACK
                         COSTS ARE CALCULATED IN $/RD.
                               FINAL STATISTICS

       TOTAL EXPECTED COST OF ALL PATHS $   1.60205/RD
       AVERAGE COST FOR ALL PATHS $   0.92328/RD

      COSTS, IN $/RD, DUE TO:(  PER RD     PER UL    PER ST     PER MT    PER SQ-FT)
           COST PERCENT VECTOR:(  0.0        1.00000   0.0        0.0       0.0     )
  TOTAL EXPECTED COST   VECTOR:(  0.0        1.60205   0.0        0.0       0.0     )

       EQUIPMENT,PUBLICATION,AND DESIGN COSTS ARE RESPECTIVELY,:  0.050  0.002  0.115  $MILLIONS.

       THE TOTAL COST FOR DEVELOPEMENT AND DISTRIBUTION OF  411.  THOUSAND ROUNDS IS $    0.825  MILLIONS
```

Figure E3. Procurement/Reuse Analysis Results, 38 Round Pack, 2.75 Inch Rocket

```
//R0179@TS JOB (3IRG,A2RP,68010179,JCAP),'SHORT',CLASS=F,TIME=1
//GO EXEC PGM=APC,REGION=100K
//STEPLIB DD DSN=JCDMNVH.LOAD,DISP=SHR
//GO.FT06F001 DD SYSOUT=A
//GO.FT05F001 DD *
          3     411.     2.75 IN ROCKET DISTRIB OF 38 RD PACK
   .05     .002        .115
   1
         36        982.        4.9167  3.0208  2.0208
   1      1     2  1.          1.50205      1.   PROCURE/RETURN%REPAIR
   2      2     3  1.          .17          1.   PACK%UNITIZE
   3      3     4  .05         .314         1.   LOAD TRUCK
   4      3     5  .95         .215         1.   LOAD RAILCAR
   5      5     6  .2274       1.03         1.   LAP TO SIERRA
   6      5     7  .3516       .61          1.   LAP TO ANNISTON
   7      5     8  .0526       .81          1.   LAP TO BLUEGRASS
   8      5     9  .0526       .23          1.   LAP TO RED RIVER
   9      5    10  .1263       1.15         1.   LAP TO CONCORD
  10      5    11  .1368       .95          1.   LAP TO SUNNY POINT
  11      4    12  .5          .77          1.   LAP TO FT HOOD
  12      4    13  .5          .96          1.   LAP TO FT RUCKER
  13      5    14  .0263       .79          1.   LAP TO FT CAMPBELL
  14      5    15  .0263       .97          1.   LAP TO FT BRAGG
  15      6    16  1.          44.34        2.   SIERRA RECEIVE AND SHIP
  16      7    17  1.          12.56        2.   ANNISTON RECEIVE AND SHIP
  17      8    18  1.          72.46        2.   BLUEGRASS RECEIVE AND SHIP
  18      9    19  1.          35.39        2.   RED RIVER RECEIVE AND SHIP
  19     16    20  1.          .65          1.   SIERRA STORAGE
  20     17    21  1.          .65          1.   ANNISTON STORAGE
  21     18    22  1.          .66          1.   BLUEGRASS STORAGE
  22     19    23  1.          .65          1.   RED RIVER STORAGE
```

Figure E4. Distribution Input Data, 2.75 Inch Rocket

23	20	10	1.	.21	1.	SIERRA TO CONCORD
24	21	11	.7006	.59	1.	ANNISTON TO SUNNY POINT
25	21	15	.1497	.53	1.	ANNISTON TO FT BRAGG
26	21	13	.1497	.82	1.	ANNISTON TO FT RUCKER
27	22	14	1.	.41	1.	BLUEGRASS TO CAMPBELL
28	23	12	1.	.95	1.	RED RIVER TO FT HOOD
29	10	24	1.	36.54	4.	CONCURD HANDLING
30	24	25	1.	82.28	4.	CONCORD TO CHINHAE
31	25	26	1.	19.33	4.	CHINHAE HANDLING
32	26	27	.9	15.29	4.	CHINHAE TO YONGSAN
33	27	28	1.	.73	1.	YONGSAN HANDLING STORAGE
34	28	29	.9	.99	4.	YONGSAN TO VIJONGBU
35	26	29	.1	15.27	4.	CHINHAE TO VIJONGBU
36	29	30	1.	.46	1.	VIJONGBU HANDLING
37	28	31	.1	.99	4.	YONGSAN TO USERS
38	30	31	1.	.5	4.	VIJONGBU TO USERS
39	31	32	1.	.09	1.	USERS HANDLING ,UNPACK
40	11	33	1.	25.14	4.	SUNNY POINT HANDLING
41	33	34	1.	59.13	4.	SUNNY POINT TO NORDENHAM
42	34	35	1.	24.15	4.	NORDENHAM HANDLING
43	35	36	.9	21.07	4.	NORDENHAM TO MIESAU
44	36	37	1.	.73	1.	MIESAU HANDLING STORAGE
45	37	38	.9	16.04	4.	MIESAU TO GRAFENWOEHR
46	35	38	.1	25.95	4.	NORDENHAM TO GRAFENWOEHR
47	38	39	1.	.46	1.	GRAFENWOEHR HANDLING
48	37	40	.1	16.04	4.	MIESAU TO USERS
49	39	40	1.	8.02	4.	GRAFENWOEHR TO USERS
50	40	41	1.	.09	1.	USERS HANDLING AND UNPACK
51	12	42	1.	.09	1.	FT HOOD HANDLING %UNPACK
52	13	43	1.	.09	1.	FT RUCKER HANDLING,UNPACK
53	14	44	1.	.09	1.	FT CAMPBELL HANDLING,UNPACK
54	15	45	1.	.09	1.	FT BRAGG HANDLING,UNPACK

Figure E4. Distribution Input Data, 2.75 Inch Rocket (Con't)

DEVELOPMENT AND DISTRIBUTION COSTS FOR ALTERNATIVE 3, 2.75 IN ROCKET DISTRIB OF 38 RD PACK
COSTS ARE CALCULATED IN $/RD.

UNIT LOAD PARAMETERS

38 ROUNDS, 982. POUNDS, 4.92 FEET LONG, 3.02 FEET WIDE, 2.02 FEET HIGH
0.02632 UNIT LOAD/RD, 0.01292 STON/RD, 0.01975 MTON/RD, 0.39085 SQ FT/RD

DISTRIBUTION TABLE

ACTIVITY	FROM	TO	PROBABILITY	COST DEPENDENCIES;COEFFICIENTS IN $/RD RD	UL	ST	MT	SQ-FT	
1	1	2	1.0000	1.6020	0.0	0.0	0.0	0.0	PROCURE/RETURN&REPAIR
2	2	3	1.0000	0.1000	0.0	0.0	0.0	0.0	PACK&UNITIZE
3	3	4	0.0500	0.3140	0.0	0.0	0.0	0.0	LOAD TRUCK
4	3	5	0.9500	0.2160	0.0	0.0	0.0	0.0	LOAD RAILCAR
5	5	6	0.2274	1.0800	0.0	0.0	0.0	0.0	LAP TO SIERRA
6	5	7	0.3516	0.6100	0.0	0.0	0.0	0.0	LAP TO ANNISTON
7	5	8	0.0526	0.8100	0.0	0.0	0.0	0.0	LAP TO BLUEGRASS
8	5	9	0.0526	0.2300	0.0	0.0	0.0	0.0	LAP TO RED RIVER
9	5	10	0.1263	1.1600	0.0	0.0	0.0	0.0	LAP TO CONCORD
10	5	11	0.1368	0.9500	0.0	0.0	0.0	0.0	LAP TO SUNNY POINT
11	4	12	0.5000	0.7700	0.0	0.0	0.0	0.0	LAP TO FT HOOD
12	4	13	0.5000	0.9500	0.0	0.0	0.0	0.0	LAP TO FT RUCKER
13	5	14	0.0263	0.7900	0.0	0.0	0.0	0.0	LAP TO FT CAMPBELL
14	5	15	0.0263	0.9700	0.0	0.0	0.0	0.0	LAP TO FT BRAGG
15	6	16	1.0000	0.0	1.1800	0.0	0.0	0.0	SIERRA RECEIVE AND SHIP
16	7	17	1.0000	0.0	0.3305	0.0	0.0	0.0	ANNISTON RECEIVE AND SHI
17	8	18	1.0000	0.0	1.9068	0.0	0.0	0.0	BLUEGRASS RECEIVE AND SH
18	9	19	1.0000	0.0	0.9313	0.0	0.0	0.0	RED RIVER RECEIVE AND SH
19	16	20	1.0000	0.6600	0.0	0.0	0.0	0.0	SIERRA STORAGE
20	17	21	1.0000	0.6600	0.0	0.0	0.0	0.0	ANNISTON STORAGE

Figure E5. Distribution Input Data Echo, 2.75 Inch Rocket

21	18	22	1.0000	0.6600	0.0	0.0	0.0	0.0	BLUEGRASS STORAGE
22	19	23	1.0000	0.6500	0.0	0.0	0.0	0.0	RED RIVER STORAGE
23	20	10	1.0000	0.2100	0.0	0.0	0.0	0.0	SIERRA TO CONCORD
24	21	11	0.7006	0.5900	0.0	0.0	0.0	0.0	ANNISTON TO SUNNY POINT
25	21	15	0.1497	0.5300	0.0	0.0	0.0	0.0	ANNISTON TO FT BRAGG
26	21	13	0.1497	0.8200	0.0	0.0	0.0	0.0	ANNISTON TO FT RUCKER
27	22	14	1.0000	0.4100	0.0	0.0	0.0	0.0	BLUEGRASS TO CAMPBELL
28	23	12	1.0000	0.9500	0.0	0.0	0.0	0.0	RED RIVER TO FT HOOD
29	10	24	1.0000	0.0	0.0	0.0	0.7215	0.0	CONCORD HANDLING
30	24	25	1.0000	0.0	0.0	0.0	1.6247	0.0	CONCORD TO CHINHAE
31	25	26	1.0000	0.0	0.0	0.0	0.3817	0.0	CHINHAE HANDLING
32	26	27	0.9000	0.0	0.0	0.0	0.3019	0.0	CHINHAE TO YONGSAN
33	27	28	1.0000	0.7300	0.0	0.0	0.0	0.0	YONGSAN HANDLING STORAGE
34	28	29	0.9000	0.0	0.0	0.0	0.0195	0.0	YONGSAN TO VIJONGBU
35	26	29	0.1000	0.0	0.0	0.0	0.3213	0.0	CHINHAE TO VIJONGBU
36	29	30	1.0000	0.4600	0.0	0.0	0.0	0.0	VIJONGBU HANDLING
37	28	31	0.1000	0.0	0.0	0.0	0.0195	0.0	YONGSAN TO USERS
38	30	31	1.0000	0.0	0.0	0.0	0.0099	0.0	VIJONGBU TO USERS
39	31	32	1.0000	0.0900	0.0	0.0	0.0	0.0	USERS HANDLING ,UNPACK
40	11	33	1.0000	0.0	0.0	0.0	0.4569	0.0	SUNNY POINT HANDLING
41	33	34	1.0000	0.0	0.0	0.0	1.1676	0.0	SUNNY POINT TO NORDENHAM
42	34	35	1.0000	0.0	0.0	0.0	0.4769	0.0	NORDENHAM HANDLING
43	35	36	0.9000	0.0	0.0	0.0	0.4160	0.0	NORDENHAM TO MIESAU
44	36	37	1.0000	0.7300	0.0	0.0	0.0	0.0	MIESAU HANDLING STORAGE
45	37	38	0.9000	0.0	0.0	0.0	0.3167	0.0	MIESAU TO GRAFENWOEHR
46	35	38	0.1000	0.0	0.0	0.0	0.4729	0.0	NORDENHAM TO GRAFENWOEHR
47	38	39	1.0000	0.4600	0.0	0.0	0.0	0.0	GRAFENWOEHR HANDLING
48	37	40	0.1000	0.0	0.0	0.0	0.3167	0.0	MIESAU TO USERS
49	39	40	1.0000	0.0	0.0	0.0	0.1584	0.0	GRAFENWOEHR TO USERS
50	40	41	1.0000	0.0900	0.0	0.0	0.0	0.0	USERS HANDLING AND UNPAC
51	12	42	1.0000	0.0900	0.0	0.0	0.0	0.0	FT HOOD HANDLING %UNPACK
52	13	43	1.0000	0.0900	0.0	0.0	0.0	0.0	FT RUCKER HANDLING,UNPAC
53	14	44	1.0000	0.0900	0.0	0.0	0.0	0.0	FT CAMPBELL HANDLING,UNP
54	15	45	1.0000	0.0900	0.0	0.0	0.0	0.0	FT BRAGG HANDLING,UNPACK

Figure E5. Distribution Input Data Echo, 2.75 Inch Rocket (Con't)

```
DEVELOPMENT AND DISTRIBUTION COSTS FOR ALTERNATIVE   3, 2.75 IN ROCKET DISTRIB OF 38 RD PACK
                              COSTS ARE CALCULATED IN $/RD.
                                     FINAL STATISTICS

     TOTAL EXPECTED COST OF ALL PATHS $   6.96176/RD
     AVERAGE COST FOR ALL PATHS $   6.11106/RD

    COSTS, IN $/RD, DUE TO:(  PER RD     PER UL    PER ST     PER MT    PER SQ-FT)
       COST PERCENT VECTOR:(   0.62519   0.07285   0.0        0.30196   0.0     )
 TOTAL EXPECTED COST  VECTOR:(  4.35245   0.50714   0.0        2.10217   0.0     )

     EQUIPMENT,PUBLICATION,AND DESIGN COSTS ARE RESFECTIVELY,:  0.050  0.002  0.115  $MILLIONS.

     THE TOTAL COST FOR DEVELOPEMENT AND DISTRIBUTION OF  411.  THOUSAND ROUNDS IS $    3.028  MILLIONS
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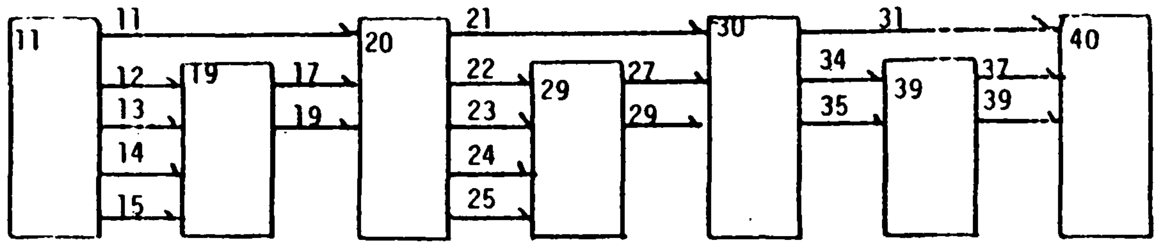
Figure E6. Distribution Analysis Results, 2.75 Inch Rocket

NETWORK FOR 60-ROUND PACK, SEPARATE RETURN OF PACKAGING

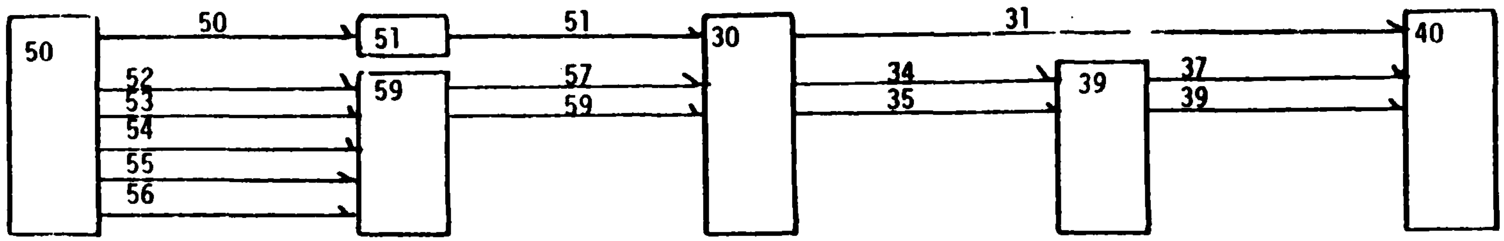


DATA FOR NETWORK

ARC	NODE FROM	NODE TO	ARC PROBABILITY	ARC COST DEPENDENCIES; COEFFICIENTS IN $/RD RD	UL	
11	11	20	.9575	1.6000		PROC CNTR
12	11	19	.0182	.8650		RET CNTR, EUR
13	11	19	.0168	.7050		RET CNTR, PAC
14	11	19	.0037	.2200		RET CNTR, RUCKER
15	11	19	.0037	.1780		RET CNTR, HOOD
17	19	20	.8000			NO REPAIR NEEDED,CNTR
19	19	20	.2000	1.6000		REPLACE CNTR
21	20	30	.9575	2.1000		PROC BOX
22	20	29	.0182	1.8310		RET BOX,EUR
23	20	29	.0168	1.4640		RET BOX,PAC
24	20	29	.0037	.3570		RET BOX,RUCKER
25	20	29	.0037	.2660		RET BOX,HOOD
27	29	30	.2000	.2000		REP BOX
29	29	30	.8000			NO REPAIR NEEDED,BOX
31	30	40	.9970		.3000	PROC SKID
34	30	39	.0015		.0756	RET SKID,RUCKER
35	30	39	.0015		.0616	RET SKID,HOOD
37	39	40	.2000		.1200	REP SKID
39	39	40	.8000			REP NOT NEEDED,SKID

Figure E7. Network for 60-round pack, separate return of packaging.

NETWORK FOR 60-ROUND PACK, CONSOLIDATED RETURN OF PACKAGING

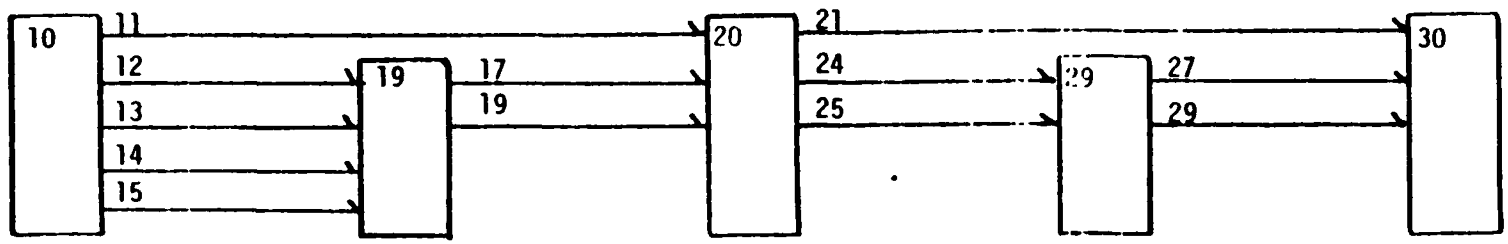


DATA FOR NETWORK

ARC	NODE FROM	NODE TO	ARC PROBABILITY	ARC COST DEPENDENCIES; COEFFICIENTS IN $/RD RD	UL	MT	
50	50	51	.09575	1.6000			PROC CNTR
51	51	30	1.0000	2.1000			PROC BOX
52	50	59	.0182	2.4860			CNTR&BOX RET,EUR
53	50	59	.0168	2.4260			CNTR&BOX RET,PAC
54	50	59	.0037	.6365			CNTR&BOX RET,RUCKER
55	50	59	.0037	.4773			CNTR&BOX RET,HOOD
56	50	59				2.2681	DUMMY
57	59	30	.2000	1.8000			CNTR REPL &BOX RPR
59	59	30	.8000				CNTR&BOX, NO REP
31	30	40	.9970		.3000		PROC SKID
34	30	39	.0015		.0756		RET SKID,RUCKER
35	30	39	.0015		.0616		RET SKID,HOOD
37	39	40	.2000		.1200		REP SKID
39	39	40	.8000				REP NOT NEEDED,SKID

Figure E8. Network for 60-round pack, consolidated return of packaging.

NETWORK FOR 50-ROUND PACK, SEPARATE RETURN OF PACKAGING: 2.75 IN ROCKET

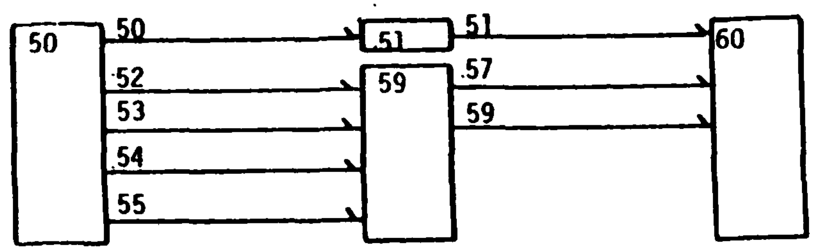


DATA FOR NETWORK

ACTIVITY	FROM	TO	PROBABILITY	RD	UL	ST	MT	SQ-FT	
				COST DEPENDENCIES; COEFFICIENTS IN $/RD					
11	10	20	.9575	1.6000					PROCURE CNTR
12	10	19	.0182	.8650					RTN CNTR,EUR
13	10	19	.0168	.7050					RTN CNTR,PAC
14	10	19	.0037	.2200					RTN CNTR,RUCKER
15	10	19	.0037	.1780					RTN CNTR,HOOD
17	19	20	.8000						NO CNTR DAMAGE
19	19	20	.2000	1.6000					REPLACE DAMAGED CNTR
21	20	30	.9925		1.5000				PROCURE 2 BOXES FOR UL
24	20	29	.0037		.3590				RTN 2 BOXES,RUCKER
25	20	29	.0037		.2675				RTN 2 BOXES,HOOD
27	29	30	.8000						NO BOX DAMAGE
29	29	30	.2000		.5000				REPAIR 2 BOXES

Figure E9. Network for 50-round pack, separate return of packaging: 2.75 inch rocket.

NETWORK FOR 50-ROUND PACK CONSOLIDATED RETURN OF PACKAGING,2.75 IN ROCKET

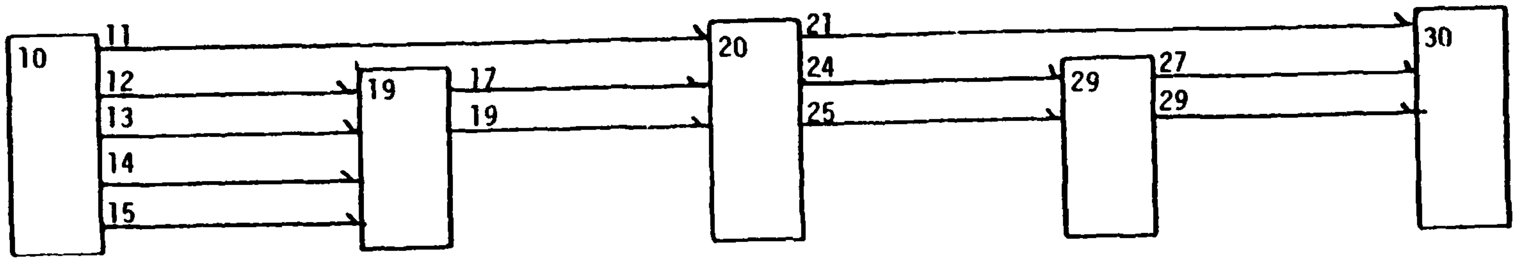


DATA FOR NETWORK

ACTIVITY	FROM	TO	PROBABILITY	COST DEPENDENCIES;COEFFICIENTS IN $/RD RD	UL	ST	MT	SQ-FT	
50	50	51	.9575	1.6000					PROCURE CNTR
51	51	60	1.0000		1.5000				PROCURE 2 BOXES FOR UL
52	50	59	.0182		2.3743				CONSOL RTN, EUR
53	50	59	.0168		2.2931				CONSOL RTN, PAC
54	50	59	.0037		.6370				CONSOL RTN, RUCKER
55	50	59	.0037		.4778				CONSOL RTN, HOOD
57	59	60	.8000						NO DAMAGE
59	59	60	.2000		2.1000				RPR BOXES,RPLC CNTRS

Figure E10. Network for 50-round pack consolidated return of packaging, 2.75 inch rocket.

NETWORK FOR 38-ROUND PACK SEPARATE RETURN OF PACKAGING, 2.75 IN ROCKET

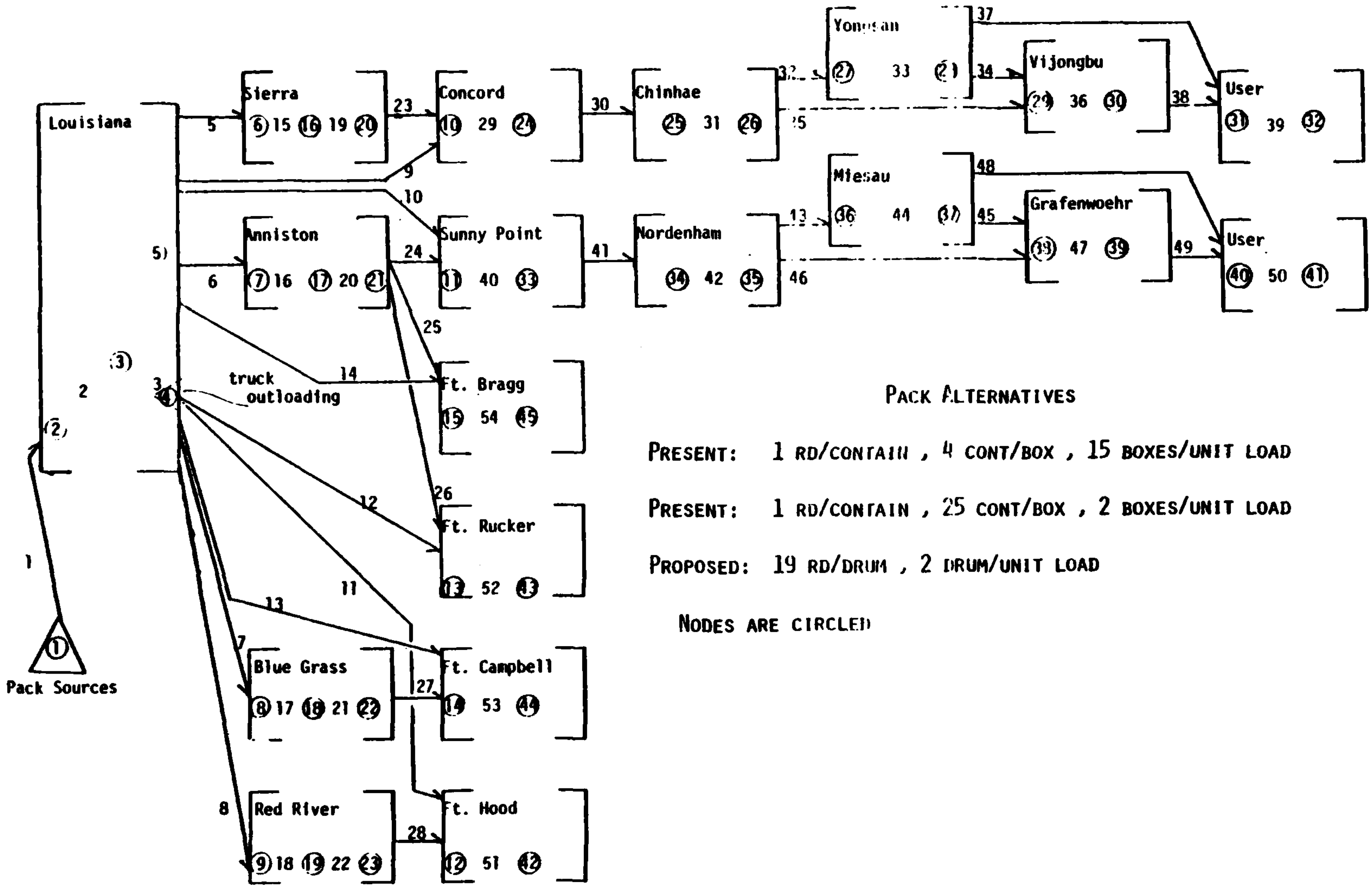


DATA FOR NETWORK

A ARC	NODE FROM	NODE TO	ARC PROBABILITY	ARC COST DEPENDENCIES;COEFFICIENTS IN $/RD RD	UL	ST	MT	SQ-FT	
11	10	20	.8300		1.3705				PROCURE 2 DRUMS FOR UL
12	10	19	.0728		1.0218				RTN 2 DRUMS,EUR
13	10	19	.0672		.8293				RTN 2 DRUMS,PAC
14	10	19	.0150		.1041				RTN 2 DRUMS,RUCKER
15	10	19	.0150		.0768				RTN 2 DRUMS,HOOD
21	20	30	9970		.3212				PROCURE PALLET
17	19	20	.8000						NO DRUM DAMAGE
19	19	20	.2000		.3289				RPR DRUM
24	20	29	.0015		.0947				RTN PALLET,RUCKER
25	20	29	.0015		.0778				RTN PALLET,HOOD
27	29	30	.8000						NO PALLET DAMAGE
29	29	30	.2000		.1000				RPR PALLET

Figure E11. Network for 38-round pack separate return of packaging, 2.75 inch rocket.

ROCKET, HE, 2.75 IN (M490) DISTRIBUTION



PACK ALTERNATIVES

PRESENT: 1 RD/CONTAIN , 4 CONT/BOX , 15 BOXES/UNIT LOAD

PRESENT: 1 RD/CONTAIN , 25 CONT/BOX , 2 BOXES/UNIT LOAD

PROPOSED: 19 RD/DRUM , 2 DRUM/UNIT LOAD

NODES ARE CIRCLED

Figure E 12. Rocket, HE, 2.75 inch (M490) distribution.

```
Development and distribution costs for alternative 1, 2.75 inch rocket
      Distribution of 60-round pack costs are calculated in $/rd
                         Final statistics

  Total expected cost of all paths $   9.61002/rd
  Average cost for all paths       $   8.79224/rd

  Costs, in $/rd, due to: (Per Rd          Per UL      Per ST   Per MT    Per Sq-Ft)
     Cost percent vector: ( 0.71532         0.03342     0.0      0.25126   0.0     )
Total expected cost vector: ( 6.87422       0.32119     0.0      2.41461   0.0     )
```

Equipment, Publication, and Design costs are respectively: *0.0 0.0 0.0 $Millions*

The total cost for development and distribution of 411. Thousand rounds is $ 3.950 Millions

Figure E13. Cost analysis results for 60-round pack development, procurement/reuse, and distribution.

Development and distribution costs for alternative 2, 2.75 inch rocket
Distribution of 50-round pack costs are calculated in $/rd
Final statistics

Total expected cost of all paths	$	8.30289/rd
Average cost for all paths	$	7.51811/rd

Costs, in $/rd, due to:	(Per Rd	Per UL	Per ST	Per MT	Per Sq-Ft)
Cost percent vector :	(0.73335	0.04642	0.0	0.22023	0.0)
Total expected cost vector :	(6.08891	0.38543	0.0	1.82855	0.0)

Equipment, Publication, and Design Costs are respectively: 0.0 0.0 0.0 $Millions

The total cost for development and distribution of 411. Thousand rounds is $3.412 Millions

Figure E14. Cost analysis results for 50-round pack development, procurement/reuse, and distribution.

Development and distribution costs for alternative 3, 2.75 inch rocket
Distribution of 38-round pack costs are calculated in $/rd
Final Statistics

Total expected cost of all paths $ 6.96176/rd
Average cost for all paths $ 6.11106/rd

Costs, in $/rd, due to:	(Per rd	Per UL	Per ST	Per MT	Per Sq-Ft)
Cost percent vector :	(0.62519	0.07285	0.0	0.30196	0.0)
Total Expected cost vector:	(4.35245	0.50714	0.0	2.10217	0.0)

Equipment, Publication, and Design costs are respectively: 0.050 0.002 0.115 $Millions

The total cost for development and distribution of 411. Thousand rounds is $ 3.028 Millions

Figure E15. Cost analysis results for 38-round pack development, procurement/reuse, and distribution.

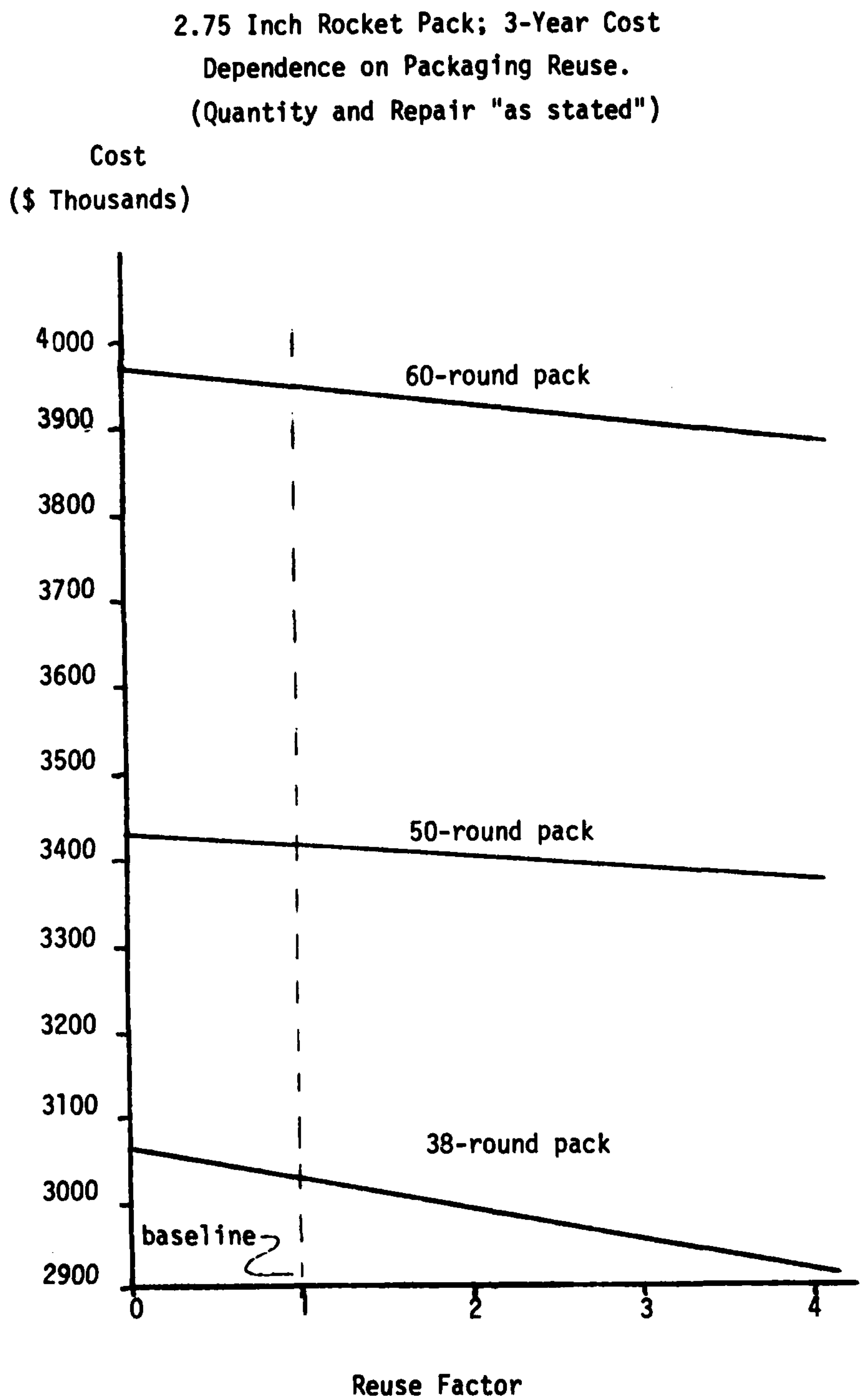


Figure E16. Total cost sensitivity to reuse factor.
(a reuse factor of 4 indicates reuse 4 times as high as percentages provided).

2.75 Inch Rocket Pack; 3-Year Cost

Dependence on Quantity

(reuse & repair "as stated")

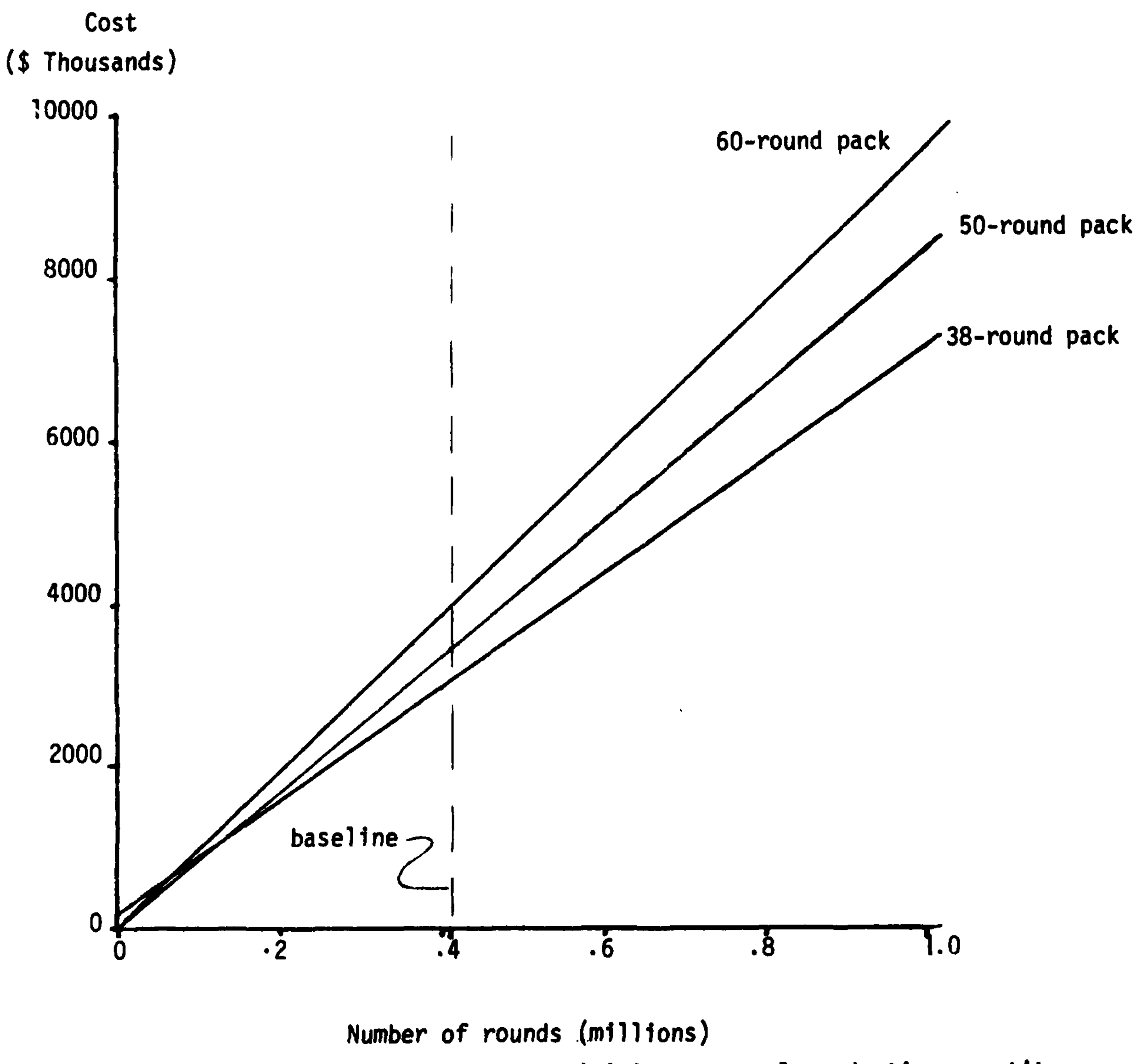


Figure E17. Total cost sensitivity to total production quantity.

2.75 Inch Rocket Pack; 3-Year Cost Dependence on Repair Rate.

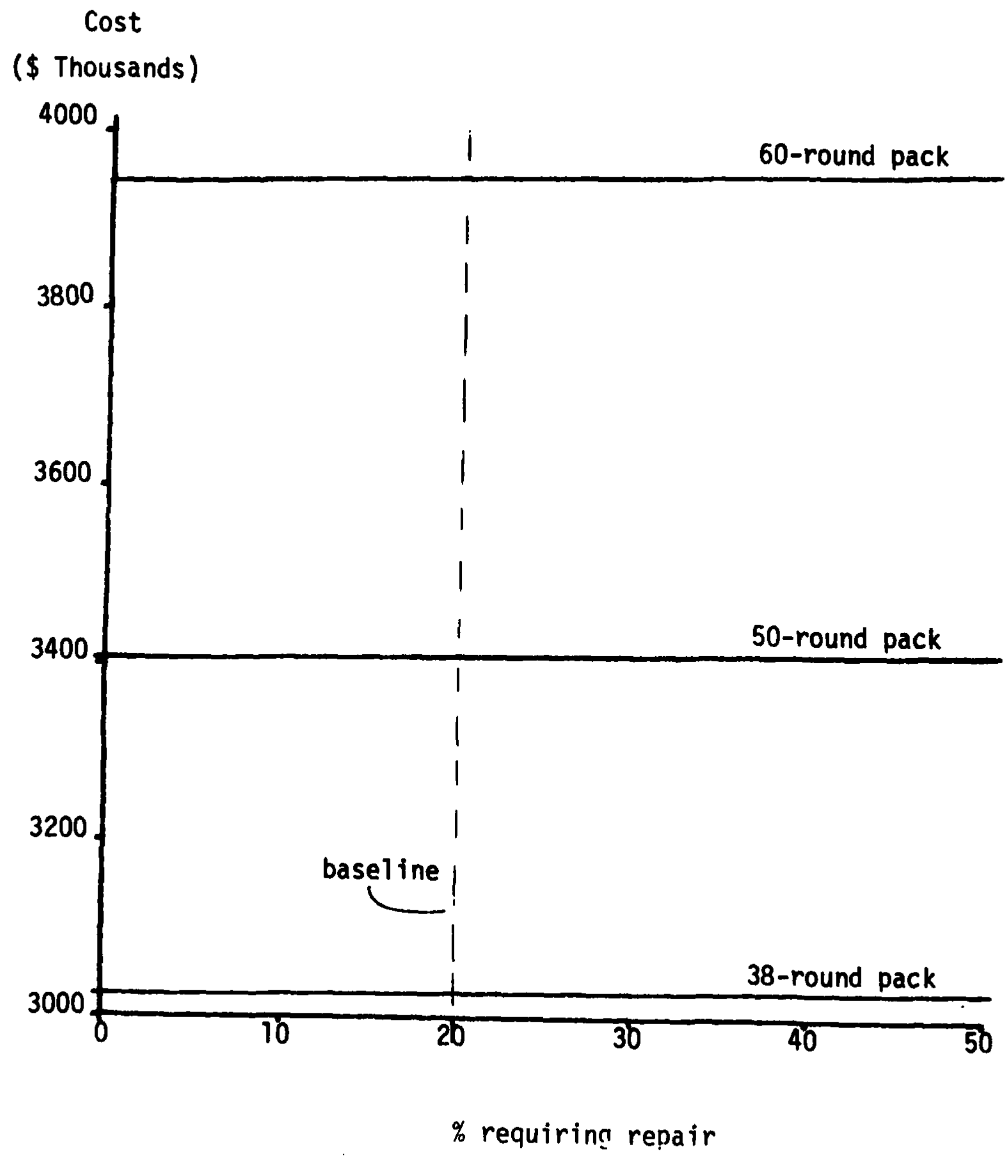


Figure E18. Total cost sensitivity to per cent of packaging requiring repair. (Same percentage for each pack component)

APPENDIX F

EXPLANATION OF TERMS

APPENDIX F 1. EXPLANATION OF TERMS

Blocking and Bracing - The physical shoring up of the interior of a shipping container after it has been stuffed with general cargo to prevent the cargo from shifting within its shipping container.

Break Bulk Point - A transshipping activity to which unitized shipment units for various ultimate consignees may be consigned for further distribution as separate shipment units. (DOD Reg 4500.32-R)

Commercial Container Service - The preparation of general cargo (unitized and loose) and its transportation to an area where a commercial concern is responsible for loading and discharging the container onto and off the vessel as well as the vessel transport. The assumption here is that the cargo is loaded in a container at the depot and the depot is responsible for transportation of the cargo to the contractor's loading point.

Commercial Packaging - The methods and materials employed by the supplier to satisfy the requirements of the commercial distribution system.

Containerization - The use of shipping containers and/or van trailers when used in conjunction with other means of transport in the movement of goods.

Coupling - The physical operation of connecting two 8' X 8' X 20' chassis mounted containers for shipment so that it takes on the configuration of an 8' X 8' X 40' container.

Documentation - The preparation of all documents necessary for the transportation and control of shipped cargo.

Government Break Bulk Service - This is the preparation of general cargo (unitized and loose) transported to the terminal facility for shipment by conventional lift-on, lift-off vessels. This method of shipment also includes the movement of vehicles by conventional lift-on, lift-off vessels.

Gross Weight - The combined weight of a container and contents, including packaging material (Ref. Pg A1-4, DOD Reg 4500.32-R).

In-House Operations - An operation, function, or activity totally performed by Government employees with Government facilities at a Government installation, as distinguished from an operation performed under contract by an industrial contractor.

Inspection and Maintenance - Those operations of making sure the containers are prepared for line haul and shipment and the correction of any deficiencies such as faulty brakes, stop lights, etc.

Intermode Compatibility - By means of size, weight, cube and design, capable of being ransported by, and directly interchangeable between land, sea, and air modes of transportation.

Life Cycle Costs - Cost accrued between points in time when the project or item of hardware becomes a recognized entity and is phased out of inventory.

Line Haul - Transportation of freight over the tracks of a railroad or over the routes of a trucking company, airline, or steamship company from point of origin to the destination, escluding local pick-up, delivery, and switching (Ref. Pg A1-5, DOD Reg 4500.32-R).

Load Shipment - The quantity of freight required for the application of a rail car or truck load rate, or a rail car or truck loaded to its carrying capacity (Ref. Para 2-1, AR 55-16).

Marking - Numbers, nomenclature, symbols, and colors affixed to items or containers for identification during handling, shipment, and storage.

Military Packaging - The materials and methods or procedures prescribed in Federal/Military specifications, standards, drawings, or other authorized documents which are designed to provide the degree of packaging protection determined necessary to prevent damage and deterioration during worldwide distribution of materiel.

MILVAN - The Army-owned demountable container, conforming to U.S. and international standards, operated in a centrally controlled fleet for movement of military cargo.

MILVAN Chassis - The compatible chassis to which the MILVAN is attached by coupling the lower four standard corner fittings of the container to compatible mounting blocks in the chassis.

Net Weight - The new weight of an item being shipped, including the weight of packaging material.

Packaging - Application or use of appropriate wrappings, cushioning, interior containers, and complete identification marking, up to but not including the exterior shipping container (Ref. AR 320-5).

Packing - The preparation of general cargo for shipment (palletizing, crating, or loose packaging) which will be sent in unitized, loose, or containerized shipments.

Pallet - A low portable platform, usually double-faced, on which materials are stacked for storage or transportation. They are usually handled by forklift trucks.

Palletized Unit Load - Quantity of any items, packaged or unpackaged, which is arranged on a pallet in a specified manner and securely strapped or fastened thereto so that the whole is handled as a unit (Ref. AR 320-5).

Preservation - The application of unit protective measures, including cleaning, drying, preservative materials, and containers, when necessary.

Receiving - The physical operation of unstuffing (unloading) of general cargo from its shipping container, truck, or railcar.

Repacking - This operation consists of coopering cargo received in damaged condition.

Retrograde Cargo - Cargo being returned from an overseas command to continental United States (Ref. AR 320-5).

Roll-on/Roll-off (RO/RO):

Cargo - Cargo loaded aboard a trailer-type conveyance, and vehicles transported to a vessel at the port of loading, towed or driven on to the vessel, stowed, and towed or driven off at port of discharge.

Vessel - Vessel which has the ability to accommodate the loading and the discharging of the wheeled cargo by rolling onto and off the vessel.

Selection of Line Items - This includes the picking or selection of supply items from inventory at participating depots.

Spotting - The physical operation of moving a shipping container around from one area to another for the purposes of maintenance, unstuffing, stuffing, storage, coupling, and uncoupling.

Stuffing - The physical operation of loading the packaged general cargo (unitized or loose) into its shipping container.

Through Government Bill-of-Lading (TGBL) - See AR 55-20 for policy and responsibilities.

Ton - A unit of measurement or weight of the following various values: (Ref. Pg A1-8, DOD Reg 45.00.32-R)

Short (ST)	2000 pounds
Long (LT)	2240 pounds
Measurement (MT or MTON)	40 cubic feet
Metric (MET)	2204.6 pounds

Transportation Control and Movement Document (TCMD) - A multi-purpose document which is used as a basic movement and control document, terminal handling document (e.g., dock receipt), cargo manifest, or tracing document (Ref. Para 1-3d(1), DOD Reg 4500.32-R).

Transportation Control Number (TCN) - An alpha-numeric code number assigned to control MILSTRIP and NON-MILSTRIP shipments from origin to destination. Also, per page A1-8, DOD Reg 4500.32-R, "The 17-position number assigned to control a shipment/consolidated shipment unit within the Defense Transportation System" (Ref. Para 2c, AR 55-16).

Uncoupling - The physical operation of disconnecting the 8' X 8' X 40' chassis mounted container configuration so that there are now two 8' X 8' X 20' bogey mounted containers.

Unitization - The assembly into single loads of more than one package of one or more different line items of supply in such a manner that the loads can be moved in an unbroken state from source to a distribution point or user, as far forward in the supply system as practical.

Worldwide Costs and Capabilities Guide - DA Pam 55-5, a guide which includes cost factors to provide traffic management guidance to shippers for use in the procurement cycle and routing of export cargo.

2. EXPLANATION OF TERMS*

Alternative - An approach or program, among two or more, that is possible way of fulfilling an objective, mission or requirement.

Benefits -

a. Expected Annual Benefit - The dollar value (in constant dollar) of goods and services expected to result from a program or project for each of the years it is in operation.

b. Expected Annual Effects - An objective, non-monetary measure of a program effects expected for each of the years a program or project is in operation. When dollar value cannot be placed on the effects of comparable programs or projects, an objective measure of the effects may be available and useful to enable the comparison of alternative means of achieving specified objectives on the basis of their relative present value costs. These effects should be estimated for each year of the planning period and are not to be discounted.

Benefit-Cost Analysis - An analytical approach to solving problems of choice. It requires the definition of objectives, identification of alternative ways of achieving each objective, and the identification, for each objective, of that alternative which yields the required level of benefits at the lowest cost. This same analytical process is often referred to as cost-effectiveness analysis when the benefits or outputs of the alternatives cannot be quantified in terms of dollars. (In either form of analysis qualitative and quantitative factors, foreseeable secondary or side effects, and non-economic benefits are explicitly considered.)

Cost-Effective Alternative - That alternative which -

a. Maximizes benefits and outputs when costs for each alternative are equal (the most effective alternative); or

b. Minimizes costs when benefits and outputs are equal for each alternative (the most efficient alternative); or

c. Maximizes differential output per dollar difference when costs and benefits of all alternatives are unequal.

*Definitions are from AR 37-13, Ref 10.

Cost Effectiveness Analysis - (See Benefit Cost-Analysis.)

Defense Economic Analysis Council (DEAC) - Serves in an advisory capacity to the Assistant Secretary of Defense (Compotroller) on maters related to economic analysis and program evaluation. The Council is designed to encourage DOD-wide application of the concepts of economic analysis and program evaluation in the planning, programming, budgeting, and evaluation processes and to strengthen analytical capabilities throughout Department of Defense.

Discount Rate - The interest rate used to discount or calculate future costs and benefits so as to arrive at their present values. (See also Present Values.)

Discounting - A technique for converting various cash flows occurring over time to equivalent amounts at a common point in time, considering the time value of money, to facilitate a valid comparison.

Economic Analysis - A systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner. The determination of efficiency and effectiveness is implicit in the assessment of the cost effectiveness of alternative approaches and is accomplished by:

a. Systematically identifying the benefits and other outputs and costs associated with alternative programs, missions, and functions and/or of alternative ways for accomplishing a given program (usually referred to as projects and activities).

b. Highlighting the sensitivity of a decision to the values of the key variables and assumptions on which decisions are based including technical, operational, schedule and other performance considerations.

c. Evaluating alternative methods of financing investments, such as lease or buy; and

d. Using benefits and costs to compare the relative merits of alternatives as an aid in -

(1) Making trade-offs between alternatives;

(2) Recommending the cost-effective alternative; and

(3) In establishing or changing priorities.

Economic Life - The period of time over which the benefits to be gained from a project may reasonably be expected to accrue to the Department of Defense. (Although economic life is not necessarily the same as physical life or technological life, it is significantly affected by both the obsolescence of the investment itself and the purpose it is designed to achieve.) The conomic life of a project begins in the year in which it starts producing benefits. Thus, it is possible that investments may occur several years prior to the time the project starts producing benefits.

Effectiveness - The performance or output received from an approach or program. (See Output and Output Measures.)

Equipment - Machinery, furniture, vehicles, machines used or capable of use in the maufacture of supplies or in performance or services or for any administrative or general plant purposes.

Expected Annual Cost - The expected annual dollar value (in constant dollars) of resources, goods, and services required to establish and carry out a program or project.

Historical Cost - The cost of any objective based upon actual dollar or equivalent outlay ascertained after the fact. May use any one of a number of methods of cost determination.

Investment Costs - Costs associated with the acquisition of equipment, real property, non-recurring services, non-recurring operations and maintenance (start-up) costs, and other one time costs. Investment costs need not all occur in a single year.

Objectives - Goals or results that the decision maker wants to attain. It is the end product, or output, of a program.

Output - The products, functions, tasks, services, or capabilities an organization exists to rpdocue, accomplish, attain or maintain. The objectives justifying the existence of the organization and its consumption of resources. Classes of output information are defined as follows:

a. External Benefits - The results of products or services produced by an organization expressed in terms of benefits received by other organizations, for example, adequacy and quality of major items of equipment being repaired as received from maintenance units or tactical assistance resulting from effects of ordnance delivered.

b. Organizational Products - Relates to the description of what is being produced by an organization for external use or effect. For example, numbers of major items of equipment repaired or amount of ordnance delivered.

c. Evaluated Work Measures - Focuses on levels of activity in terms of reflecting efficiency and effectiveness through application of engineered, historical, or assumed standards, for example, earned manhours, years.

d. Levels of Activity - Relates to the number of manhours used or units of work performed, for example, number of overtime hours worked, number of square feet covered, number of personnel trained. (Reclassification of cost is not output measures, but sometimes permit to be inferred, for example, number of personnel assigned, number of activities managed, dollar value of activity managed.)

Output Measures - Useful descriptors of functions, tasks or missions performed by an organization, and of capabilities possessed.

Physical Life - The estimated number of years that a machine, piece of equipment or building can physically be used by the Department of Defense in accomplishing the function for which it was procured or constructed.

Present Values -

a. Present Value Benefit - Each year's expected yearly benefit multiplied by its discount factor and then summed over all years of the planning period.

b. Present Value Cost - Each year's expected yearly cost multiplied by its discount factor and then summed over all years of the planning period.

c. Present Value Net Benefit - The difference between present value benefit and present value cost.

Program Evaluation - Program evaluation is economic analysis of on-going actions to determine how best to improve an approved program or project based on actual performance. Program evaluation studies entail a comparison of actual performance with the approved program or project.

Real Property - Land and rights, therein, utility generation plants and distribution systems, building, structures, and improvements thereto.

Recurring Costs - Expenses for personnel, materiel consumed in used, operating, overhead, support services, and other items incurred on an annual basis.

Residual Value - The computed value of existing facilities, and other assets or facilities and other assets not in being, at any point in time.

Sunk Cost - A cost which is irrevocably committed to a project; such costs have no bearing on the results of comparative cost studies.

Technological Life - The estimated number of years before technology will make the existing or proposed equipment or facilities obsolete.

Terminal Value - The expected value of either existing facilities, and other assets or facilities and other assets not yet in being, at the end of their useful life.

Uniform Annual Cost - The amount of money which if budgeted in equal yearly installments would pay for the project. The total present value of these installments would be equal to the total present value computed from the estimated life-cycle costs.