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A COST TRADE-OFF ANALYSIS OF F-16 LINE REPLACEABLE UNIT (LRU) PACKAGING OPTIONS

THESIS

Paul F. Schikora
Captain, USAF

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Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

Paul F. Schikora, B.S.
Captain, USAF

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Preface

The purpose of this study was to develop and apply a life cycle cost model to alternative packaging options for various line replaceable units (LRUs) peculiar to the F-16C/D model aircraft. The model, as developed, can be applied to any other packaging decision for similar items.

As anticipated early in the study, data collection proved to be a most difficult task. A great deal of the data required for model application is based on forecasts over the next twenty years. For a study of this size, literally thousands of calculations are necessary, which must be repeated for all sensitivity analyses performed. It has become obvious that application of this model to any system of significant size requires the assistance of a computer.

While engaged in this study, I was fortunate to have the assistance of many experienced, knowledgeable people. I am particularly grateful to the people at the Air Force Packaging Evaluation Agency, specifically, Mr. Larry Wood, for their patience and time in making me a "packaging expert." Also, thanks to the people at the F-16 SPO, too numerous to mention, for educating me on the the F-16's LRUs. Thanks are also due to my brother Rick, for lending me the wisdom of his AFIT experience, and for his unwavering "personal motivation" - I couldn't have done it without him. Finally, I of course would like to thank my faculty advisor, Major (Lt Col select) Robert Trempe for his sage advice; "molte grazie" sir.

Paul F. Schikora

Table of Contents

List of Figures

List of Tables

AFIT/GLM/LSM/88S-64

Abstract

Packaging is a critical part of any electronic item's logistics support system. Different packaging options have varying characteristics, including price, weight, durability, shock protection, and ease of opening and closure. Each of these characteristics has a different impact on the packaged item's logistics life cycle costs (LCC). By analyzing the cost trade-offs between alternative packaging options, a least total cost option can be identified.

This study compares the LCC of different packaging options for four LRUs from the F-16C/D model aircraft. Two options for each LRU are examined: the current container, either a wooden crate or fiberboard box; and a proposed reusable molded plastic container. The objective was to see if the advantages of the plastic containers could result in sufficiently lower recurring LCC to offset their higher acquisition cost. There were five main stages in the study: LCC model development, data collection, model application and sensitivity analysis, comparison of results including qualitative factors, and packaging option selection. The model can be applied to similar packaging decisions.

The results show that the proposed container would have a higher total LCC for all four LRUs. Sensitivity analysis was performed and proved the results to be quite insensitive to changes in LRU mean time between failure (MTBF), the major variable factor in the model. Additionally, formulas for determining the model's LCC break-even point with respect to MTBF and LRU shipment rates were developed and presented.

The final recommendation of the study is to choose the proposed container for one of the LRUs, based on a small difference in LCC and the qualitative advantages of the proposed container. Recommendations for future research are presented.

A COST TRADE-OFF ANALYSIS OF F-16 LINE REPLACEABLE UNIT (LRU) PACKAGING OPTIONS

I. Introduction

General Issue

Packaging is a critical but often overlooked element of logistics support for any weapon system. Packaging is necessary to protect an item from damage due to rough handling in transport, environmental hazards, and extended storage periods. Packaging container designs are based both on the size of an item and the level of protection the item requires. Many types of containers (wooden crates, fiberboard boxes, molded plastic containers, etc.) can be designed to provide the necessary protection. The best packaging design for any item is one that meets the item's protective requirements at the least total cost over the lifetime of the item.

Specific Problem (F-16 SPO, undated:1)

Wooden crates are currently used to package twelve of the F-16C/D avionics system's line replaceable units (LRUs). Though the crates are less expensive than alternative modern containers (such as molded plastic or fiberglass), their heavier weight and shorter life span could lead to greater recurring costs over the lifetime of the LRUs. These higher recurring costs might make the life cycle cost (LCC) of using wooden containers higher than that of an alternative container. No effort has been made to identify and compare alternative packaging options to determine what would be the best (i.e. have the lowest LCC) container for the LRUs.

Research Objective/Investigative Questions

The goal of this research effort is to identify and examine alternative packaging options for the twelve LRUs, and to determine the best container for each LRU. To do so requires answering the following questions:

1. What are the packaging requirements of the LRUs? Consider the LRUs':
    a. Size and shape.
    b. Fragility.
    c. Special preservation requirements (humidity control, corrosion protection, etc.).
2. What alternative containers in the Air Force supply system would meet these requirements?
3. What is the total LCC of each packaging option for each LRU?
4. What are the qualitative factors that should be considered when choosing among alternative packaging options, and how do they impact LCC estimates?

Scope

This research will investigate only alternative containers that are currently in the Air Force supply system. Personnel at the Air Force Packaging Evaluation Activity

(AFPEA) indicate that their are sufficient existing containers to make this a reasonable restriction. Additionally, it is difficult to estimate the costs of developing a new container unless it is actually developed (Thompson et al., 1988).

As requested by the F-16 System Program Office (SPO), the sponsor of this research, only the following LRUs, peculiar to the F-16C/D model aircraft, will be studied (F-16 SPO, undated:1):

1. Dual Mode Transmitter (DMT)
2. Modular Low Power Radio Frequency (MLPRF)
3. Programmable Signal Processor (PSP)
4. Enhanced Fire Control Computer (EFCC)
5. Data Entry Display (DED)
6. Data Entry Electronic Unit (DEEU)
7. Advanced Central Interface Unit (ACIU)
8. Multiple Function Display (MFD)
9. Program Display Generator (PDG)
10. Wide Angle Conventional Heads Up Display, Display Unit (WAC HUD DU)
11. Wide Angle Conventional Heads Up Display, Electronics Unit (WAC HUD EU)
12. Radar Antenna

Summary

This chapter gave an introduction to this study, starting with a statement of the problem, followed by the general research objective and specific investigative questions. Finally, the scope of the research was stated. The following chapter will present background material relevant to this issue. Topics to be covered include a quick description of the F-16 avionics system, packaging in general, containers and factors in container selection, life cycle costing (LCC) as a decision tool, and finally, the application of LCC methods to packaging options.

II. Background

Introduction

This research project crosses several functional lines (F-16 maintenance, packaging, and life cycle costing). In order to acquaint the reader with these functional areas, this chapter presents a brief discussion of each. First, a cursory review of the F-16 avionics maintenance procedures is given. Next, packaging and containers are discussed in greater detail. Finally, life cycle costing in general, and specifically its application to packaging decisions, are reviewed.

F-16 Avionics Overview (F-16 SPO, undated:1)

The F-16 aircraft's avionics systems (radar, navigation, communications, etc.) are designed of interconnected LRUs (replaceable at base level) for ease of maintenance. When a malfunction occurs in an avionics system, the failure is traced to the defective LRU, which flightline maintenance personnel remove, and replace with an LRU known to be good. The defective LRU is then placed in the container that the good LRU came in, and is sent to the base level Avionics Intermediate Shop (AIS) if repair is authorized at base level. Otherwise, the LRU is sent to base supply for processing and shipment to the appropriate repair depot.

Packaging

Definition. Packaging serves several functions in any application, and means different things to different people. To Marketing in a commercial concern, packaging is a way to present a product in a such a way as to improve sales. To people in the distribution cycle, packaging is a means to protect the product during handling, storage, and transportation. To a retail consumer, packaging is often a means of storing a product while it is being used up (as in breakfast cereal or dishwashing detergent). Although these are accurate descriptions, they are limited in scope, reflecting a particular user's interface with the packaging (Anthony, 1985:719).

Perhaps packaging can best be defined as a system:

> The system concept of packaging explains it as, not merely the physical container, but an interrelated set of activity components consisting of:
>
> - Basic raw materials (i.e., wood, sand, ore and chemicals)
> - Converting operations that form packaging materials and containers
> - Production operations whereby the package is filled, closed, sealed, and quality checked
> - Unitizing [consolidation] or other preparations for distribution
> - Distribution through channels, involving storage, handling, and transportation
> - Emptying of packaging through product usage
> - Disposal, reuse, or recycling of the packaging
>
> [Anthony, 1985:719]

Functions of Packaging (Anthony, 1985:719-720). There are categorically four functions that packaging performs.

These are containment, protection, communication, and utility.

Containment. This refers to a package's ability to hold its contents. When a product spills or leaks from a containers, losses are incurred. The more valuable the contents, the more money should be put into a container design that eliminates leakage. For example, bird seed is usually shipped in a bag of some sort. Although the bags occasionally leak, the value of bird seed does not justify a more dependable container. On the other hand, hazardous materials must be shipped in containers designed and built to regulatory specifications. The nature of the product makes it necessary to invest in a more dependable container.

Protection. This refers to a package's ability to shield its contents from the hazards inherent in handling, shipping, and extended storage. As with containment, the more valuable a product is, the more money should be spent on a container that can provide better protection.

Communication. This refers to how well a package conveys the nature of its contents. This is the key function of packaging from a marketing standpoint. Communication includes advertising, product identification, consumer information, special handling requirements, shipping information, etc. Additionally, a container like a wire mesh box communicates simply by allowing the user to see the product.

Utility. This is the function that facilitates the interaction between a user and a product. This includes retail product features such as ease of opening/closing and handling aids. It also includes distribution features like interfaces with materials handling equipment (MHE) such as forklifts or storage racks.

Levels of Packaging. The level of packaging refers to the amount of packaging between the outer container and the product. There are three basic levels of packaging: primary, secondary and tertiary (Leonard, 1977:8).

The primary package is the one that actually holds the product, and nothing but the product. Examples are most anything found on the grocer's shelf such as cans of soup, bags of sugar, or packages of bacon.

A secondary package is one that holds a number of primary packages, usually of the same product, for ease of storing and distribution. This is usually thought of as the shipping container. A case of detergent boxes or motor oil is an example of secondary packaging.

Tertiary packaging involves combining multiple primary or secondary packages, of like or different products, onto a pallet or skid for handling as a unit load (also known as unitizing). Tertiary packaging also includes the method of securing the unit load to the pallet. An example would be multiple cases of paint, secured by metal strapping, on a wooden skid bound for a regional distribution center. Tertiary packaging makes it easier and quicker to move multiple items with the aid of MHE (Leonard, 1977:8-9).

The containers for the F-16 LRUs perform as both the primary package (they hold the LRUs) and as the secondary (shipping) package.

Containers (Zacharias, 1985:710-716)

"A container simply defined is `a thing in which material is held or carried (Zacharias, 1985:710).'" Despite this seemingly simple concept, containers are at the center of the packaging system. Everything throughout the packaging cycle, from initial packaging, through the distribution cycle, to the end user, revolves around the container. For many people, the terms "container" and "packaging" are synonymous, but that is not totally correct. Packaging encompasses more than the container. As discussed in the last section, packaging is a complete system, of which the container is an important part. This section will discuss the various categories and uses of containers, as well as the factors to be considered in container selection.

Categories and Uses. There are almost as many different containers as there are products. However, all containers can be classified in several ways.

Containers can be classified by the material of which they are made. Probably the most commonly known material is fiberboard. This material can further be broken down as cardboard, corrugated fiberboard, and multi-wall corrugated fiberboard. Containers are also made of wood, paper, glass, metal and various types of plastic. Each type of material has certain advantages in different applications. Corrugated fiberboard is relatively strong and inexpensive, making it the material of choice when it is suitable. However, some items are too heavy or are not well contained by fiberboard. Paper is inexpensive and flexible, making it appropriate for packaging of dry bulk materials (such as powders or grain). Glass is good for packaging liquids, and is impervious to most chemicals, but has a tendency to break. Wood and steel are very strong, but are heavy, and are easily affected by caustic material. Plastics, the most recently applied packaging material (Thompson et al., 1988), combine the advantages of several other packaging materials. Plastics are lightweight and very strong, making plastic containers easy to handle and long lasting. Additionally, plastics are impervious to most chemicals and are highly break resistant, making them a good choice for packaging hazardous materials. Plastics can be molded to most any shape, and do not deteriorate organically like wood and paper products can. Unfortunately, some plastics do not stand up well to heat or direct exposure to sunlight (Zacharias, 1985:710). Also, most plastic containers cost more than similar containers made of wood or fiberboard (Thompson et al., 1988).

Containers can also be classified by their reusability. Containers are either disposable or reusable. A disposable container is just that: it is disposed of after the product it contains is removed by the user, or the container material is recycled. Example of disposable containers include paper or plastic bags, beverage bottles and cans, and the basic cardboard box. A reusable container is one that is intended to be reused as a container after its product is removed by the end user. Reusable containers can further be classified as short-life or long-life. Short-life reusable containers are generally thought of as having a life of ten or less round-trip shipments from supplier to user. Short-life containers are usually made of some type of wood or corrugated fiberboard. Long-life reusable containers last significantly longer than other types of containers, often over 100 round trips. Containers in this category are usually made of metal or plastic (Thompson *et al.*, 1988).

Finally, containers can also be classified by their general shape, form, and the material they are intended to hold. There are boxes, crates, drums, bottles, bags, tubes, sacks, etc. Boxes and crates hold just about any dry product, bulky item, or primary package. Drums and bottles usually hold liquids or solid petroleum products. Bags and sacks usually hold dry bulk goods such as powder or grain. Additionally, containers are designed especially to hold hazardous materials, which can be a liquid, solid, or bulk goods.

Factors in Container Selection (Zacharias, 1985:710). There are many factors to consider when choosing a container for a particular application. The first factor to consider is the item to be packaged. The container must be properly designed to accept the item's size and shape. It must also be strong enough to hold the item's weight. An item's fragility will also help determine container selection. Steel pipe can stand up to more abuse in transit that sheets of glass can. If an item is sensitive to electric shock, its container must be static shock resistant. Finally, any special preservation requirements (humidity control, etc.) of the item must be considered.

The environment in which the container will be handled or stored will also be of concern in container selection. High humidity or exposure to moisture can rust steel and rot wooden or paper containers. Extreme temperatures are a factor, especially when considering plastic, wood or paper containers. Plastics can melt under high temperature, and with wood or paper there is the potential for fire.

Regulatory constraints are another factor, especially when handling food or hazardous materials. Food must be properly preserved and left uncontaminated. Hazardous materials must be properly contained for the good of the public in general, as well as the product handlers.

Ideally, after all the above factors have been considered, the weight of the container should be as low as possible. Lighter containers put less wear and tear on MHE as well as people. Also, lighter containers used for shipping and distribution will result in lower freight costs.

Life Cycle Costing (LCC)

There are many books dealing with the idea and process of LCC in great detail (e.g. Seldon, 1979; Blanchard, 1978). To do a complete discourse on LCC is beyond the scope of this research paper; indeed, several theses have been written on LCC alone (e.g. Cira and Jennings, 1981; Douville, 1983).This section is intended only as a basic introduction to the concept and functioning of LCC.

LCC is a cost estimating tool generally used in making decisions about buying equipment or capital resources. Initiated by the Department of Defense in the early 1960s (Seldon, 1979:2), LCC estimates the total cost of an item at the end of its lifetime, rather than just its purchase price. LCC analysis includes:

> ... all expenses for research and development, production, modification, transportation, introduction of the item into inventory, new facilities, operation, support, maintenance, disposal, and any other costs of ownership, less any salvage revenue at the end of its lifetime [Seldon, 1979:9]...

LCC does not include any costs that have already been incurred at the time of the LCC analysis (sunk costs) or invariant expenses, such as headquarters costs (Seldon, 1979:9).

There are many ways to group these costs into a simplified cost model, but one of the simplest is:

$$LCC = A + R - S \tag{1}$$

where:

"A" is acquisition costs. These include all research and development, production, and entry into inventory costs.

"R" is recurring costs. These are all costs incurred in the operation and support of the item throughout its life.

"S" is salvage value. This is what the item can be sold for at the end of its life.

Of course, LCC analysis may be used in evaluating alternatives involving the purchase of multiple items, in which case the figures in the model above would be summed for all the items.

Steps in LCC Analysis (Blanchard, 1986:369-399). There are six major steps in the LCC analysis process: definition of system requirements, cost breakdown (cost categories), cost estimating, cost model building, cost profile, and evaluation of alternatives.

Definition of System Requirements. In evaluating alternatives based on LCC, the analyst needs to project each alternative in terms of life cycle activities. In other words, one has to consider the expected future state of the system that each alternative will operate in. In packaging decisions, pertinent factors will be shipment rates of the item(s) packaged, environmental conditions, and the like.

Cost Breakdown. An LCC analyst must identify and group all costs incurred in an item's life cycle. There is no set rule for breaking down costs, so long as the method used can be tailored to the specific application.

Cost Estimating. Having identified and broken down all costs that need to be considered, the next step is estimating costs to be incurred in the acquisition and operation of an item. Cost estimates can be derived from known factors or rates, estimating relationships, and expert opinion.

When estimating costs, it is usually necessary to consider the time value of money through discounting future cash outlays and accounting for inflation.

Cost Model Building. The cost model is the analytic tool which combines the cost structures and estimates to generate LCC data in a timely manner. Today, computers are often used to build LCC models. Computer models compute costs quickly, and provide for easy sensitivity analysis of the LCC data.

Cost Profile. Once costs are determined for each year in the life cycle, and inflated to reflect real budgetary requirements, they can be profiled on a single chart to compare discounted LCC vs. inflated, undiscounted figures, which show actual budgetary requirements. Cost profiles can also be done to show the results of various sensitivity analyses.

Evaluation of Alternatives. Once the LCC for each alternative has been determined, they are compared to one another. The LCC is used as a tool in evaluating the alternatives, along with any qualitative factors that impact the decision. Finally, a preferred approach is selected based on predetermined decision criteria appropriate for the organization and project(s) being considered.

Present Value Factor Analysis. When considering future expenses in a decision making process, the analyst should take into consideration the time value of money (Seldon, 1979:122). The present value factor adjusts future expenditures into an equivalent dollar value in the present. The basis for PVF analysis is the concept that one would rather spend a dollar one year in the future than spend a dollar today. The reason for this is that the dollar could be invested elsewhere today and earn some rate of return for that year. This has the effect of lowering the value of a dollar in the future when compared to a dollar today.

The PVF accounts for the time value of money by discounting future expenditures so they can all be compared in current day dollars. The actual PVF is based on the discount rate selected. The discount rate is usually the rate of return that can be made on the best alternative investment of dollars now (such as the rate of interest on a savings account). The effect of discounting on LCC estimates is to make projects that defer expenditures more attractive than projects that require money sooner (Seldon, 1979:122-123). Of course, the effects of inflation on future prices will somewhat offset the discounting.

The application of discounting is easy, but the determination of an appropriate PVF is not (Blanchard, 1986:395). The proper PVF depends on the type of business enterprise and the potential return on its invested capital. The potential rate of return for government investments is particularly difficult to determine (Seldon, 1979:122).

LCC and Packaging

Past research (Arnestad & Emerson, 1976) and current expertise in the packaging field (Thompson, et. al., 1988;

Miller, 1986:1) show that an application of general LCC methods is best for determining the least-cost method of packaging for any particular application. If the item being packaged has yet to be fielded, the standard LCC methods can be applied to all packaging options (i.e. consider acquisition costs, recurring lifetime operation and support costs, and salvage value).

At this point, it is necessary to define the life cycle over which the packaging options will be evaluated. When a decision is made to go with a packaging option, that option is being selected for the life time of the system it supports. In the commercial world, packaging is selected for the expected marketing life cycle of the product it protects. For example, when selecting packaging for a new model of video cassette recorder (VCR), packaging will have to be provided for all of the VCRs expected to be produced in the future. Therefore, when evaluating packaging options, the analyst must consider each option's cost for all of the VCRs expected to be produced.

For this research effort, each option considered for a particular LRU must provide packaging for all of those LRUs in the Air Force system as long as they are around. Therefore, the life cycle used to determine packaging LCC is the life cycle of the LRU being packaged. In fact, in evaluating LRU packaging options, this research is actually comparing the packaging portion of the recurring cost segment of the LRUs' total LCC.

Summary

This chapter was intended to give the reader some background into the different functional areas being researched. The areas covered included the F-16 avionics system, packaging and containers, life cycle costing (LCC), and finally, the application of LCC techniques to packaging decisions.

The following chapter now introduces and explains the specific methods to be applied in this project. It begins by introducing the basic LCC model to be used, and its application to the different packaging options being considered. The bulk of the remainder of the chapter describes each of the LCC variables in detail, including how they are calculated, and how the data needed for calculations will be collected. Next, the specific steps to be accomplished in this project will be presented. Finally, significant anticipated problems will be discussed.

III. Methodology

Introduction

Before the basic LCC model shown in Eq (1) can be applied, it must be developed to fit the specific decision process. Additionally, the method to be followed in applying LCC analysis must be detailed. This chapter presents these steps. It begins by stating the specific LCC model that will be used in evaluating the LRU packaging options. Next, the model is broken out by variable, and described in detail. All of the variables are described, their calculations are specified, and the steps to collect the required data are discussed. Next, the specific steps to be followed in applying the LCC model are presented. The chapter ends with a brief discussion of anticipated problems.

Specific LCC Model

The LCC model to be used in evaluating LRU packaging options in this study is described by:

$$LCC = A + \left[\sum_{i=1}^{n} (R_i + T_i + L_i) \right] - S_n \qquad (2)$$

where:

A = acquisition costs

R_i = the container replacement cost in year "i"

T_i = the LRU transportation cost in year "i"

L_i = the packaging labor cost in year "i"

S_n = the packaging salvage value (in year "n")

n = the lifetime of the LRU under consideration

These costs have been identified as relevant to packaging selection decisions (Thompson, et.al., 1988; Miller, 1986:2; AFALD, 1983:1-3). It should be noted that there is no present value factor in Eq (2). When doing cost comparison studies, the F-16 SPO prefers figures to be computed in current day dollars. As such, present value factor analysis will not be a part of this study. This should be considered when evaluating the results of this study.

Variable Definitions

This section describes the variables in Eq (2) in detail. All data required to compute the variables are identified, and the general methods of collecting this data are described.

Acquisition costs (A). These are computed on the basis of one container for each spare LRU. Items installed on aircraft will not require a package, but any spares in the system will. These costs include all costs associated with acquisition (purchase price, costs of adding to the Air Force inventory, etc.). When detemining the LCC of the option to stay with a current container, acquisition costs will be based on the number of LRUs to be purchased in FY 1989 and beyond. Acquisition costs for proposed containers will consider all LRUs, either on hand or projected for purchase.

Container replacement cost in year "i" (R_i). This is defined by:

$$R_i = (SHIP_i/CLT) \times CCOST \tag{3}$$

where:

$SHIP_i$ is the expected number of LRU round trip shipments in year "i", defined as:

$$SHIP_i = NRTS_i \times (FLYHOURS_i/MTBF_i) \tag{4}$$

where:

$NRTS_i$ is the Not Reparable This Station percentage, the proportion of LRU failures that require shipment to depot for repair, in year "i". NRTS figures will be forecast from historical data.

$FLYHOURS_i$ is the projected number of F-16C/D type aircraft flying hours in year "i" (F-16 SPO forecast).

$MTBF_i$ is the projected LRU mean time between failure in year "i" and will be projected from past data.

CLT is the container life time, the average number of round trips the type of container being considered will last before it needs replacement. Figures are available from past research, and remain constant over time.

CCOST is the cost of one of the containers being considered.

LRU shipment transportation costs in year "i" (T_i). Transportation costs for shipments between a base and repair depot will be considered. Although there will be LRU shipments between operational bases, such shipments can not be accurately projected, and their exact costs therefore cannot be estimated. Transportation costs in year "i" are computed by:

$$T_i = \sum_{j=1}^{m} (SRATE_j \times WEIGHT \times SHIP_{i,j}) \qquad (5)$$

where:

$SRATE_j$ is the transportation shipping cost (rate, i.e. dollars per pound per round-trip) between base "j" and the LRU's repair depot. A baseline figure will be established from current shipping rates.

WEIGHT is the weight in pounds of the LRU plus the container under consideration.

$SHIP_{i,j}$ is the expected number of LRU round trip shipments in year "i" from base "j". Computed the same way as $SHIP_i$ in Eq (4), but broken out by base (by breaking out $FLYHOURS_i$ by base).

"m" is the number of bases being studied.

<u>Packaging labor costs in year "i"</u> (L_i). This is the cost attributed to packing and unpacking the LRU each year. Each shipment requires two pack/unpack operations; one at origin and one at the repair depot. More cumbersome packaging methods will result in longer time and higher cost to package an item. Labor costs are computed by:

$$L_i = 2(PUT \times SHIP_i \times MANCOST_i) \qquad (6)$$

where:

PUT is the average pack/unpack time (hours) for the container under consideration, determined from past research.

$SHIP_i$ is as described in Eq (4) above.

MANCOST is the appropriate labor cost rate, in dollars per manhour, based on current contractor manpower cost figures.

Salvage Value (S_n). This is the residual value of any containers left over after the life time of the LRUs (in year "n"). If they can be sold or have useful life remaining, their salvage value must be subtracted from total costs.

Specific Research Steps

The following steps are required to determine the LCC of different packaging options for each LRU:

1. Determine the LRU's minimum packaging requirements. Factors to be considered include:

   - Fragility of the LRU
   - *Size and weight of* the LRU
   - Preservation requirements for the LRU

This information can be gathered from the F-16 SPO engineering office, or the contractor that makes the LRU.

2. Identify alternative containers within the Air Force supply system that meet minimum packaging requirements for the LRU. The AFPEA has records of all such containers.

3. Collect the necessary data (MTBF, NRTS, flying hours, container lives, etc.) and compute all the cost elements identified in Eqs (2) through (6) for each LRU.

4. Apply the appropriate LCC model to each packaging alternative for the LRU.

5. Perform any appropriate sensitivity analysis on cost driving factors. For example, MTBF, NRTS, and

FLYHOURS all affect the number of LRU failures and in turn, LRU shipments. By varying these factors, it can be seen what effect their variability has on packaging option costs.

6. Compare the LCC for all the packaging options.

7. Repeat the first five steps for each LRU.

Once the LCC of all packaging options have been computed and compared, any qualitative factors will be addressed.

Finally, once all the quantitative and qualitative differences between the packaging options have been addressed, a "best" packaging option can be identified for each LRU. Normally, the option with the lowest LCC will be selected. However, if qualitative differences are significant and/or LCC differences are minimal, a container other than the lowest cost container may be selected based on the qualitative factors.

Anticipated Problems

The major problem will be data collection. LRU failure rates, flying hours, and projected F-16C/D force strength are known, but must be manually extracted from existing USAF Maintenance Data Collection (MDC) records and Air Staff aircraft programming documents. Acquisition data on alternative reusable containers is also available, but only in a vast data bank of such information.

Summary

This chapter presented the specific methodology to be used in this research project. First, the specific LCC model to be used was presented, followed by a detailed discussion of the variables in the model. Next, the research steps to be followed in this project were specified. Finally, anticipated significant problems were addressed. The next chapter goes into detailed specifics on the methods actually used for data collection and forecasting.

IV. Data Collection

Application of the LCC model developed in the last chapter requires the collection of a great deal of data, and in some cases, making forecasts of future trends for the data. This chapter explains the data collection and forecasting methods used, in order to support the validity of the results of the data analysis.

LRU Reliability and Maintainability Data

Reliability and Maintainability (R&M) data on all of the F-16's systems is collected and stored in a central data base known as the F-16 Centralized Data System (CDS) (Bachman, 1988). Access to the F-16 CDS is available at all F-16 operational units, the F-16 SPO, intermediate maintenance organizations (such as Air Force Air Logistics Centers), and F-16 system contractors (Dynamics Research, 1987:3).

MTBF Figures.

MTBF data on the LRUs is available within the F-16 CDS on a monthly and cumulative basis. This data for the time period of January 1985 through May 1988, inclusive, has been extracted and is presented in Tables 13 through 18 in Appendix A. The MTBF is derived by simply dividing the flying hours by the number of failures.

Future Forecasts.

As can be seen from the MTBF tables, monthly MTBF figures have not been very constant. There are several ways to forecast future MTBF figures using the data presented. In order to determine an acceptable method, a review of a typical LRU's life cycle reliability curve becomes necessary.

Figure 1 shows a typical time versus failure rate curve. During the early stages of an electronic system's life, the system experiences an excessively high failure rate. This is attributed to many built in flaws which cause the system to break often (Arsenault and Roberts, 1980:106). As these flaws are discovered and corrected, the failure rate decreases and eventually levels off (Blanchard, 1986:26). This period is referred to as "infant mortality (Arsenault and Roberts, 1980:106)" or the burn-in period (Patton, 1979:8-5). After the burn-in period, the failure rate remains relatively stable for a long period of time, referred to as the useful operating life of the system. Finally, at the end of the system's useful operating life, the age of the system results in increasingly higher failure rates in what is known as the wearout period.

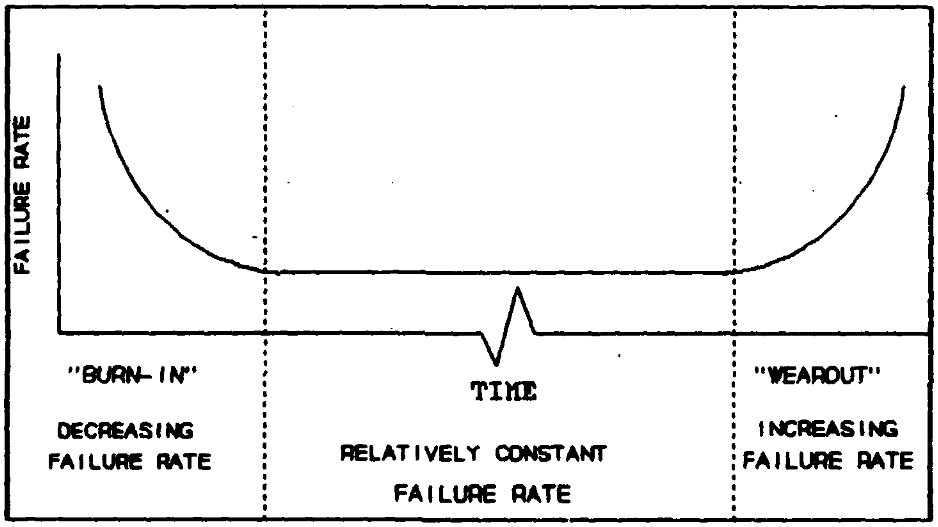


Figure 1. Typical LRU life cycle failure rate curve (Patton, 1979:8-5)

A curve similar to Figure 1 can be applied to the MTBF figures. The failure rate is simply the inverse of MTBF (Blanchard, 1986:26), so a typical LRU's life cycle MTBF curve would look like Figure 2.

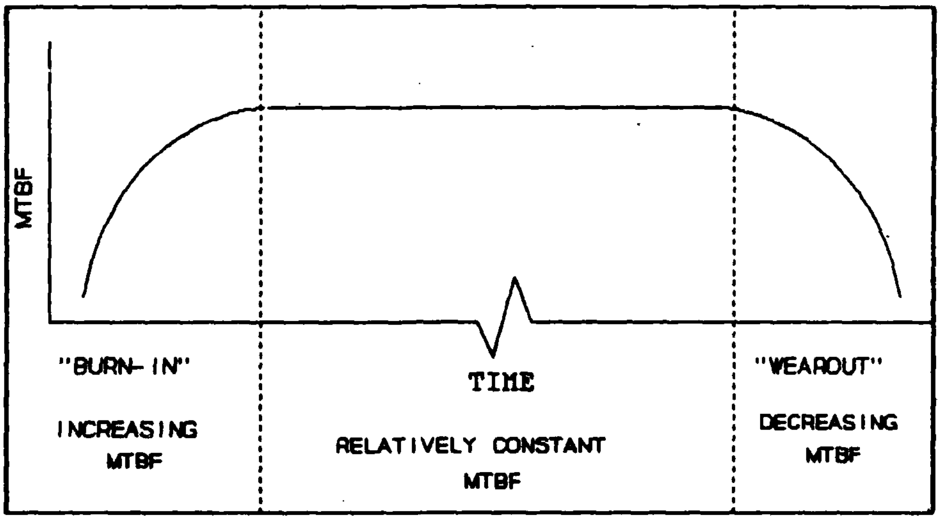


Figure 2. Typical LRU life cycle MTBF curve

Assuming that an LRU has reached the useful operating life phase of its life cycle, where MTBF is constant, the mean of the most recent year's MTBF figures would provide an acceptably accurate forecast for the remainder of the system's useful life. According to the F-16 SPO, this is a reasonable assumption, and they would like the total MTBF figure for the most recent twelve month period to be used in the LCC analysis (Murphy, 1988). This means that MTBF will be projected as constant for all years. These figures are given in Table 1.

However, the assumption that the last twelve months of data is a good predictor of future rates requires further investigation, as the accuracy of future forecasts directly

Table 1. LRU MTBF Figures

LRU	MTBF
WAC HUD DU	244.91
MLPRF	130.07
DEEU	272.06
ACIU	55.24
Radar Ant.	432.58
DMT	111.68

impacts the importance of sensitivity analyses done in conjunction with the LCC analysis. After less than four full years in the field, it is possible that a system may not have reached the useful operating life phase of its life cycle. If so, it can be expected from Figure 2 that the system's actual MTBF in the future will be higher than the last twelve months of data would indicate.

In order to determine whether or not the assumption is reasonable, two curves were plotted for each LRU (Figures 7 through 12, Appendix A). First, a time series of the monthly MTBF figures was plotted. Looking at this curve gives a general idea of where the data is headed, and if it has tended to level off. Over this curve was plotted a best fit logarithmic curve of the form:

$$Y = A \times \log(B \times T) \qquad (7)$$

where A and B are curve fitting parameters, T is time, and log is the common logarithmic function. This type of curve was selected because it generally has the same characteristics as the first two phases in Figure 2: increasing at a decreasing rate and eventually leveling out.

If the LRU has reached its operationally useful life, the plot of the MTBF data will appear to be levelling out. As well, the best fit logarithmic curve will be shaped much like the first two phases of the curve in Figure 2. If the LRU has yet to reach its useful operating life, the MTBF plot will be expected to show a general increase over the last twelve months. Also, the MTBF data will be expected to fall above the logarithmic curve plot for the last twelve months of data.

There are more intricate mathematical methods to analyze the fit of the MTBF data to a life cycle curve. Also, there are advanced forecasting methods available to predict future MTBF rates if it is determined that the last twelve months of data are not a very good predictor of future rates. However, since the F-16 SPO wants the LCC analysis based on the last twelve months of data, use of these advanced methods are considered beyond the scope of this research, but could be considered for future research. When it appears that the last twelve months of MTBF data for an LRU are not an accurate predictor of future rates, that discrepancy will be noted, and considered in the sensitivity analysis for that LRU.

<u>NRTS Figures</u>. NRTS figures for an LRU are available in the F-16 CDS for any continuous time period. The figures are broken out by base. During the initial phase in of an electronic system, NRTS rates tend to be high, but drop to a constant figure very quickly (Schikora, 1988). As such, the

average NRTS data for the previous 24 months will be used for all future forecasts, making NRTS a constant through all years. The NRTS figures for the five bases currently operational with the F-16C/D model are combined, and averaged for a future forecast. Detailed NRTS data is shown in Appendix B. Total figures are summarized in Table 2.

Table 2. LRU NRTS Data Summary

LRU	Failures	NRTS	Percent
WAC HUD DU	769	122	15.86%
MLPRF	1605	113	7.04%
DEEU	928	72	7.76%
ACIU	2926	5	0.17%
Radar Ant.	453	116	25.61%
DMT	1915	667	34.83%

Flying Hours

Flying hour projections were not gathered directly; such direct estimates are not available. Rather, to estimate future flying hours at a particular base for a particular year, the projected number of F-16C/D aircraft at that base in that year will be multiplied times an estimated annual utilization rate (number of flying hours per aircraft per year).

F-16C/D Force Strengths. The projected F-16C/D force strengths were collected for all applicable bases through the year 2007. This data is shown in Appendix C. Current force strengths are unclassified and are listed by the bases' actual names. Future force strengths and locations are classified when revealed together (Murphy, 1988); therefore, future

F-16C/D bases are listed by code numbers 1 through 29. This data was collected from the Worldwide F-16 Beddown Plan.

Utilization Rate. The annual utilization rate used in computing flying hours is estimated at 240 flying hours per aircraft for all years. This estimate is based on past years' data and current outlook for future funding (Murphy, 1988).

Container Data

Container costs, shipping weights, and packaging labor costs are shown in Appendix D.

Current Containers. Specifications and drawings of the current LRU containers were obtained from the Packaging Management Division at Ogden ALC (Pierce, 1988). Six of the twelve LRUs under consideration are currently packaged in durable standardized reusable fiberboard containers known as FastPacks (Goble, undated:1). These FastPacks are lightweight and Air Force stock items. Since an initial premise of this study was that specialized heavy containers were currently being used, those LRUs that are packaged in FastPacks will no longer be considered. Those LRUs are:

(1) Programmable Signal Processor (PSP)
(2) Enhanced Fire Control Computer (EFFC)
(3) Data Entry Display (DED)
(4) Multiple Function Display (MFD)
(5) Program Display Generator (PDG)
(6) Wide Angle Conventional Heads Up Display, Electronics Unit (WAC HUD EU)

Specialized packaging instructions (SPI) and drawings for the following LRUs still under consideration at this point are shown in Appendix E.

(1) Modular Low Power Radio Frequency (MLPRF)
(2) Data Entry Electronics Unit (DEEU)
(3) Advanced Central Interface Unit (ACIU)
(4) Dual Mode Transmitter (DMT)
(5) Radar Antenna
(6) Wide Angle Conventional Heads Up Display, Display Unit (WAC HUD DU)

Shipping weights were taken from the SPIs. Container costs and packaging labor costs were provided by the appropriate contractors (Malley, 1988; Smith, 1988). Labor costs were estimated at $12.50 per man-hour (Malley, 1988). The life time for these containers is estimated at ten round trip shipments apiece (Wood, 1988; Malley, 1988).

Proposed Containers. One type of reusable molded plastic containers was selected for use as proposed containers. This type of container has a single piece top which secures to the base with attached metal latches. Within the base is a floating metal platform suspended at four corners by rubber shock mounts. Attached to the floating platform are four straps attached to moveable tiedown lugs (a drawing of a representative container is in Appendix E). The adjustable straps secure the packaged item to the platform, and allow the container to hold items of varying dimensions.

This type of container was selected for its many advantageous features. The containers are weatherproof, and as such may be stored outdoors if necessary. When properly closed, the containers provide a water- and vapor-proof seal, eliminating the requirement to wrap and seal a moisture sensitive item before packaging. This type of container provides the maximum shock protection available in a commercial container (Wood, 1988), making it acceptable for the most fragile of items. They also have handles, which allow them to be carried by two people if a forklift is not available. The containers come in four sizes, and their specifications and prices are shown in Appendix E. These containers have an estimated life of 100 round trips apiece (Wood, 1988).

Of the six LRUs remaining under consideration, the Radar Antenna and the WAC HUD DU cannot be packaged in any of the reusable molded plastic containers under consideration. The antenna has a pyramid like base, and would not tie down securely to the floating platform. Also, the antenna exceeds the maximum height for any of the containers. The WAC HUD DU is too long to fit in any of the containers. As such, these LRUs will no longer be considered, though some data was collected for them, and is shown in the various appendices for future reference. Also, some tables in the appendices were designed on a spreadsheet program before the Antenna and the WAC HUD DU were eliminated from consideration, so blank areas exist in some tables.

The DMT is within the size limits for container 4 (as numbered on the specification sheet in Appendix E), but exceeds the weight limit (118 pounds vs. a maximum of 91 pounds). Noting that container 3 is identical to container 2, except for a heavier platform suspension, it is reasonable to assume that container 4 could be altered with a heavier suspension system so that it can carry the DMT. Also, since container 3 costs less than container 2, despite having a heavier capacity, it is reasonable to assume that an altered container 4 could be procured from the manufacturer at the same price as the current container 4 (Wood, 1988). As such, the remainder of this analysis will use the specifications for container 4 as the proposed container for the DMT.

Shipping weights for the proposed containers were obtained simply by adding the weight of the LRU to the empty weight of the selected containers. Proposed container costs were given on their specification sheet (Appendix E). Packaging labor costs for the proposed containers were based on man-hour estimates from the Air Force Packaging Evaluation Agency (AFPEA) (Wood, 1988), times $12.50 per man-hour. Table 3 shows the containers selected for each LRU.

Table 3. Proposed Containers

LRU	Container
MLPRF	4
DEEU	3
ACIU	3
DMT	4

Shipping Costs

To determine the shipping costs between each base, the contractors, and Ogden ALC, it was necessary to consult three sources. The rate for any overseas to CONUS movement is based on the government rate for MAC airlift between appropriate aerial ports (Department of the Air Force, 1987:1-40). Within CONUS shipment costs to commercial contractors are based on a representative routine commercial air freight service's government rates (American Airlines, 1988:1-4). Within CONUS shipment costs to Ogden ALC are based on the LOGAIR government tariff for shipments from those bases with LOGAIR service (HQ AFLC, 1987:4); otherwise, those figures are based on commercial air rates. These transportation costs are shown in Appendix F.

Repairs on the DEEU and ACIU will be performed at General Dynamics in Ft. Worth TX through 1990, and at Ogden ALC starting in 1991. Repairs on the MLPRF and the DMT will be performed at Westinghouse Electric Corporation in Hunt Valley MD through 1992, and at Ogden ALC starting in 1993 (Moyer et.al., 1988).

Spares Levels

Information on the number of current and projected LRU spares in the Air Force inventory was obtained from the LRUs' item managers (Moyer et.al., 1988). Total numbers of LRUs purchased through fiscal year (FY) 1988 (current), and projected purchases from FY 1989-on are shown in Table 4.

Table 4. LRU Spares Levels

LRU	CURRENT	FY 1989 - on
MLPRF	347	52
DEEU	161	10
ACIU	183	45
DMT	890	93

Summary

This chapter presented details on how necessary data was collected or estimated. The following chapter explains how that data was analyzed, as well as the results and findings of that analysis.

V. Data Analysis and Findings

Introduction

Now that all required data has been collected, the LCC model developed in Chapter 3 must be applied to each of the four LRUs under consideration. This chapter details the results of the LCC model application. It begins with a presentation of intermediate computations in the LCC model application. Next, the results of the LCC model application are presented. Finally, sensitivity analysis is performed on the LCC model results with respect to varying MTBF figures.

Intermediate Computations

To aid in the literally thousands of computations necessary to apply the LCC model to four LRUs over a twenty year span, a spreadsheet was developed using Boeing Calc (copyright, The Boeing Company), a three-dimensional spreadsheet program, which has the capability for multiple sheets as well as the rows and columns common to most spreadsheet programs (Boeing Company, 1987:iii). Many of the tables in the appendices are direct output of the spreadsheet. To make computational formulas for the final LCC more manageable, several intermediate calculations were performed, and their results are presented here for future reference.

Acquisition Costs. Costs for the current container option for each LRU were computed by multiplying the number of LRUs planned for purchase from FY 1989-on (Table 4) by the cost of the container (Table 20, Appendix D). Costs for the proposed container options were computed by multiplying the cost of each container by the sum of the current and future LRU spares levels from Table 4.

LRU Shipments and Shipping Costs. The expected number of LRU round trip shipments by base, per year, was computed using Eq (4), and is presented in Appendix G (this data is also presented for the Antenna and the WAC HUD DU). This data was then condensed to projected total life cycle shipments for each LRU (through twenty years) by base, and is shown in Appendix H (also including the Antenna and WAC HUD DU). Finally, LRU transportation costs were calculated for the twenty year life cycle as follows. For each LRU/packaging option, the projected total number of shipments by base (Appendix H) was multiplied by the round-trip transportation cost per pound for that base (Appendix F), and the weight of the LRU and container (Table 19, Appendix D), giving the projected life cycle shipping costs by LRU, base, and container option (Appendix I).

It should be noted that such direct life cycle cost computation would not be possible if present value factors were being considered. In such a case, each year's shipping costs would have to be computed, multiplied by the appropriate present value factor, and then summed.

Replacement Costs. Replacement costs were also computed for the twenty year life cycle directly. The projected total number of shipments for each LRU (Appendix H) was divided by the appropriate container lifetime (10 round trips for the current containers, 100 for the proposed containers) giving the expected number of container replacements. This figure was then multiplied by the appropriate container cost (Table 20, Appendix D) to give the total life cycle replacement cost for each container.

Labor Costs. As with the other recurring costs, labor costs were computed for the entire life cycle directly. The total number of projected shipments for each LRU (Appendix H) was multiplied by twice the appropriate pack/unpack labor (Table 21, Appendix D).

Salvage Costs. Since the current containers are designed specifically for the item it carries, they have no other use. Once the LRU it carries is eliminated from inventory, the container will be virtually useless. Therefore, salvage value for the current containers will be assumed to be zero. The proposed containers, however, can be used for a number of items. When the LRUs are eliminated from inventory, those containers in useable shape can be returned to the general inventory and used for some other item. It is expected that at the end of the LRUs' life cycle (20 years) each container, on the average, will have half its useful life remaining. Actually, some will be brand new, and some will ready for scrap; however, for this study, the salvage value for the proposed containers will be computed as half the acquisition cost.

LCC Model Results

This section will present the results of the LCC model application. Results will be presented by LRU and container option, breaking the LCC out into the different cost components in Eq (2): acquisition, container replacement, transportation, and packaging labor costs, and salvage value.

Modular Low Power Radio Frequency (MLPRF). The LCC figures for the MLPRF are shown in Table 5. Switching to the proposed container would result in additional life cycle costs of $36,233 as opposed to staying with the current container, an increase of 2.47%.

Table 5. Life Cycle Cost Comparison for the MLPRF, in Dollars

COST CATEGORY	CURRENT CONTAINER	PROPOSED CONTAINER
ACQUISITION	7,176	313,714
RECURRING		
SHIPPING	1,243,169	1,254,368
REPLACEMENT	39,600	22,562
LABOR	179,349	71,740
SALVAGE	--	(156,857)
TOTAL	1,469,294	1,505,527

Data Entry Electronics Unit (DEEU). The LCC figures for the DEEU are shown in Table 6. Switching to the proposed container would result in additional life cycle costs of $248,314, an increase of 110%.

Table 6. Life Cycle Cost Comparison
for the DEEU, in Dollars

COST CATEGORY	CURRENT CONTAINER	PROPOSED CONTAINER
ACQUISITION	330	111,022
RECURRING		
SHIPPING	181,987	389,197
REPLACEMENT	4,994	9,816
LABOR	37,798	18,899
SALVAGE	--	(55,511)
TOTAL	225,109	473,423

<u>Advanced Central Interface Unit (ACIU)</u>. The LCC figures for the ACIU are shown in Table 7. Switching to the proposed container would result in additional life cycle costs of $87,118, an increase of 205%.

Table 7. Life Cycle Cost Comparison
for the ACIU, in Dollars

COST CATEGORY	CURRENT CONTAINER	PROPOSED CONTAINER
ACQUISITION	2,567	148,029
RECURRING		
SHIPPING	34,863	52,455
REPLACEMENT	936	1,065
LABOR	4,100	2,050
SALVAGE	--	(74,015)
TOTAL	42,466	129,584

<u>Dual Mode Transmitter (DMT)</u>. The LCC figures for the DMT are shown in Table 8. Switching to the proposed container

would result in additional life cycle costs of $937,304, an increase of 11.27%.

Table 8. Life Cycle Cost Comparison
for the DMT, in Dollars

COST CATEGORY	CURRENT CONTAINER	PROPOSED CONTAINER
ACQUISITION	19,623	778,388
RECURRING		
SHIPPING	6,711,591	8,324,954
REPLACEMENT	348,888	130,060
LABOR	1,240,123	413,374
SALVAGE	--	(389,194)
TOTAL	8,320,225	9,257,529

Sensitivity Analysis

Acquisition costs are known and not subject to change. The salvage value of 50% the original value for the proposed containers is taken as given, and in reality, should not change much at all. As such, acquisition cost and salvage value will not be subject to sensitivity analysis. What is left are the recurring costs.

Much of the data that went into computing the recurring costs are known, including transportation cost rates, F-16C/D fleet strengths, container costs, labor costs, and shipping weights. However, three elements used to compute recurring costs were projected from past data: LRU Mean Time Between Failure (MTBF), LRU Not Reparable This Station (NRTS) rates, and aircraft utilization rates.

The NRTS projections are expected to be fairly close due to the nature of NRTS rates over time (Schikora, 1988). Similarly, the aircraft utilization rate has remained stable over time for the F-16, and is not expected to change (Murphy, 1988). Therefore, sensitivity analysis on these factors does not appear to be warranted. On the other hand, MTBF data is rather dynamic in the short run, and subject to long term change as shown in Figure 2. Since it is unknown at present whether or not the various LRUs are in the "useful operating life" portion of their life cycles, it is quite possible that MTBF projections based on the last twelve months data will not be accurate. Therefore, sensitivity analysis was performed on the LCC model results based on changes in projected MTBF. Figures used in the sensitivity analysis ranged from 70% of projected MTBF to 140% of projected MTBF in order to sufficiently demonstrate the model's sensitivity to MTBF. Results of the analysis will be presented in both graphical and tabular form.

Also, for each LRU, a break-even point will be computed, giving the MTBF rate at which the total LCC cost for each packaging option would be the same, given all other factors remain the same. The break-even point turns out to be rather easy to compute. MTBF only affects the number of shipments from a base as in Eq (4):

$$\mathrm{SHIP}_i = \mathrm{NRTS}_i \times (\mathrm{FLYHOURS}_i \div \mathrm{MTBF}_i) \qquad (4)$$

Referring to Eq (4), if MTBF is multiplied by a factor, "a", then SHIP is multiplied by a factor of "1/a". From that, referring to Eqs (3), (5), and (6), it can be seen that all recurring costs will also be multiplied by a factor of "1/a". Non-recurring costs are unaffected. Therefore, to find the break-even point, that is, where total costs for each option are equal, you need to find "a" such that:

$$(RC_c/a) + NRC_c = (RC_p/a) + NRC_p \tag{8}$$

where RC is the projected recurring costs for the current (RC_c) and proposed containers (RC_p), NRC is the projected non-recurring costs for the current (NRC_c) and proposed (NRC_p) containers, and "a" is the percentage of projected MTBF where the break-even point occurs. Grouping like terms and simplifying produces:

$$(RC_c - RC_p)/a = NRC_p - NRC_c \tag{9}$$

Eq (9) furthers simplifies to:

$$(RC_c - RC_p)/(NRC_p - NRC_c) = a \tag{10}$$

Once "a" is found, multiplying it by the projected MTBF gives the break-even point with respect to MTBF. If "a" is negative, there is no break-even point; the LCC curves will never meet. It should be noted that this type of break-even point analysis is made possible because all recurring costs were computed for the entire life cycle directly. If present value factor analysis was part of this study, the break-even point could not be computed this way.

MLPRF Sensitivity Analysis. The results are shown in Table 9 and Figure 3. The graph in Figure 3 shows that the LCC curves for the two packaging options slowly approach each other as MTBF decreases. The break-even point is a MTBF of 75.8% of the projected MTBF, or 98.59 hours. Thus, if the actual MTBF for the MLPRF were to average 98.59 hours for the next twenty years, the cost of both packaging options would be equal.

DEEU Sensitivity Analysis. These results are shown in Table 10 and Figure 4. The two LCC curves approach each other as MTBF increases. This is due to the large weight difference between the two containers: fewer shipments will bring the difference in transportation costs between the two containers closer together. However, there is no break-even point;the cost of the proposed container will always exceed the cost of the current container, regardless of MTBF.

ACIU Sensitivity Analysis. The ACIU results are shown in Table 11 and Figure 5. As with the DEEU, the two LCC curves slowly approach each other as MTBF increases. Again, however, there is no break-even point where the proposed container will have an LCC equal to the current container.

DMT Sensitivity Analysis. These results are in Table 12 and Figure 6. Again, the two LCC curves slowly approach each other as MTBF increases, but they never cross. As with the previous two LRUs, there is no break-even point.

Table 9. Relationship of Container LCC to MTBF for MLPRF

MTBF	PERCENT OF PROJECTED MTBF	--- LCC (Dollars) ---	
		CURRENT	PROPOSED
91.05	70.00%	2,095,920	2,083,528
104.06	80.00%	1,834,826	1,842,694
110.56	85.00%	1,727,316	1,743,528
117.06	90.00%	1,631,753	1,655,379
123.57	95.00%	1,546,248	1,576,510
130.07	100.00%	1,469,294	1,505,527
136.57	105.00%	1,399,669	1,441,305
143.08	110.00%	1,336,373	1,382,921
149.58	115.00%	1,278,582	1,329,614
156.08	120.00%	1,225,606	1,280,749
169.09	130.00%	1,131,880	1,194,295
182.10	140.00%	1,051,543	1,120,193

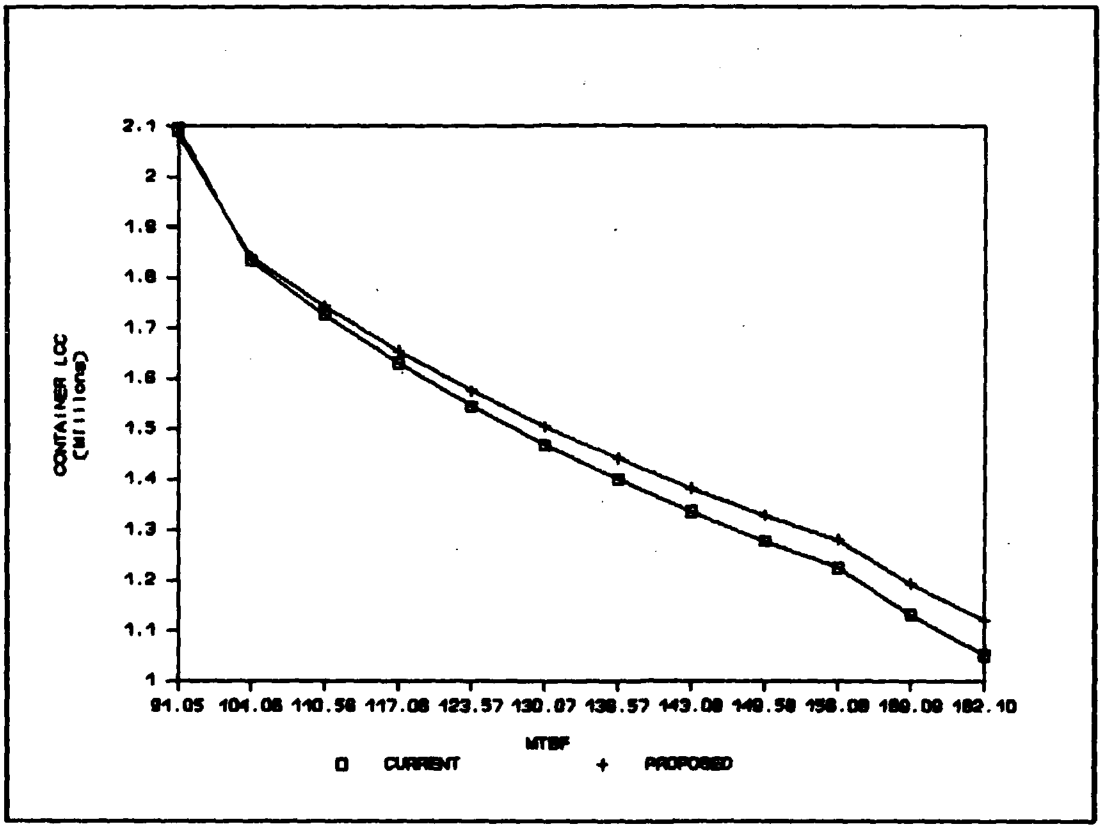


Figure 3. LCC (dollars) vs. MTBF (hours) for the MLPRF

Table 10. Relationship of Container LCC to MTBF for DEEU

MTBF	PERCENT OF PROJECTED MTBF	--- LCC (Dollars) --- CURRENT	PROPOSED
190.44	70.00%	321,443	652,528
217.65	80.00%	281,304	577,901
231.25	85.00%	264,776	547,172
244.85	90.00%	250,084	519,858
258.46	95.00%	236,939	495,418
272.06	100.00%	225,109	473,423
285.66	105.00%	214,405	453,522
299.27	110.00%	204,675	435,431
312.87	115.00%	195,790	418,913
326.47	120.00%	187,646	403,771
353.68	130.00%	173,237	376,982
380.88	140.00%	160,886	354,020

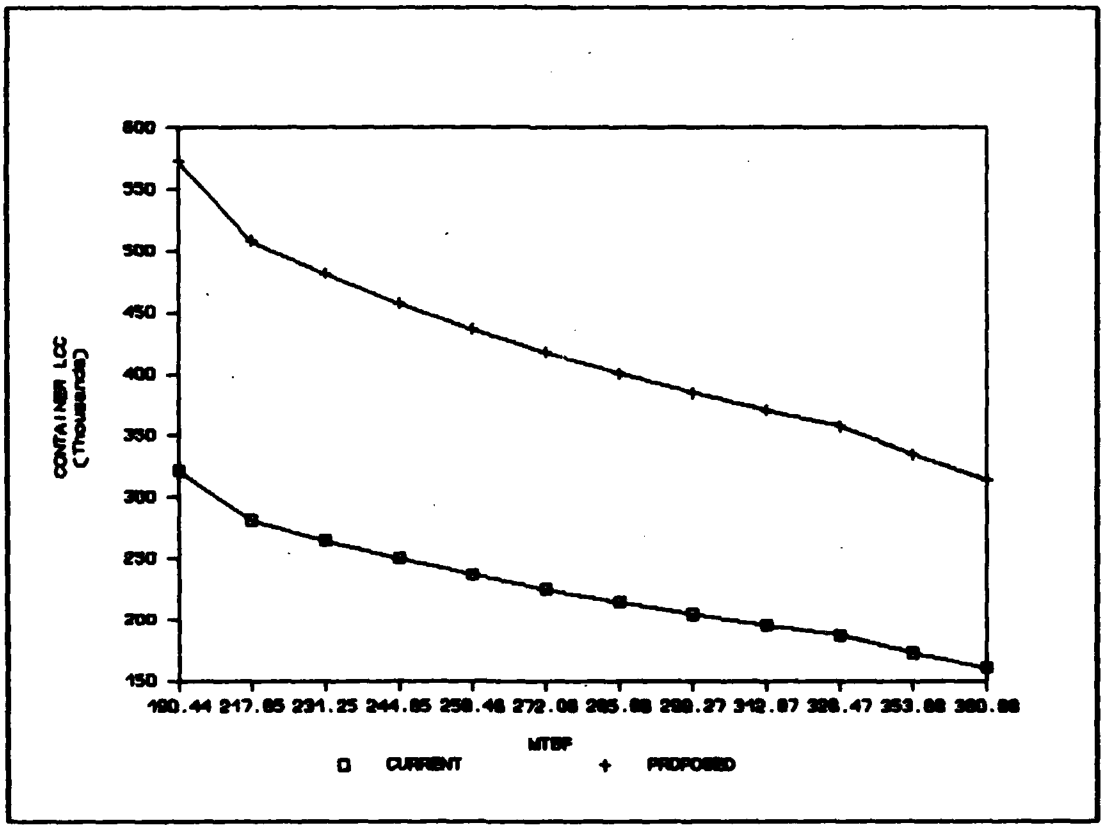


Figure 4. LCC (dollars) vs. MTBF (hours) for the DEEU

Table 11. Relationship of Container LCC to MTBF for ACIU

MTBF	PERCENT OF PROJECTED MTBF	--- LCC (Dollars) --- CURRENT	PROPOSED
38.67	70.00%	59,566	153,399
44.19	80.00%	52,441	143,476
46.95	85.00%	49,507	139,390
49.72	90.00%	46,899	135,758
52.48	95.00%	44,566	132,509
55.24	100.00%	42,466	129,584
58.00	105.00%	40,566	126,938
60.76	110.00%	38,839	124,532
63.53	115.00%	37,262	122,336
66.29	120.00%	35,816	120,323
71.81	130.00%	33,259	116,760
77.34	140.00%	31,066	113,707

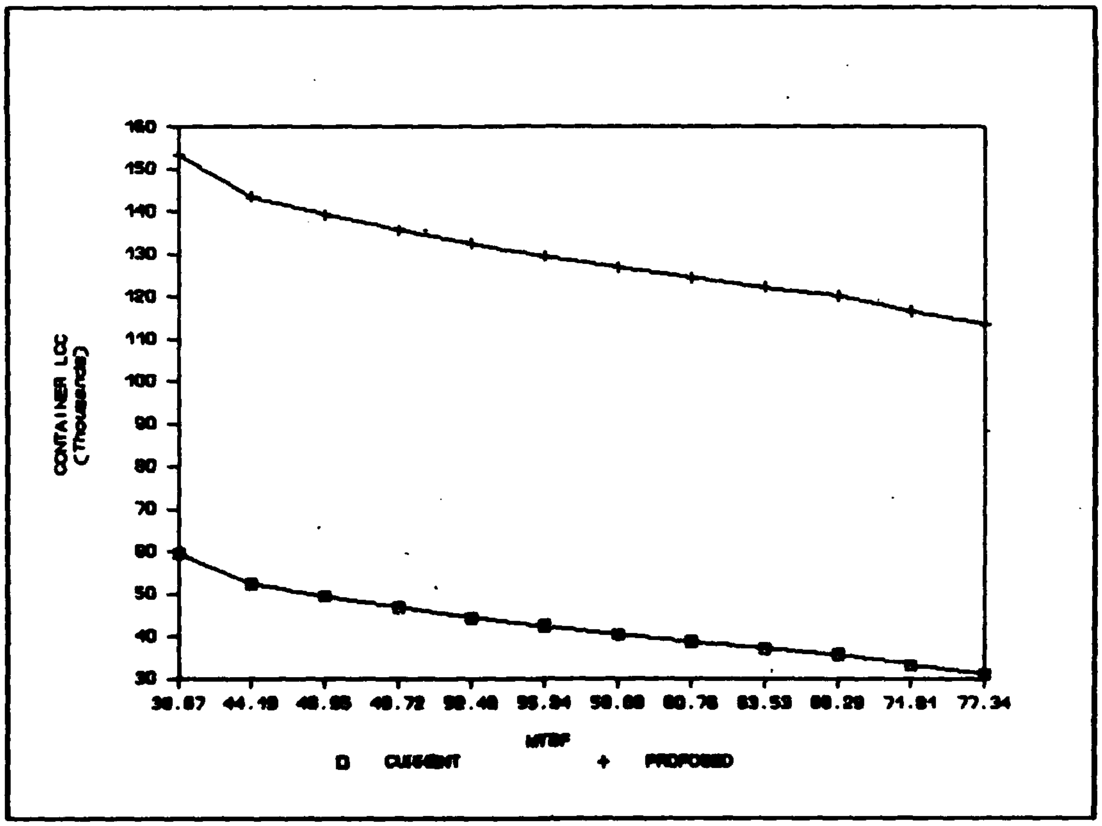


Figure 5. LCC (dollars) vs. MTBF (hours) for the ACIU

Table 12. Relationship of Container LCC to MTBF for DMT

MTBF	PERCENT OF PROJECTED MTBF	--- LCC (Dollars) --- CURRENT	PROPOSED
78.18	70.00%	11,877,626	13,058,244
89.34	80.00%	10,395,375	11,474,613
94.93	85.00%	9,785,037	10,822,529
100.51	90.00%	9,242,514	10,242,900
106.10	95.00%	8,757,099	9,724,283
111.68	100.00%	8,320,225	9,257,529
117.26	105.00%	7,924,958	8,835,227
122.85	110.00%	7,565,625	8,451,317
128.43	115.00%	7,237,538	8,100,790
134.02	120.00%	6,936,791	7,779,473
145.18	130.00%	6,404,701	7,210,990
156.35	140.00%	5,948,624	6,723,719

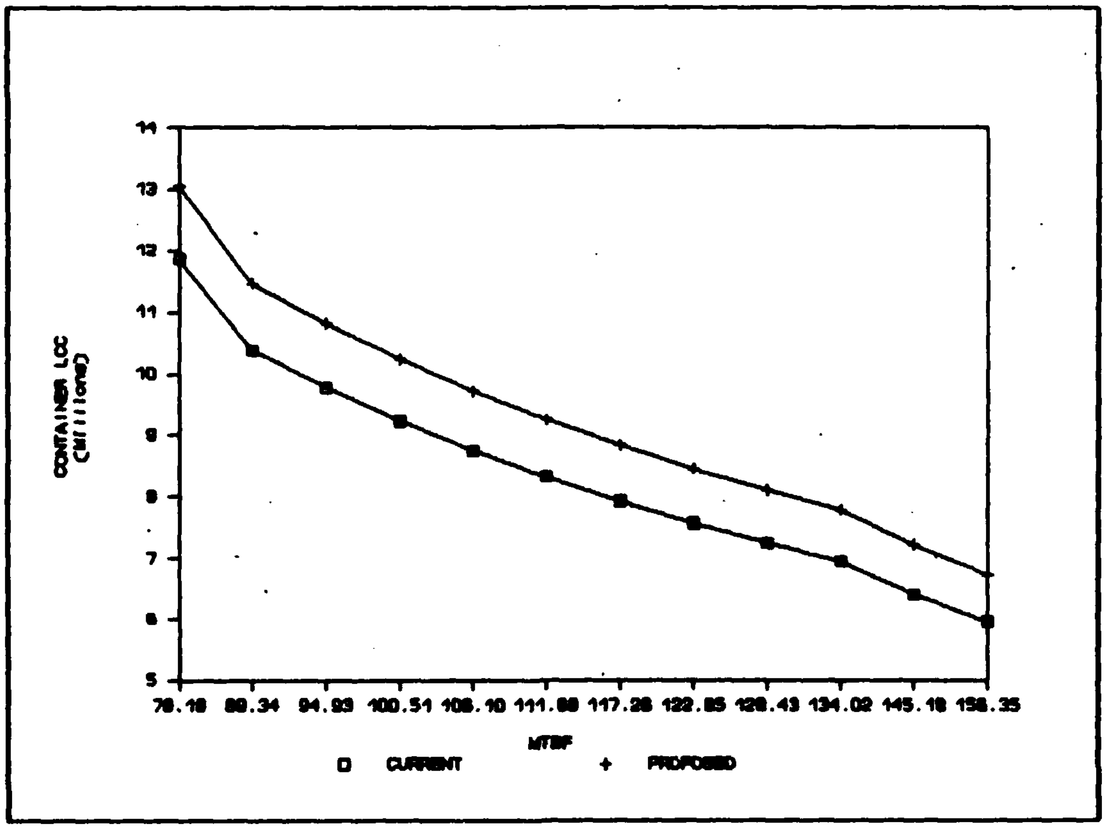


Figure 6. LCC (dollars) vs MTBF (hours) for the DMT

Summary

This chapter presented the results of the LCC model applications. It started with presentation of intermediate calculations in the model application process. Next, the computed life cycle costs for both packaging options was presented for each LRU. Finally, a sensitivity analysis was performed in order to determine how sensitive the model is to changes in LRU mean time between failure. The next chapter summarizes the findings of this study and presents appropriate recommendations.

VI. Summary and Recommendations

Introduction

In the previous chapter, the LCC model was applied to both packaging options for each LRU, and the model was analyzed for its sensitivity to changes in MTBF. This chapter will summarize the results of this study. It will begin with a discussion of quantitative factors to be considered in container selection; specifically, the results of the LCC model application and sensitivity analysis. Next, qualitative factors which should be considered in the selection of packaging options will be discussed. Finally, recommendations will be made as to container selection for the LRUs and possible future research.

Quantitative Considerations

LCC Model Results. The results of the LCC model application indicate that total life cycle costs of the proposed container exceed those of the current packaging method in all four cases. The significantly higher LCC for both packaging options for the DMT, relative to the other LRUs, is due to the much higher number of shipments expected for the DMT, which is due to its higher NRTS rate.

The difference in packaging life cycle costs between the present and proposed containers was the least (as a percentage - 2.47%) for the MLPRF. The difference in shipping costs for both options (0.9%) was minimal. The proposed container would result in 43% lower replacement and 60% lower labor costs. However, these savings were not enough to offset the higher acquisition costs (less salvage) for the proposed container of $149,681.

Switching to the proposed container for the DEEU and the ACIU would more than double the container LCC for each LRU. This is due mainly to two factors. First, the current container for both of these LRUs is a fiberboard box with specialized padding and bracing inside. This type of container is much lighter than the proposed container for both LRUs, which resulted in significantly higher shipping costs for the proposed container in both instances (114% increase for the DEEU; 50% increase for the ACIU). Secondly, the cost of the current container is less than 10% of the cost for the proposed container in each instance. Therefore, even though the proposed containers last ten times as long as the current containers, their replacement costs are higher.

The life cycle costs were most significant for the DMT. Switching to the proposed container would increase LCC by over $937,000. The cause for this increase is the weight differential between the two containers. The additional weight of the proposed container resulted in an increase in shipping costs of 24%, or over $1.6 million. Unlike with the MLPRF, the savings in replacement (63%) and labor costs (67%) more than offset the higher acquisition (less salvage) cost, but could not totally offset the increased shipping cost.

Sensitivity Analysis. The results of the sensitivity analysis showed the life cycle model to be rather insensitive to changes in LRU MTBF in all four of the applications in this study. This is fortunate, since the time series graphs in Appendix A would seem to indicate that the last twelve months' data is not a good predictor of future rates. Although the MTBF data for the MLPRF might be leveling out, the DEEU and DMT rates appear to still be climbing, and the ACIU rates don't seem to be following any particular pattern. However, despite these uncertainties, the model's results are still valid because of the model's insensitivity to MTBF.

Although the model is insensitive to MTBF (and hence the number of LRU shipments) in all four applications here, the same conclusion can not be said for the generic model as a whole. In the applications presented here, increases in the number of shipments resulted in increasingly higher shipping costs for the proposed containers as opposed to the current container, which offset benefits generally realized through lower replacement and labor costs. However, if the proposed container weighed less than the current container, increases in shipments would result in increasingly lower shipping, replacement, and labor costs for the proposed container, as opposed to the current container. These benefits would eventually outweigh the higher acquisition costs for the proposed container, and would result in a container LCC curve much more sensitive to changes in MTBF, NRTS, and flying hour projections.

Since the number of LRU shipments drives recurring costs, which are a major portion of any container's LCC, a break-even point with respect to the projected number of LRU shipments may be helpful in future applications of this model. Following the logic in Eqs (8) through (10), to find the break-even point with respect to the number of LRU shipments, you need to find "b" such that:

$$(RC_c)b + NRC_c = (RC_p)b + NRC_p \qquad (11)$$

where RC and NRC are as defined in Eq (8), and "b" is the percentage of the projected LRU shipments where the break-even point occurs. Grouping like terms and simplifying produces:

$$(RC_c - RC_p)b = NRC_p - NRC_c \qquad (12)$$

Eq (12) further simplifies to:

$$b = (NRC_p - NRC_c)/(RC_c - RC_p) \qquad (13)$$

Once "b" is found, multiplying it by the projected number of shipments gives the break-even point of the model with respect to the projected number of LRU shipments. The term "b" can also be multiplied times the projected NRTS rate to find the break even point with respect to NRTS. If "b" is negative, there is no break-even point. Again, this break-even point analysis can only be accomplished when recurring costs are computed for the entire life cycle directly (i.e. no present value factor analysis). The term "b" can be applied to NRTS only when NRTS is a constant projection.

Qualitative Considerations

The molded plastic containers considered in this study have several qualitative advantages over the currently used containers. First is their durability. They can be stored in most any environmental conditions with no damage to the container or its contents. This frees up scarce storage space at many operational maintenance units. Also, their durability allows then to absorb intransit shocks that would damage wooden or fiberboard containers and possibly their contents. From that, it is reasonable to assume that intransit damage to the LRU could be reduced by the use of the proposed containers. However, there have not been studies to determine how much damage could be reduced (Wood, 1988), so what could be significant dollar savings in favor of the proposed containers can not be quantified in this study. Also, if intransit damage could be reduced with the proposed containers, flying unit readiness could be improved. Fewer LRUs would have to be returned to depot upon receipt because of intransit damage, and instead, those LRUs could go to fix grounded aircraft.

A second advantage of the plastic containers is their ease of opening and sealing. The current containers require packaging specialists to insure that the item is properly preserved, and the container is properly sealed before shipment. This requires packaging personnel to deploy with a flying unit on an exercise or operation, to insure proper protection of the LRUs should they need to be returned to depot from the deployed location. Since the plastic containers automatically provide a moisture and vapor seal, no preservation of the item is required (Wood, 1988). And since the containers are simple to close, packaging personnel would not be required on deployments (at least not for those LRUs using the plastic containers). Additionally, the ease of packing and unpacking these containers would speed maintenance operations.

Finally, the plastic containers are more flexible with respect to material handling equipment (MHE) requirements. Most wooden crates are too heavy to be carried by one person, and are not fitted with handles, so a forklift or similar piece of MHE is required to move it. The plastic containers, however, have both forklift tine slots and handles, so if MHE is short (as on a deployment) or if time is critical, two persons together can carry the package.

Recommendations

LRU Container Selection. Adoption of the proposed container is recommended for the MLPRF. The total increase in life cycle costs is less than $2,000 per year. The qualitative advantages gained from the switch would be worth the extra cost. Actually, if the proposed container would prevent significant intransit damage to one LRU a year (as opposed to the current container), that additional cost would probably be recovered. Unfortunately, there is no way to know for sure.

For the DEEU and the ACIU, the current container design should be maintained. The relatively low number of shipments, combined with the added weight of the proposed container, would never justify the adoption of the proposed design.

Container selection for the DMT should be studied further. The DMT is the heaviest of the final four LRUs considered, and had by far the highest number of projected shipments. As such, the potential for long term cost savings is great, given a reusable molded plastic container of equal or lesser weight than the current wooden container could be utilized. A reduction of 10% in the weight of the current container would result in LCC savings of over $670,000 in transportation costs. Such potential savings justify investigating other options. Perhaps a lighter plastic container could be developed and fielded for costs comparable with the proposed container considered in this study.

Future Research. Many potential subjects for future research were discovered in the course of this study. Several recommendations for such research are presented here.

MTBF Projections. Although MTBF had relatively little effect on the results of the LCC model in this study, it could have significant effect in future studies. It is apparent from the time series graphs in Appendix A that the last twelve months of MTBF data will probably not be a good indicator of future rates. Alternative forecasting methods could be tested and developed to more accurately determine future MTBF rates from historical data on relatively young electronic systems.

Development of Other Plastic Containers. The containers considered in this study provide maximum protection, and as such are heavy and expensive. Lighter weight, less protective containers would certainly be adequate for protecting many electronic devices. Such a container might be appropriate for the recommended future study of DMT containers. Also, the WAC HUD DU and radar antenna were dropped from this study because they could not fit in any of the proposed containers. The relatively high number of projected shipments for both (Appendix H), would seem to justify investigation of the costs associated with the development and fielding of alternate plastic containers for them. The analysis would be similar to this study, and much of the data required is contained herein.

Intransit Damage Comparisons. Since intransit damage comparison data is not available, this potentially high value aspect of container LCC was not able to be determined and presented in this study. Such data may have made a significant difference in the results of this study. Research into intransit damage level comparisons between types of containers (i.e. wooden, plastic, fiberboard, etc.) would be very beneficial to any future container life cycle cost analyses.

Computer Aided LCC Analysis. Since LCC analysis has proven to require large amounts of data and computations, computer assistance in a study such as this is essential.

However, the spreadsheet developed for this study is too tailored to this specific research to be of use in future LCC analyses. Development of a generalized computer program to determine container LCC would be of great use in future LCC studies.

Container Selection and Integrated Logistics. It has been shown that container selection can have far reaching impacts throughout the logistics system, from aircraft maintenance to MHE requirements determination. No studies have been done to detail and quantify these relationships. Such research would be beneficial to the initial selection of container design for many aircraft systems.

Summary and Closing Comments

The selection of a container to package aircraft LRUs can have a large impact on life cycle costs. The significance of that impact is based primarily on the number of shipments that a particular type of LRU can be expected to make over its lifetime, and the weight difference between alternative containers. As simple as that sounds, it is really quite complex. The number of shipments an LRU will make over its lifetime is based on many factors that are unknown and must be forecasted. The accuracy of such forecasts had little effect in this study, but generally can greatly effect the outcome of similar studies. Factors could be such that a minor error in certain forecasts could invalidate the LCC model's result. Since there are so many unknowns in LCC analyses like this one, adequate sensitivity analysis is essential to give the decision maker sufficient information to consider in container selection.

Given the uncertainties inherent in container LCC projections, one might suspect that the benefits of the analysis do not justify the effort. That attitude should be avoided. As shown in this study, it is quite possible that the cost difference between container options will not change much due to error in future projections. In such a case, one can have a great deal of confidence in the results of the LCC analysis.

This chapter summarized the results of the LCC model application and presented recommendations for container selection and future research, thus completing this study. The chapter began with a summary of the quantitative results of the model application. Next, a discussion of the qualitative factors was presented. Following were recommendations on container selection. Finally, recommendations for future research were presented along with closing comments.

Appendix A: LRU Mean Time Between Failure Data

This appendix presents data on each LRU's mean time between failure (MTBF) history. Tables 13 through 18 list historical data on each LRU from the time period of January 1985 through May 1988, inclusive. This data was obtained from the F-16 Centralized Data System. These tables also list the average MTBF for the last twelve months' data.

Figures 7 through 12 show time series plots of the data in Tables 13 through 18 respectively. These figures also show the best fit logarithmic curve through the time series plots. The logarithmic curve was generated using the curve-fitting feature of Forecast Master (copyright, Scientific Systems Inc.), a computer forecasting package which automatically determines the best-fit curve by minimizing the sum of the squared errors of the curve over the fit set (Scientific Systems, 1986:11-2). Beneath each figure are comments on the plots.

Table 13. MTBF History For WAC HUD

DATE	-------	MONTHLY	------	-----	CUMULATIVE	-------
(YR/MO)	MTBF	FLYHOURS	FAILURES	MTBF	FLYHOURS	FAILURES
85/01	25.25	101.0	4.0	23.07	138.4	6.0
02	64.23	192.7	3.0	36.79	331.1	9.0
03	101.70	305.1	3.0	53.02	636.2	12.0
04	36.52	547.8	15.0	43.85	1184.0	27.0
05	37.64	828.1	22.0	41.06	2012.1	49.0
06	86.20	948.2	11.0	49.34	2960.3	60.0
07	44.04	1453.4	33.0	47.46	4413.7	93.0
08	28.83	1701.0	59.0	40.23	6114.7	152.0
09	71.92	1582.3	22.0	44.24	7697.0	174.0
10	147.91	2366.5	16.0	52.97	10063.5	190.0
11	100.07	2601.9	26.0	58.64	12665.4	216.0
12	62.28	2429.1	39.0	59.19	15094.5	255.0
86/01	91.21	3101.1	34.0	62.96	18195.6	289.0
02	86.67	3033.6	35.0	65.52	21229.2	324.0
03	80.88	3639.6	45.0	67.40	24868.8	369.0
04	138.70	4161.0	30.0	72.76	29029.8	399.0
05	163.72	4093.0	25.0	78.12	33122.8	424.0
06	172.32	4135.6	24.0	83.17	37258.4	448.0
07	302.25	5138.2	17.0	91.18	42396.6	465.0
08	116.98	4328.3	37.0	93.08	46724.9	502.0
09	153.43	3682.2	24.0	95.83	50407.1	526.0
10	398.85	6780.4	17.0	105.32	57187.5	543.0
11	323.01	5168.2	16.0	111.55	62355.7	559.0
12	197.04	5320.0	27.0	115.49	67675.7	586.0
87/01	210.29	5677.7	27.0	119.66	73353.4	613.0
02	255.46	6642.0	26.0	125.19	79995.4	639.0
03	262.83	7884.8	30.0	131.36	87880.2	669.0
04	273.74	8212.3	30.0	137.47	96092.5	699.0
05	243.32	8029.4	33.0	142.24	104121.9	732.0
06	174.72	9085.3	52.0	144.40	113207.2	784.0
07	251.00	8534.0	34.0	148.83	121741.2	818.0
08	229.04	8932.7	39.0	152.48	130673.9	857.0
09	302.07	8156.0	27.0	157.05	138829.9	884.0
10	227.21	10451.8	46.0	160.52	149281.7	930.0
11	279.93	8957.6	32.0	164.49	158239.3	962.0
12	190.89	8399.3	44.0	165.64	166638.6	1006.0
88/01	187.22	9361.1	50.0	166.67	175999.7	1056.0
02	331.75	8957.3	27.0	170.78	184957.0	1083.0
03	389.56	12465.8	32.0	177.06	197422.8	1115.0
04	278.19	9458.5	34.0	180.05	206881.3	1149.0
05	230.57	10145.2	44.0	181.92	217026.5	1193.0

DATA FOR LAST TWELVE MONTHS (87/06 - 88/05):

MTBF	FLYHOURS	FAILURES
244.91	112904.6	461.0

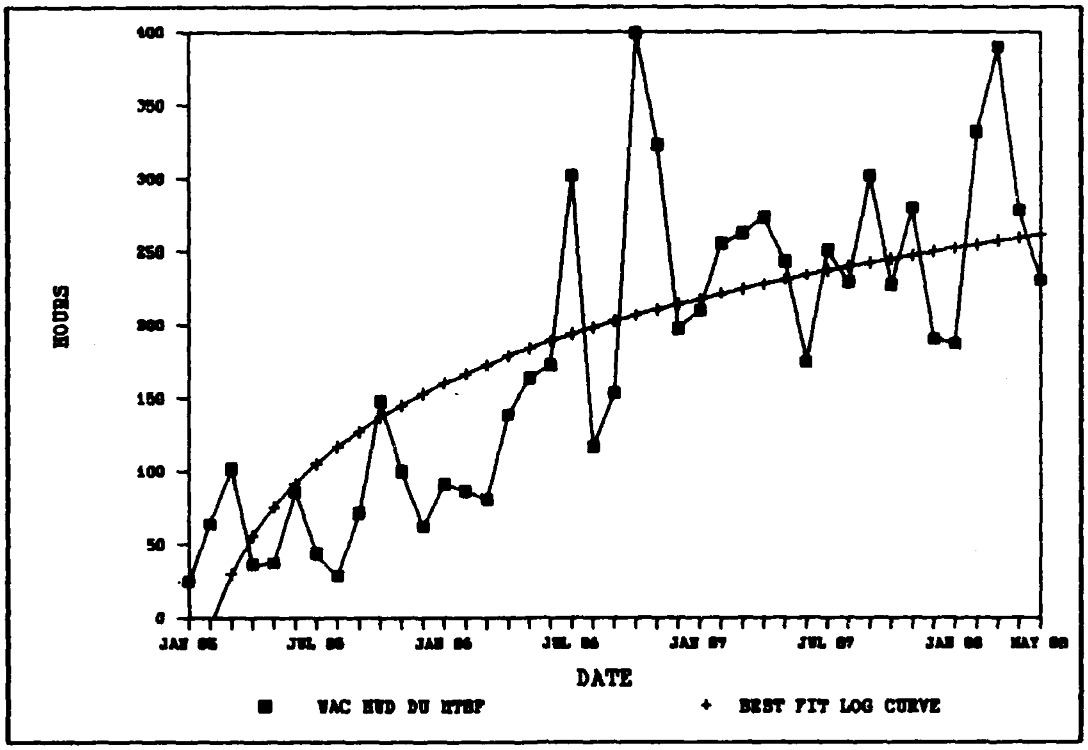


Figure 7. MTBF and Logarithmic Plots for WAC HUD DU

The best-fit logarithmic curve follows the general shape expected for an MTBF curve in the beginning of a system's life. For the last twelve months' actual MTBF data, six points fall above the logarithmic curve, and six fall below. Use of the last twelve months' data to forecast future rates is supported by these plots.

Table 14. MTBF History For MLPRF

DATE	-------	MONTHLY	------	-----	CUMULATIVE	-------
(YR/MO)	MTBF	FLYHOURS	FAILURES	MTBF	FLYHOURS	FAILURES
85/01	0.00	101.0	0.0	69.20	138.4	2.0
02	96.35	192.7	2.0	82.77	331.1	4.0
03	61.02	305.1	5.0	70.69	636.2	9.0
04	78.26	547.8	7.0	74.00	1184.0	16.0
05	69.01	828.1	12.0	71.86	2012.1	28.0
06	135.46	948.2	7.0	84.58	2960.3	35.0
07	80.74	1453.4	18.0	83.28	4413.7	53.0
08	85.05	1701.0	20.0	83.76	6114.7	73.0
09	65.93	1582.3	24.0	79.35	7697.0	97.0
10	94.66	2366.5	25.0	82.49	10063.5	122.0
11	118.27	2601.9	22.0	87.95	12665.4	144.0
12	105.61	2429.1	23.0	90.39	15094.5	167.0
86/01	119.27	3101.1	26.0	94.28	18195.6	193.0
02	77.78	3033.6	39.0	91.51	21229.2	232.0
03	125.50	3639.6	29.0	95.28	24868.8	261.0
04	69.35	4161.0	60.0	90.44	29029.8	321.0
05	74.42	4093.0	55.0	88.09	33122.8	376.0
06	42.20	4135.6	98.0	78.60	37258.4	474.0
07	95.15	5138.2	54.0	80.30	42396.6	528.0
08	149.25	4328.3	29.0	83.89	46724.9	557.0
09	111.58	3682.2	33.0	85.44	50407.1	590.0
10	132.95	6780.4	51.0	89.22	57187.5	641.0
11	90.67	5168.2	57.0	89.33	62355.7	698.0
12	57.83	5320.0	92.0	85.67	67675.7	790.0
87/01	86.03	5677.7	66.0	85.69	73353.4	856.0
02	114.52	6642.0	58.0	87.52	79995.4	914.0
03	99.81	7884.8	79.0	88.50	87880.2	993.0
04	114.06	8212.3	72.0	90.23	96092.5	1065.0
05	167.28	8029.4	48.0	93.55	104121.9	1113.0
06	121.14	9085.3	75.0	95.29	113207.2	1188.0
07	98.09	8534.0	87.0	95.48	121741.2	1275.0
08	129.46	8932.7	69.0	97.23	130673.9	1344.0
09	153.89	8156.0	53.0	99.38	138829.9	1397.0
10	254.92	10451.8	41.0	103.81	149281.7	1438.0
11	151.82	8957.6	59.0	105.70	158239.3	1497.0
12	142.36	8399.3	59.0	107.09	166638.6	1556.0
88/01	131.85	9361.1	71.0	108.17	175999.7	1627.0
02	144.47	8957.3	62.0	109.51	184957.0	1689.0
03	107.46	12465.8	116.0	109.38	197422.8	1805.0
04	139.10	9458.5	68.0	110.45	206881.3	1873.0
05	93.94	10145.2	108.0	109.55	217026.5	1981.0

DATA FOR LAST TWELVE MONTHS (87/06 - 88/05):

MTBF	FLYHOURS	FAILURES
130.07	112904.6	868.0

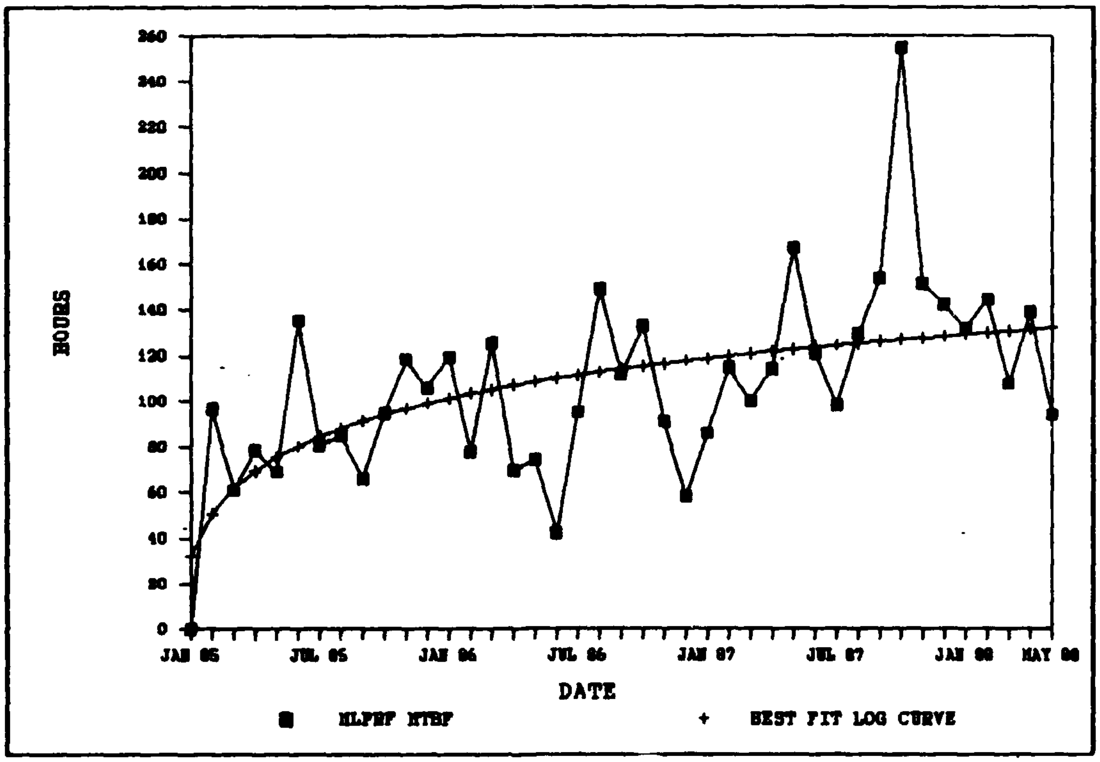


Figure 8. MTBF and Logarithmic Plots for MLPRF

The logarithmic curve follows the general shape expected for an MTBF curve. For the last twelve months' actual MTBF data, three points lie below the logarithmic curve, three lie virtually on the curve, and six points lie above the curve. This indicates that MTBF for the MLPRF is still increasing. Therefore, the last twelve months' data may not be a good indicator of future rates.

Table 15. MTBF History For DEEU

DATE (YR/MO)	MONTHLY			CUMULATIVE		
	MTBF	FLYHOURS	FAILURES	MTBF	FLYHOURS	FAILURES
85/01	25.25	101.0	4.0	34.60	138.4	4.0
02	96.35	192.7	2.0	55.18	331.1	6.0
03	61.02	305.1	5.0	57.84	636.2	11.0
04	42.14	547.8	13.0	49.33	1184.0	24.0
05	69.01	828.1	12.0	55.89	2012.1	36.0
06	67.73	948.2	14.0	59.21	2960.3	50.0
07	66.06	1453.4	22.0	61.30	4413.7	72.0
08	36.98	1701.0	46.0	51.82	6114.7	118.0
09	52.74	1582.3	30.0	52.01	7697.0	148.0
10	71.71	2366.5	33.0	55.60	10063.5	181.0
11	49.09	2601.9	53.0	54.13	12665.4	234.0
12	59.25	2429.1	41.0	54.89	15094.5	275.0
86/01	64.61	3101.1	48.0	56.33	18195.6	323.0
02	216.69	3033.6	14.0	62.99	21229.2	337.0
03	227.48	3639.6	16.0	70.45	24868.8	353.0
04	115.58	4161.0	36.0	74.63	29029.8	389.0
05	163.72	4093.0	25.0	80.01	33122.8	414.0
06	98.47	4135.6	42.0	81.71	37258.4	456.0
07	93.42	5138.2	55.0	82.97	42396.6	511.0
08	88.33	4328.3	49.0	83.44	46724.9	560.0
09	83.69	3682.2	44.0	83.46	50407.1	604.0
10	173.86	6780.4	39.0	88.94	57187.5	643.0
11	172.27	5168.2	30.0	92.65	62355.7	673.0
12	108.57	5320.0	49.0	93.73	67675.7	722.0
87/01	153.45	5677.7	37.0	96.64	73353.4	759.0
02	118.61	6642.0	56.0	98.15	79995.4	815.0
03	254.35	7884.8	31.0	103.88	87880.2	846.0
04	200.30	8212.3	41.0	108.33	96092.5	887.0
05	200.74	8029.4	40.0	112.32	104121.9	927.0
06	252.37	9085.3	36.0	117.56	113207.2	963.0
07	258.61	8534.0	33.0	122.23	121741.2	996.0
08	297.76	8932.7	30.0	127.36	130673.9	1026.0
09	281.24	8156.0	29.0	131.59	138829.9	1055.0
10	227.21	10451.8	46.0	135.59	149281.7	1101.0
11	331.76	8957.6	27.0	140.28	158239.3	1128.0
12	262.48	8399.3	32.0	143.65	166638.6	1160.0
88/01	180.02	9361.1	52.0	145.21	175999.7	1212.0
02	319.90	8957.3	28.0	149.16	184957.0	1240.0
03	429.86	12465.8	29.0	155.57	197422.8	1269.0
04	255.64	9458.5	37.0	158.41	206881.3	1306.0
05	281.81	10145.2	36.0	161.72	217026.5	1342.0

DATA FOR LAST TWELVE MONTHS (87/06 - 88/05):

MTBF	FLYHOURS	FAILURES
272.06	112904.6	415.0

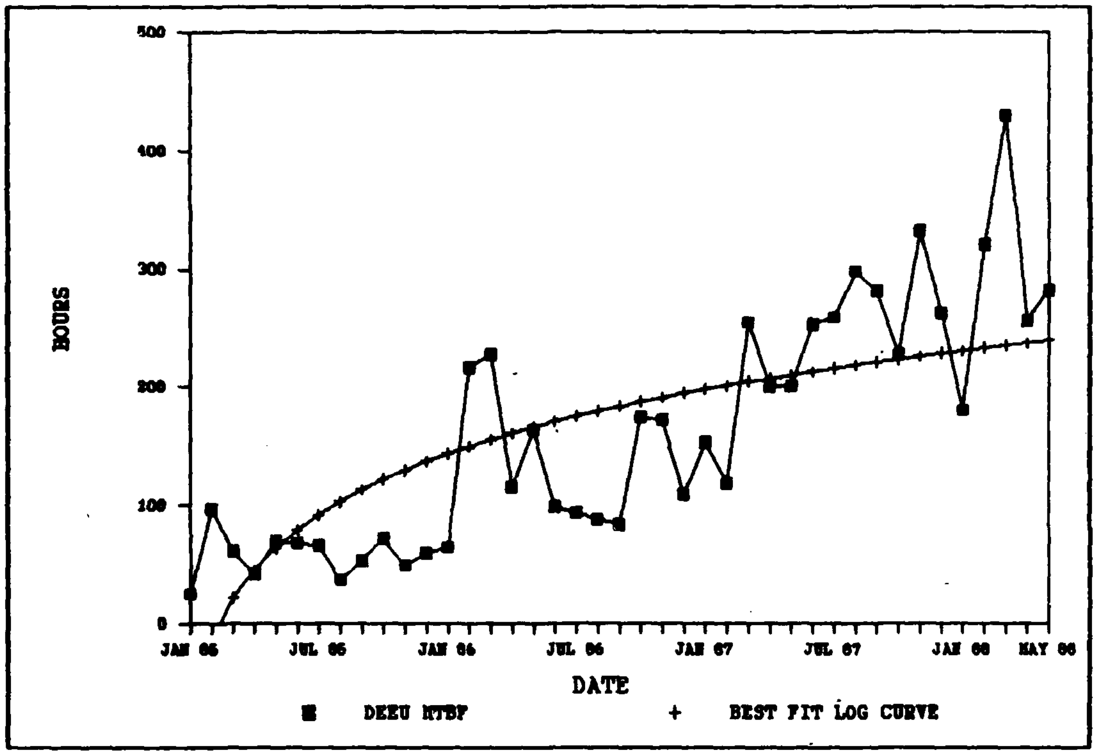


Figure 9. MTBF and Logarithmic Plots for DEEU

The logarithmic curve follows the shape expected for an MTBF curve. Of the last twelve months' actual MTBF data, one point falls below the logarithmic curve, one falls virtually on the curve, and ten points fall above the logarithmic curve. This indicates that MTBF for the DEEU is still increasing. The long term MTBF time series plot also seems to provide the same indication. Therefore, it is probable that the DEEU's MTBF will increase beyond this study's projections in the future.

Table 16. MTBF History For ACIU

DATE (YR/MO)	------- MONTHLY		------	----- CUMULATIVE		-------
	MTBF	FLYHOURS	FAILURES	MTBF	FLYHOURS	FAILURES
85/01	0.00	101.0	0.0	ERR	138.4	0.0
02	192.70	192.7	1.0	331.10	331.1	1.0
03	152.55	305.1	2.0	212.07	636.2	3.0
04	36.52	547.8	15.0	65.78	1184.0	18.0
05	46.01	828.1	18.0	55.89	2012.1	36.0
06	27.09	948.2	35.0	41.69	2960.3	71.0
07	27.42	1453.4	53.0	35.59	4413.7	124.0
08	42.53	1701.0	40.0	37.28	6114.7	164.0
09	68.80	1582.3	23.0	41.16	7697.0	187.0
10	46.40	2366.5	51.0	42.28	10063.5	238.0
11	72.28	2601.9	36.0	46.22	12665.4	274.0
12	93.43	2429.1	26.0	50.31	15094.5	300.0
86/01	55.38	3101.1	56.0	51.11	18195.6	356.0
02	50.56	3033.6	60.0	51.03	21229.2	416.0
03	107.05	3639.6	34.0	55.26	24868.8	450.0
04	78.51	4161.0	53.0	57.71	29029.8	503.0
05	99.83	4093.0	41.0	60.89	33122.8	544.0
06	49.83	4135.6	83.0	59.42	37258.4	627.0
07	146.81	5138.2	35.0	64.04	42396.6	662.0
08	100.66	4328.3	43.0	66.28	46724.9	705.0
09	65.75	3682.2	56.0	66.24	50407.1	761.0
10	88.06	6780.4	77.0	68.24	57187.5	838.0
11	97.51	5168.2	53.0	69.98	62355.7	891.0
12	54.85	5320.0	97.0	68.50	67675.7	988.0
87/01	113.55	5677.7	50.0	70.67	73353.4	1038.0
02	83.03	6642.0	80.0	71.55	79995.4	1118.0
03	73.69	7884.8	107.0	71.74	87880.2	1225.0
04	60.83	8212.3	135.0	70.66	96092.5	1360.0
05	121.66	8029.4	66.0	73.02	104121.9	1426.0
06	67.80	9085.3	134.0	72.57	113207.2	1560.0
07	56.14	8534.0	152.0	71.11	121741.2	1712.0
08	61.18	8932.7	146.0	70.33	130673.9	1858.0
09	42.93	8156.0	190.0	67.79	138829.9	2048.0
10	66.57	10451.8	157.0	67.70	149281.7	2205.0
11	46.17	8957.6	194.0	65.96	158239.3	2399.0
12	41.17	8399.3	204.0	64.02	166638.6	2603.0
88/01	51.72	9361.1	181.0	63.22	175999.7	2784.0
02	57.79	8957.3	155.0	62.93	184957.0	2939.0
03	72.06	12465.8	173.0	63.44	197422.8	3112.0
04	54.67	9458.5	173.0	62.98	206881.3	3285.0
05	54.84	10145.2	185.0	62.54	217026.5	3470.0

DATA FOR LAST TWELVE MONTHS (87/06 - 88/05):

MTBF	FLYHOURS	FAILURES
55.24	112904.6	2044.0

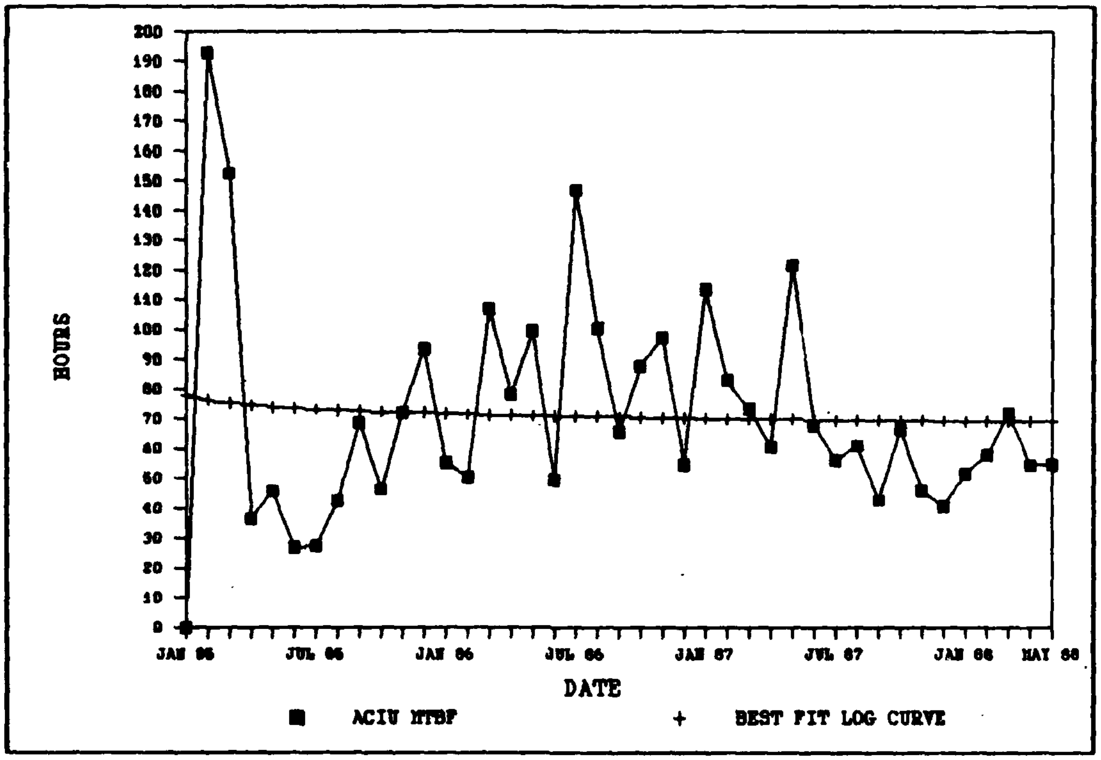


Figure 10. MTBF and Logarithmic Plots for ACIU

The best-fit logarithmic curve for the ACIU's MTBF data is virtually a straight line. This is due to the fact that the MTBF data does not follow the expected pattern for a new electronic system. Rather than starting low and increasing to a stable level, the ACIU's MTBF data starts out high, drops to a local minimum at around July 1986, increases to an approximately stable level for the next 24 months, and then decreases to a stable level over about the last 10 months.

From these plots, it is difficult to draw any conclusions about the accuracy of this study's MTBF forecast. Though the last year's data is fairly stable, there is no long term, standard trend apparent. The forecast used may or may not be accurate.

Table 17. MTBF History For ANTENNA

DATE	MONTHLY			CUMULATIVE		
(YR/MO)	MTBF	FLYHOURS	FAILURES	MTBF	FLYHOURS	FAILURES
85/01	0.00	101.0	0.0	0.00	138.4	0.0
02	96.35	192.7	2.0	165.55	331.1	2.0
03	152.55	305.1	2.0	159.05	636.2	4.0
04	91.30	547.8	6.0	118.40	1184.0	10.0
05	207.03	828.1	4.0	143.72	2012.1	14.0
06	135.46	948.2	7.0	140.97	2960.3	21.0
07	145.34	1453.4	10.0	142.38	4413.7	31.0
08	141.75	1701.0	12.0	142.20	6114.7	43.0
09	197.79	1582.3	8.0	150.92	7697.0	51.0
10	262.94	2366.5	9.0	167.72	10063.5	60.0
11	650.48	2601.9	4.0	197.90	12665.4	64.0
12	220.83	2429.1	11.0	201.26	15094.5	75.0
86/01	163.22	3101.1	19.0	193.57	18195.6	94.0
02	202.24	3033.6	15.0	194.76	21229.2	109.0
03	165.44	3639.6	22.0	189.84	24868.8	131.0
04	219.00	4161.0	19.0	193.53	29029.8	150.0
05	682.17	4093.0	6.0	212.33	33122.8	156.0
06	827.12	4135.6	5.0	231.42	37258.4	161.0
07	2569.10	5138.2	2.0	260.10	42396.6	163.0
08	332.95	4328.3	13.0	265.48	46724.9	176.0
09	283.25	3682.2	13.0	266.70	50407.1	189.0
10	398.85	6780.4	17.0	277.61	57187.5	206.0
11	574.24	5168.2	9.0	290.03	62355.7	215.0
12	295.56	5320.0	18.0	290.45	67675.7	233.0
87/01	218.37	5677.7	26.0	283.22	73353.4	259.0
02	442.80	6642.0	15.0	291.95	79995.4	274.0
03	342.82	7884.8	23.0	295.89	87880.2	297.0
04	283.18	8212.3	29.0	294.76	96092.5	326.0
05	364.97	8029.4	22.0	299.20	104121.9	348.0
06	478.17	9085.3	19.0	308.47	113207.2	367.0
07	426.70	8534.0	20.0	314.58	121741.2	387.0
08	744.39	8932.7	12.0	327.50	130673.9	399.0
09	509.75	8156.0	16.0	334.53	138829.9	415.0
10	326.62	10451.8	32.0	333.96	149281.7	447.0
11	407.16	8957.6	22.0	337.40	158239.3	469.0
12	494.08	8399.3	17.0	342.88	166638.6	486.0
88/01	374.44	9361.1	25.0	344.42	175999.7	511.0
02	597.15	8957.3	15.0	351.63	184957.0	526.0
03	235.20	12465.8	53.0	340.97	197422.8	579.0
04	675.61	9458.5	14.0	348.87	206881.3	593.0
05	634.08	10145.2	16.0	356.37	217026.5	609.0

DATA FOR LAST TWELVE MONTHS (87/06 - 88/05):

MTBF	FLYHOURS	FAILURES
432.58	112904.6	261.0

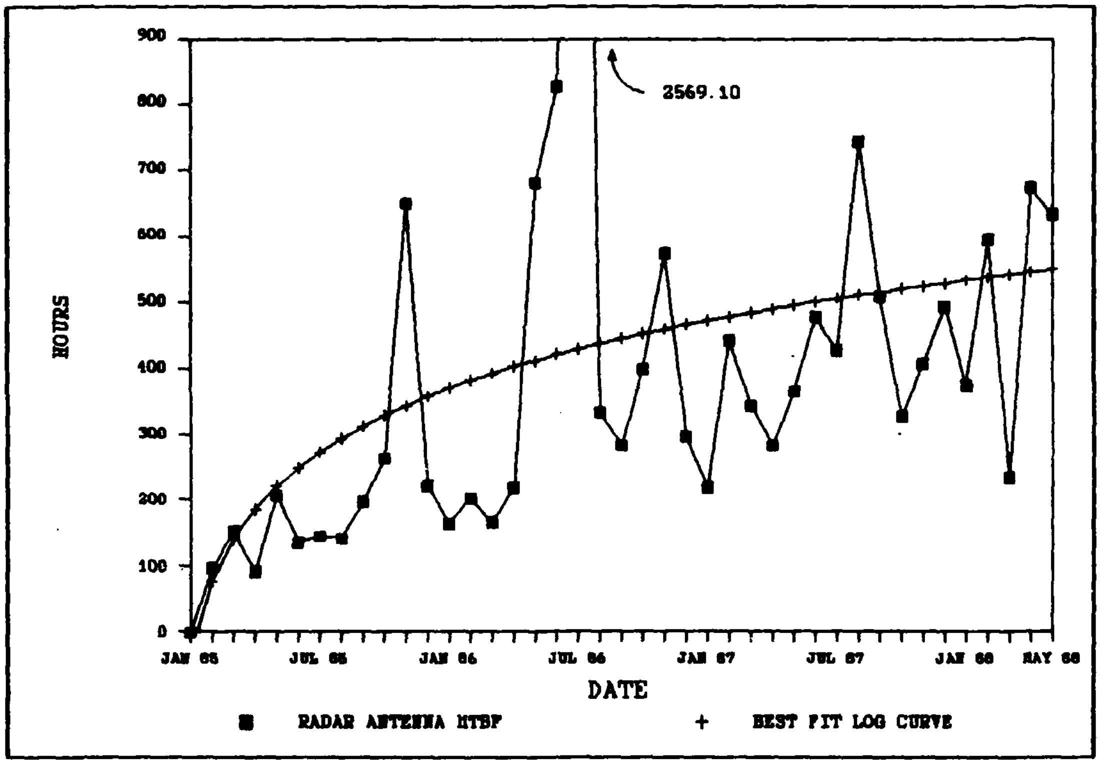


Figure 11. MTBF and Logarithmic Plots for Radar Antenna

The best-fit logarithmic curve for the radar antenna follows the general shape expected of an MTBF curve. However, the curve falls above most of the actual MTBF points, due to the effects of the apparent outlier at July 1986. The last year's actual data seems to have levelled out lately; although fluctuating, there is no apparent trend. Therefore, the projections used in this study should be fairly accurate.

Table 18. MTBF History For DMT

DATE	MONTHLY			CUMULATIVE		
(YR/MO)	MTBF	FLYHOURS	FAILURES	MTBF	FLYHOURS	FAILURES
85/01	101.00	101.0	1.0	69.20	138.4	2.0
02	48.18	192.7	4.0	55.18	331.1	6.0
03	27.74	305.1	11.0	37.42	636.2	17.0
04	22.83	547.8	24.0	28.88	1184.0	41.0
05	51.76	828.1	16.0	35.30	2012.1	57.0
06	27.89	948.2	34.0	32.53	2960.3	91.0
07	16.52	1453.4	88.0	24.66	4413.7	179.0
08	27.00	1701.0	63.0	25.27	6114.7	242.0
09	18.62	1582.3	85.0	23.54	7697.0	327.0
10	182.04	2366.5	13.0	29.60	10063.5	340.0
11	63.46	2601.9	41.0	33.24	12665.4	381.0
12	71.44	2429.1	34.0	36.37	15094.5	415.0
86/01	91.21	3101.1	34.0	40.52	18195.6	449.0
02	79.83	3033.6	38.0	43.59	21229.2	487.0
03	113.74	3639.6	32.0	47.92	24868.8	519.0
04	88.53	4161.0	47.0	51.29	29029.8	566.0
05	88.98	4093.0	46.0	54.12	33122.8	612.0
06	55.89	4135.6	74.0	54.31	37258.4	686.0
07	58.39	5138.2	88.0	54.78	42396.6	774.0
08	94.09	4328.3	46.0	56.98	46724.9	820.0
09	59.39	3682.2	62.0	57.15	50407.1	882.0
10	77.05	6780.4	88.0	58.96	57187.5	970.0
11	60.10	5168.2	86.0	59.05	62355.7	1056.0
12	123.72	5320.0	43.0	61.58	67675.7	1099.0
87/01	149.41	5677.7	38.0	64.51	73353.4	1137.0
02	73.80	6642.0	90.0	65.20	79995.4	1227.0
03	85.70	7884.8	92.0	66.63	87880.2	1319.0
04	80.51	8212.3	102.0	67.62	96092.5	1421.0
05	84.52	8029.4	95.0	68.68	104121.9	1516.0
06	85.71	9085.3	106.0	69.79	113207.2	1622.0
07	59.68	8534.0	143.0	68.98	121741.2	1765.0
08	65.68	8932.7	136.0	68.74	130673.9	1901.0
09	88.65	8156.0	92.0	69.66	138829.9	1993.0
10	106.65	10451.8	98.0	71.39	149281.7	2091.0
11	146.85	8957.6	61.0	73.53	158239.3	2152.0
12	88.41	8399.3	95.0	74.16	166638.6	2247.0
88/01	126.50	9361.1	74.0	75.83	175999.7	2321.0
02	165.88	8957.3	54.0	77.88	184957.0	2375.0
03	194.78	12465.8	64.0	80.94	197422.8	2439.0
04	210.19	9458.5	45.0	83.29	206881.3	2484.0
05	235.93	10145.2	43.0	85.88	217026.5	2527.0

DATA FOR LAST TWELVE MONTHS (87/06 - 88/05):

MTBF	FLYHOURS	FAILURES
111.68	112904.6	1011.0

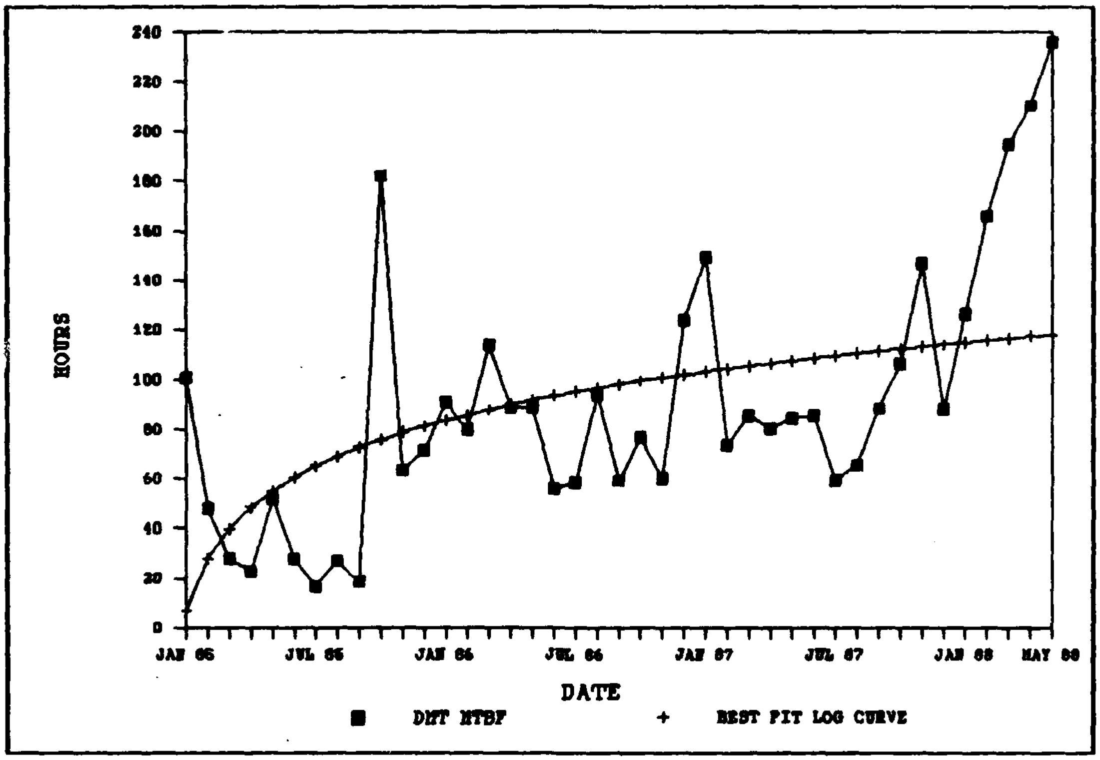


Figure 12. MTBF and Logarithmic Plots for DMT

The best-fit logarithmic curve follows the shape expected of an MTBF curve. Of the last twelve months' actual MTBF data, 6 points lie above the logarithmic curve, and six points fall below the curve. This taken alone would indicate a levelling off in the MTBF. However, the last five months have each shown a steep increase in MTBF, and nine of the last ten observations have been increases over the previous month's figure. This strongly indicates that MTBF is still increasing, and may increase significantly before levelling off. As such, it is quite probable that the DMT MTBF forecast used in this study will be lower than actual future values.

Appendix B: LRU NRTS Data by Base, Total, and Percent

BASE	WAC HUD	MLPRF	DEEU	ACIU	ANTENNA	DMT
LUKE	5	2	8	0	24	139
SHAW	76	45	49	3	25	164
HAHN	5	23	4	1	27	159
RAMSTEIN	32	38	11	1	32	178
TORREJON	0	1	0	0	2	6
NELLIS	0	1	0	0	2	10
SPANGDAL	4	3	0	0	4	11
TOTAL NRTS	122	113	72	5	116	667
TOTAL FAILS	769	1605	928	2926	453	1915
NRTS PERCENT	15.86%	7.04%	7.76%	0.17%	25.61%	34.83%

Data shown is from time period of June 1986 through May 1988 inclusive.

Appendix C: Projected F-16C/D Force Strengths by Base and Year

BASE	YEAR									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997-ON
KUNSAN	48	48	48	48	48	48	48	48	48	48
MISAWA	48	48	48	48	48	48	48	48	48	48
SPANGDAL	36	36	36	36	36	36	36	36	36	36
TORREJON	72	72	72	72	72	72	72	72	72	72
RAMSTEIN	48	48	48	48	48	48	48	48	48	48
HAHN	72	72	72	72	72	72	72	72	72	72
NELLIS	20	20	20	20	20	20	20	20	20	20
SHAW	72	72	72	72	72	72	72	72	72	72
LUKE	72	72	72	72	72	72	72	72	72	72
1			72	72	72	72	72	72	72	72
2			12	12	12	12	12	12	12	12
3				24	24	24	24	24	24	24
4				72	72	72	72	72	72	72
5				18	18	18	18	18	18	18
6				48	48	48	48	48	48	48
7				18	18	18	18	18	18	18
8					72	72	72	72	72	72
9					24	24	54	54	54	54
10					18	18	18	18	18	18
11					18	18	18	18	18	18
12						24	24	24	24	24
13						24	24	24	24	24
14						18	18	18	18	18
15						18	18	18	18	18
16							18	18	18	18
17							18	18	18	18
18							18	18	18	18
19								18	18	18
20							24	24	24	24
21								18	18	18
22								24	24	24
23								18	18	18
24								18	18	18
25								18	18	18
26									18	18
27									18	18
28										48
29									36	36

Appendix D: Container Cost and Weight Data

Table 19. LRU Shipping Weights, in Pounds

	LRU					
	WAC HUD	MLPRF	DEEU	ACIU	ANTENNA	DMT
CURRENT	175	222	62	109	185	208
PROPOSED		224	132	164		258

Table 20. Container Cost Matrix in Dollars

	LRU					
	WAC HUD	MLPRF	DEEU	ACIU	ANTENNA	DMT
CURRENT		138.00	33.03	57.04		211.00
PROPOSED		786.25	649.25	649.25		786.25

Table 21. Container Pack/Unpack Labor Cost Matrix in Dollars

	LRU					
	WAC HUD	MLPRF	DEEU	ACIU	ANTENNA	DMT
CURRENT		31.25	12.50	12.50		37.50
PROPOSED		12.50	6.25	6.25		12.50

Appendix E: Container Drawings and Specifications

This appendix presents the drawings and specifications for the current and proposed containers. Drawings are identified by Specialized Packaging Instruction (SPI) numbers, and are listed below.

SPI Number	LRU	# of Pages
011578217	WAC HUD DU	8
011322441	MLPRF	1
011560302	DEEU	4
011486286	ACIU	4
010418541	Antenna	2
011322680	DMT	1
012365003	Proposed Container	3 (one shown)

A master library of all SPIs is maintained at the Air Force Packaging Evaluation Agency, Wright-Patterson AFB OH. Drawings are also available from the responsible Air Logistics Center or the LRU contractor.

GENERAL DYNAMICS
Fort Worth Division

SPECIAL PACKAGING INSTRUCTIONS (SPI)

CODE ID	K0656	SPI NO.	011578217
SHEET 1 OF 8			

PART OR DRAWING NO.	NATIONAL STOCK NO.	CURRENT REV	
79-077-02-01C	1270-01-157-8217		ILL J. Sanchez CHK J. Clark ENGR J. Clark
ITEM NOMENCLATURE: Display Unit		ORIGINAL DATE 85231	AUTH

PRESERVATION IAW MIL-P-116

LEVEL A	IIb
LEVEL B	IIb
LEVEL C	III(see note 1)
CLEANING	C1
DRYING	D-4
PRESERVATIVE	N/A

PACKING AS SPECIFIED BELOW AND BILL OF MATERIALS

LEVEL	SPEC	STYLE	TYPE	CL	VAR	GR
A	PPP-B-601	A	overseas			B
B	PPP-B-636	RSC	CF	WR	DW	V11c
C	PPP-B-636	RSC	CF	DOM	DW	600

	LEVEL A	LEVEL B	LEVEL C
GROSS CU FT	16.6	15.4	15.4
GROSS WT LBS	175	125	103

MARKING IAW MIL-STD-129

SPECIAL MARKING:

A. Mark "SPI 011578217
on Lower Right Area of One Side"

B. Outside Dimensions in Inches Required

C. "Reusable Container – Do Not Destroy"

D. Method II labels req'd.
for level A & L packs.

	LENGTH		WIDTH		DEPTH	
CTNR I.D.	43 1/8"	IN.	21 1/8"	IN.	25 7/8	IN.
CTNR O.D. "A"	45 1/8"	IN.	23 1/8"	IN.	27 7/8	IN.
CNTR O.D. "B"	44 1/8"	IN.	22 1/8"	IN.	27 5/8	IN.
CTNR O.D. "C"	44 1/8"	IN.	22 1/8"	IN.	27 5/8	IN.
ITEM DIM	29	IN.	8	IN.	13	IN.

ITEM WT LBS 47.40

CLOSURE INSTRUCTIONS: Level A I.A.W. PPP-B-601 PARA. 3.6
Level B&C close I.A.W. method 102 of FED STD. No. 224
and tables VII or IX of PPP-B-636.

OPENING INSTRUCTIONS: Do not open until ready for use/inspection. After opening save all dunnage

NOTES:

1. For level C shipments omit barrier bag P/N 5, desiccant P/N 8, and indicator, P/N 6.
2. Level B pack shown on shts. 3 thru 8.
3. Staple P/Ns 17 to 12, 16 to 11, 15 to 10, 14 to 8, and 13 to 20 with P/N 26.
4. Nail P/N 19 to inner container, with P/N 27.
5. Nail P/N 12 to inner container, with P/N 28.
6. Nail P/N 11 to inner container, with P/N 28.
7. Wrap combine glass of item, with P/N 24, do not touch glass.
8. Wrap item in polywrap P/N 25, then place in inner container.
9. Detail #1, entire assy. is built with 66 nails P/N 27.

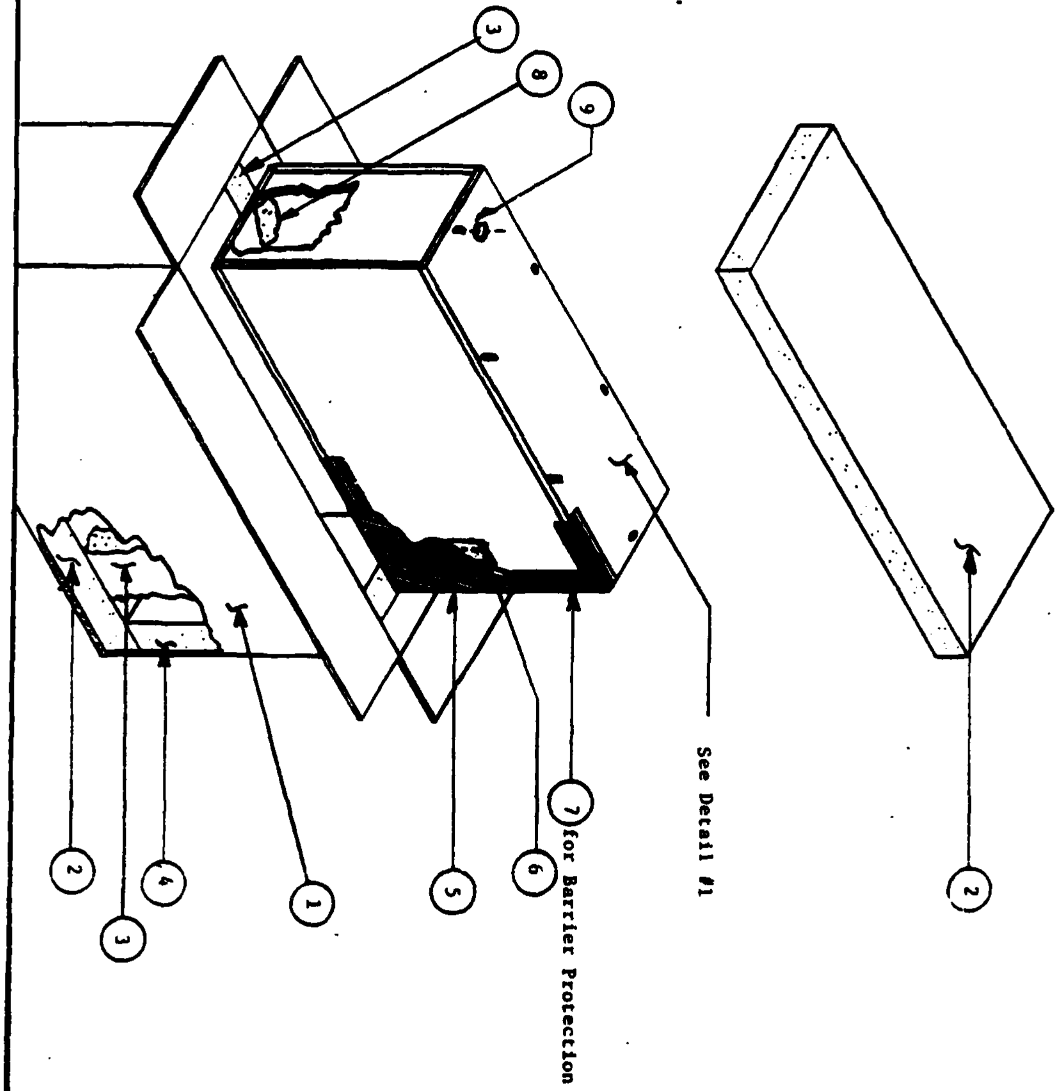
SPI No. 011573219

GENERAL DYNAMICS *Fort Worth Division* **SPI (Continuation Sheet)**	CODE ID K0656
	SPI NO 011578217
ITEM NOMENCLATURE Display Unit	SHEET 2 OF 8

PART NO.	QTY REQD	NOMENCLATURE OR DESCRIPTION	SIZE	MATERIAL SPECIFICATION
50				
49				
48				
47				
46				
45				
44				
43				
42				
41				
40				
39				
38				
37				
36				
35				
34				
33				
32				
31				
30				
29				
28	24	Nails (CM'T COATED)	3d	FF-N-105,TY.II,STY 4A
27	90	Nails (CM'T COATED)	2d	FF-N-105,TY.II,STY 4A
26	40	Staplers	No. 5	FF-N-105,TY.III, STY.4
25	1	Polyethylene wrap	46"x44"x.002 THK	L-P-378,TY.I,CL.1,GR.A,FIN
24	A/R	Tissue paper	as required	UU-P-553,TY.I,CL.1
23	2	Plywood	16 5/8"x11 7/8"x 5/8"	NN-P-530,GROUP B
22	2	Plywood	35 1/8"x13 1/8"x 5/8"	NN-P-530,GROUP B
21	2	Plywood	35 1/8"x16 5/8"x5/8"	NN-P-530,GROUP B
20	1	Plywood	15"x11 7/8"x7/8"	NN-P-530,GROUP B
19	8	Plywood	16 1/4"x1 3/4"x1/2"	NN-P-530,GROUP B
18	1	Plywood	15"x11 7/8"x7/8"	NN-P-530,GROUP B
17	2	Felt	9"x3 3/4"x1/8" THK	C-F-206,TY.1
16	1	Felt	7 3/4"x5 1/2"x1/8" THK	C-F-206,TY.1
15	1	Felt	11 7/8"x6 1/2"x1/8" THK	C-F-206,TY.1
14	1	Felt	22"x2 1/2"x1/8" THK	C-F-206,TY.1
13	1	Felt	17"x2 1/2"x1/8" THK	C-F-206,TY.1
12	2	Lumber	7 1/4"x3 3/4"x3"	MIL-STD-731,CL.2
11	1	Lumber	7 1/2"x5 1/2"x2 3/4"	MIL-STD-731,CL.2
10	1	Plywood	11 7/8"x6 1/2"x7/8"	NN-P-530, GROUP B
9	6	Anchor Bolts/Nuts	1/4"DIA.x 2" LONG	STANDARD
8	1	Desiccant	364 UNITS	MIL-D-3464,TY.1
7	A/R	Tape Press'r.Sens't.	2" WIDE x AS REQ'D	PPP-T-60, TY.IV
6	1	Humidity Indicator	STANDARD	MS20003
5	1	Barrier Bag	30"x55"	MIL-B-117,TYI,CL.E,STY.1
4	2	End Cushion	17 7/8"x13 1/8"x4" THK	MIL-P-26514,TY.I,CL.2,GR.B
3	2	Side Cushion	25 1/8"x17 7/8"x4" THK	MIL-P-26514,TY.I,CL.2,GR.B
2	2	Top/Bott. Cushion	43 1/8"x21 1/8"x4" THK	MIL-P-26514,TY.I,CL.2,GR.B
1	1	Outer Container	43 1/8"x21 1/8"x25 7/8"ID	SEE PACKAGING LEVELS SH.1

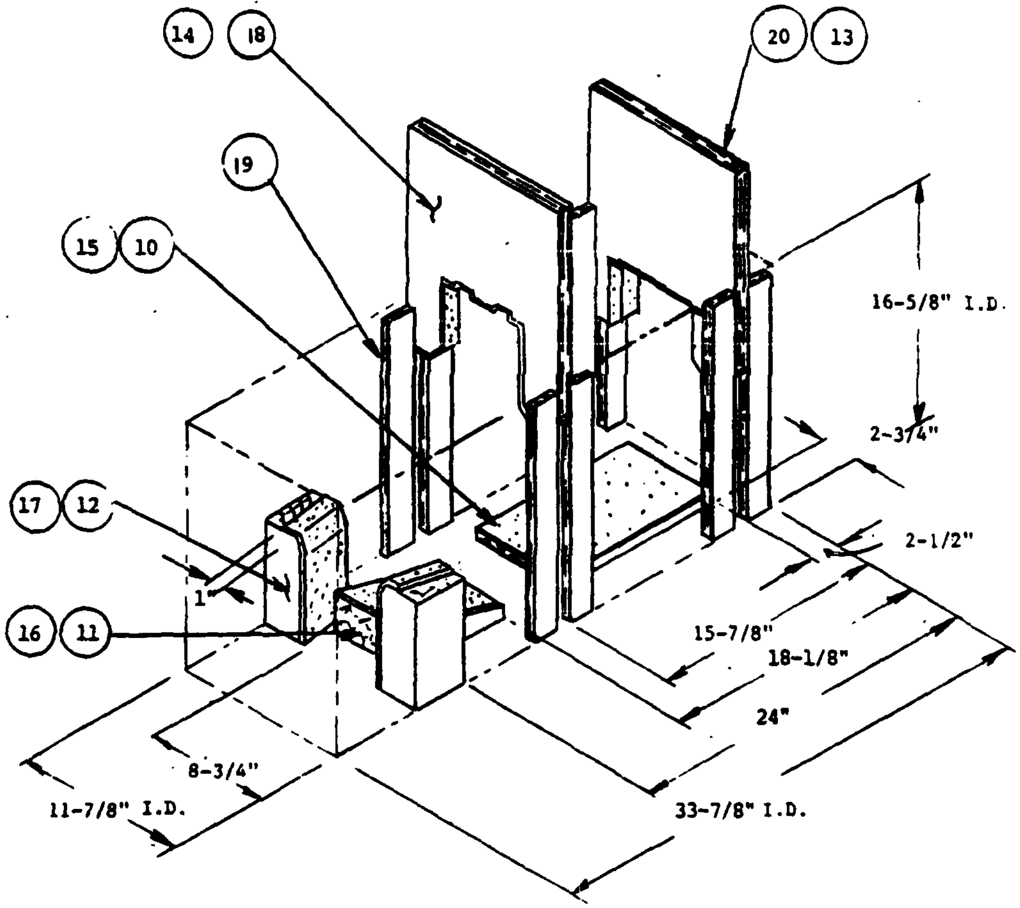
SPI NO 011578217

GENERAL DYNAMICS *Fort Worth Division* **SPI (Continuation Sheet)**	**CODE ID** K0656	**SPI NO. (TPO)** 011578217
ITEM NOMENCLATURE Display Unit		**SHEET** 3 **OF** 8



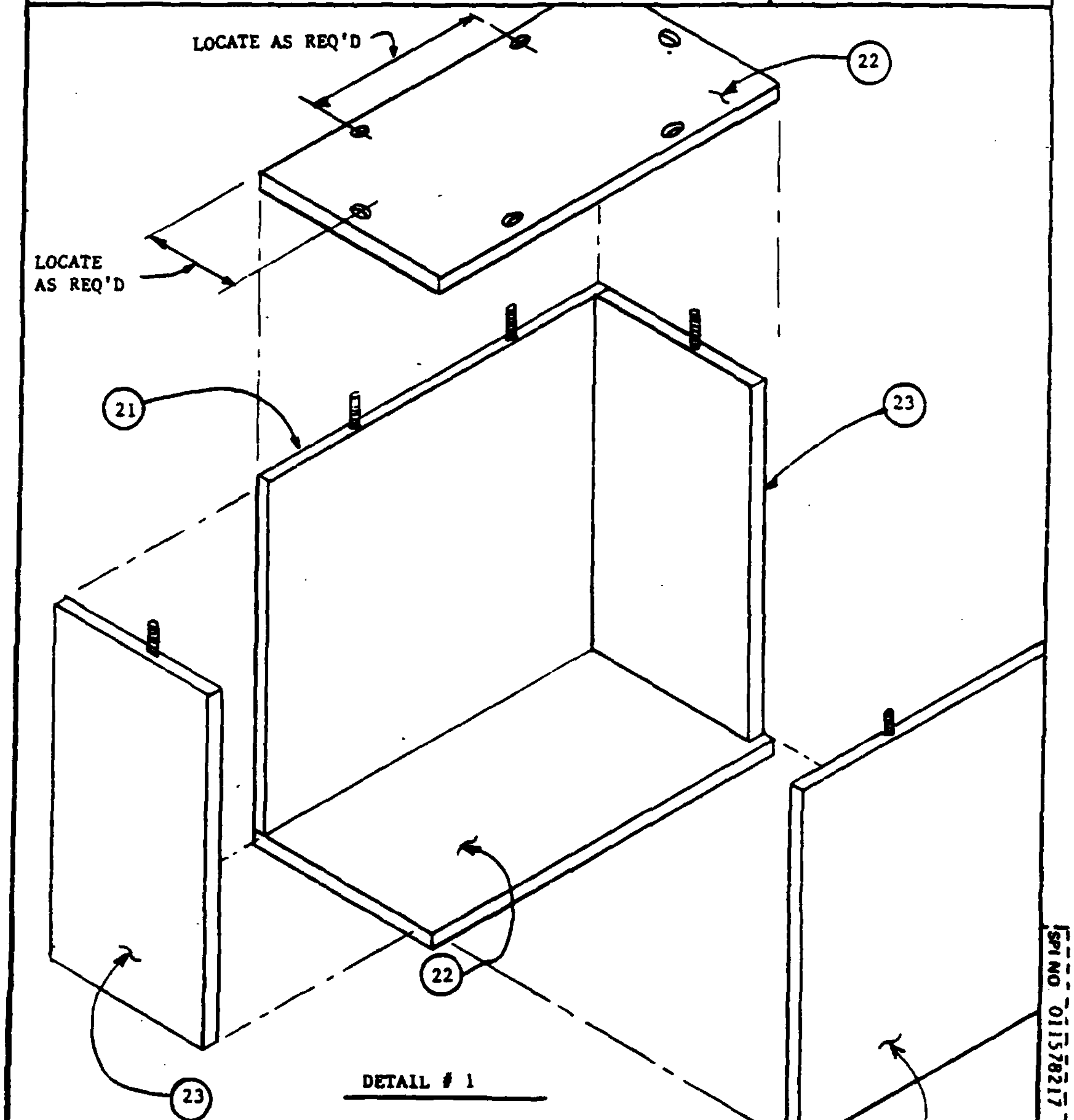
SPI NO. 011578217

GENERAL DYNAMICS *Fort Worth Division* **SPI (Continuation Sheet)**	CODE ID K0656	SPI NO. (TPO) 011578217
ITEM NOMENCLATURE DISPLAY UNIT		SHEET 4 OF 8



SPI NO. 011578217

GENERAL DYNAMICS *Fort Worth Division* **SPI (Continuation Sheet)**	CODE ID 81755	SPI NO. (TPO) 011578217
ITEM NOMENCLATURE DISPLAY UNIT		SHEET 5 OF 8



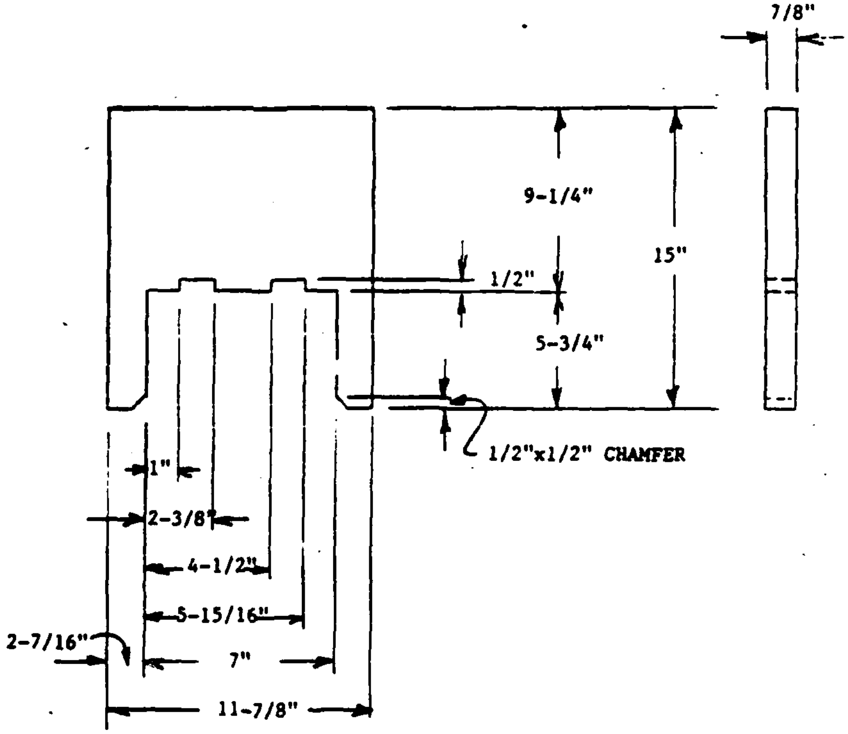
DETAIL # 1

NOTE:

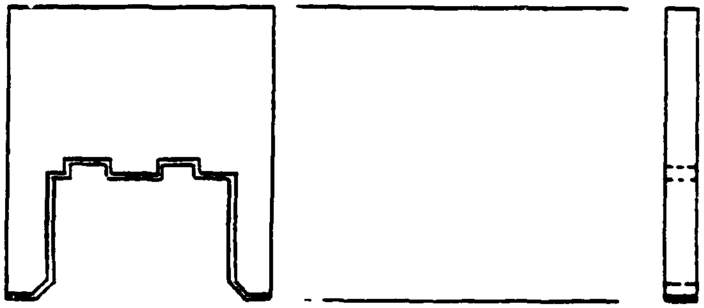
ADD TAPE, P/N 7 TO DETAIL 1 IN ORDER TO PROTECT BARRIER BAG, P/N 5.

SPI NO 011578217

GENERAL DYNAMICS *Fort Worth Division* **SPI (Continuation Sheet)**	CODE ID K0656	SPI NO. (TPO) 011578217
ITEM NOMENCLATURE DISPLAY UNIT		SHEET 6 OF 8



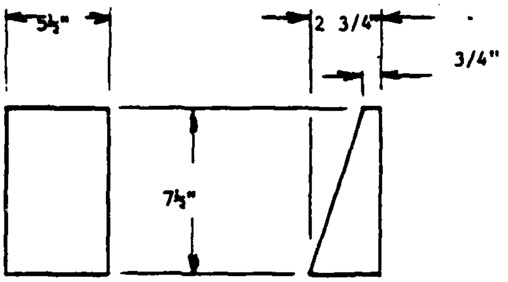
DETAIL PART 18



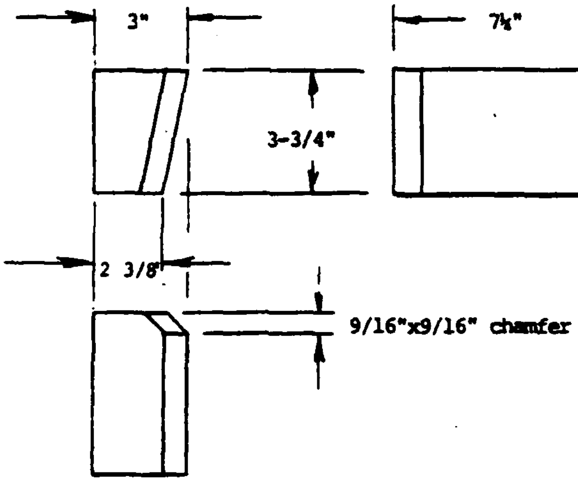
ASSEMBLY OF PART 18 & 14

SPI NO. 011578217

GENERAL DYNAMICS *Fort Worth Division* **SPI (Continuation Sheet)**	CODE ID K0656	SPI NO (TPO) 011578217
ITEM NOMENCLATURE DISPLAY UNIT		SHEET 7 OF 8



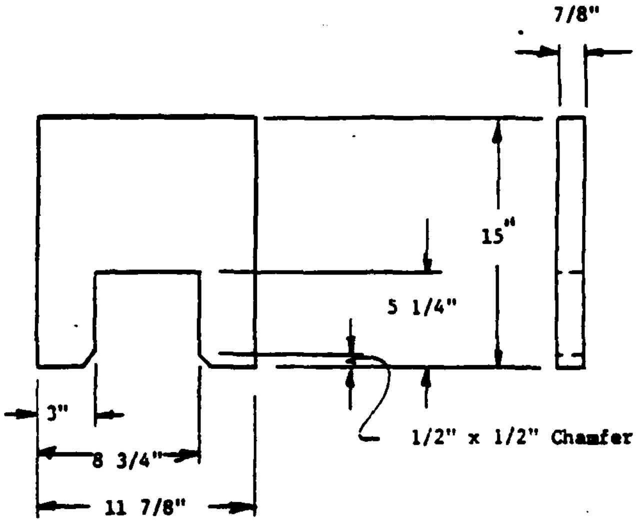
DETAIL PART (11)



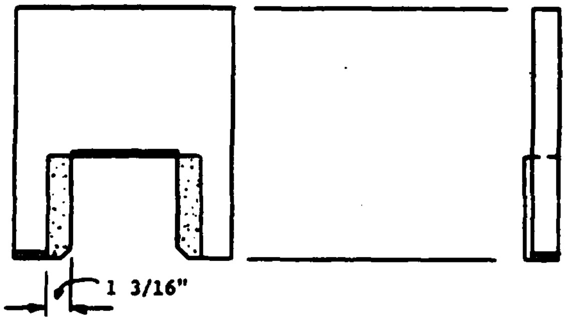
DETAIL PART (12)

SPI NO 011578217

GENERAL DYNAMICS *Fort Worth Division* **SPI (Continuation Sheet)**	**CODE ID** K0656	**SPI NO. (TPO)** 011578217
ITEM NOMENCLATURE Display Unit		**SHEET** 8 **OF** 8



Detail Part 20



Assembly of Part 20 & 13

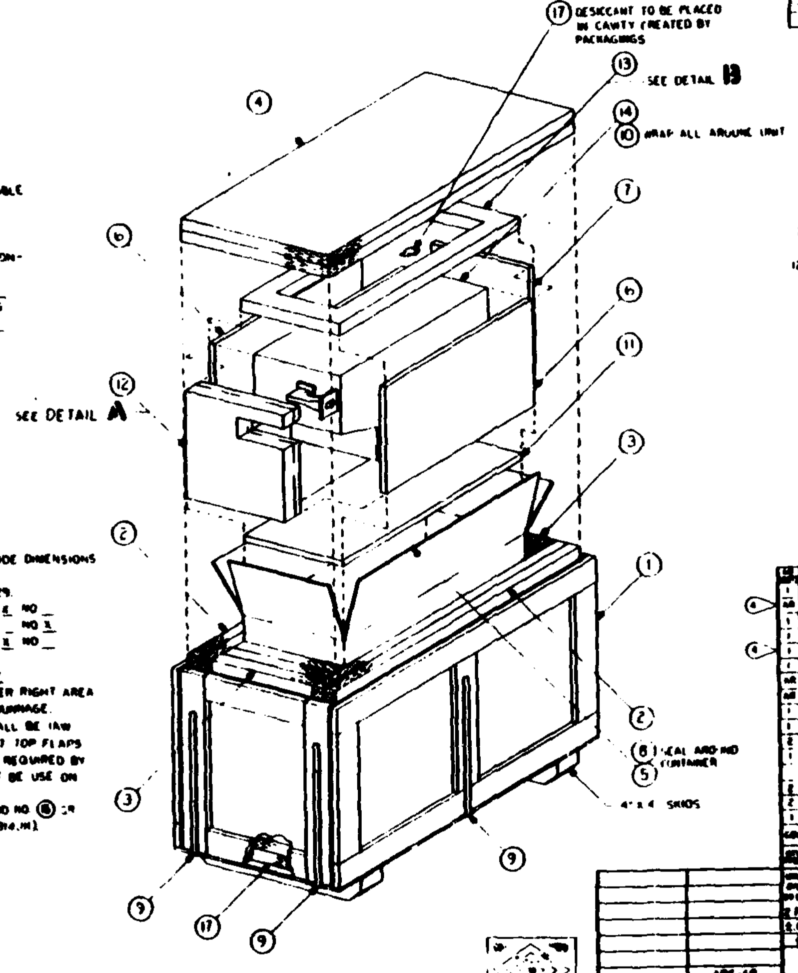
SPI NO. 011578217

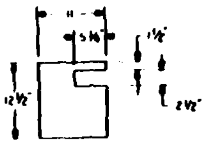
01-132-2441 1

PRESERVATION AND PACKAGING
LEVEL A
PRESERVE IAW MIL-P-116, METHOD II B
LEVEL B
SAME AS LEVEL A
LEVEL C
SAME AS LEVEL A EXCEPT BARRIER AND
DESICCANT WILL BE OMITTED
CLEANING AND DRYING IAW MIL-P-116
PRESERVATION COMPOUNDS NOT APPLICABLE
CUSHIONING AND DUNNAGE
SEE ITEM AND MATERIALS LIST
PACKING - LEVEL A, B, AND C
EXTERIOR SHIPPING CONTAINER SHALL CONFORM TO THE REQTS LISTED BELOW:

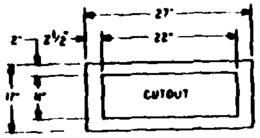
	SPEC	STYLE	TYPE
LVL A	PPP-B-601	A	OVERSEAS
LVL B	PPP-B-601	A	DOMESTIC
LVL C	PPP-B-601	A	DOMESTIC

SIZE ID: 40"L x 20"W x 25"H
GROSS CU: 17.6 CUBIC FT
GROSS WT: 222 LBS
ITEM DIM: 24.5"L x 8.5"W x 12.5"H
ITEM WT: 85 LBS





DETAIL A



DETAIL B

NOTES:
1. UNLESS OTHERWISE SPECIFIED, INSIDE DIMENSIONS ARE GIVEN FOR CONTAINERS.
2. MARKING SHALL BE IAW MIL-STD-129.
UP ARROW MARKING REQD YES X NO _
FRAGILE MARKING REQD YES _ NO X
METHOD II MARKING REQD YES X NO _
SPECIAL MARKING:
REUSABLE PACK - DO NOT DESTROY
TPO NUMBER 01-132-2441 ON LOWER RIGHT AREA OF ONE SIDE AND ON REMOVABLE DUNNAGE.
3. INTERIOR CONTAINER CLOSURE SHALL BE IAW APPLICABLE SPECIFICATION, EXCEPT TOP FLAPS SHALL BE CLOSED WITH TAPE AS REQUIRED BY PPP-B-636. ADHESIVE SHALL NOT BE USE ON TOP FLAPS.
4. FIND NO. ⑫ IS LAMINATED WITH FIND NO. ⑮ OR EQUIVALENT (WESTINGHOUSE PD553314.H)

QTY	PART NO	DESCRIPTION	SPEC		FIND NO
[illegible]		DESICCANT	MIL-D-3464	TY II	17
1		CUSHIONING, TOP, 40" x 20" x 4" THK	MIL-P-26514, TY I, CL 2, GR A		16
AR		ADHESIVE	MMM-A-[illegible]	3M SCOTCH GRIP	15
1		MODULAR LPRF			14
1		BLOCKING, MTR, 2" THK	PPP-C-1752, TY I, CL 2		13
1		BLOCKING, INTERIOR, 3" THK	PPP-C-1752, TY I, CL 2		12
1		BLOCKING, MTR, 27" x 17" x 1" THK	PPP-C-1752, TY I, CL 2		11
AR		POLYETHYLENE WRAP	L-P-378, TY I, CL 2		10
AR		STRAPPING, STEEL, FLAT	QQ-S-781, [illegible] CL 1, REG DUTY, FIN A		9
1		BARRIER, [illegible], 54" x 30"	MIL-B-131, CL 1		8
1		BLOCKING, MTR, [illegible] x 1" THK	PPP-C-1752, TY I, CL 2		7
2		BLOCKING, MTR, [illegible] x 1" THK	PPP-C-1752, TY I, CL 2		6
1		CONTAINER, 27" x 17" x 16"	PPP-B-636, TY CF, CL DOM, GR 275 STY RSC		5
1		CUSHIONING, BOT, 40" x 20" x 4" THK	MIL-P-26514, TY I, CL 2, GR A		4
2		CUSHIONING, END, [illegible] x 6" THK	MIL-P-26514, TY I, CL 2, GR A		3
2		CUSHIONING, SIDE, 40" x 17" x 4" THK	MIL-P-26514, TY I, CL 2, GR A		2
1		CONTAINER, SHIPPING, 40" x 20" x 25"	PPP-B-601	PLYWOOD, .375 THK	1

PARTS LIST

Westinghouse Electric Corporation

MODULAR LPRF

13 APR 84

APG-68

APPLICATION

D 18323 01-132-2441

GENERAL DYNAMICS
Fort Worth Division

SPECIAL PACKAGING INSTRUCTIONS (SPI)

CODE ID 81755	SPI NO. 01-156-0302 SHEET 1 OF 4		
PART OR DRAWING NO. 16E10000-857	NATIONAL STOCK NO. 5895011560302WF	CURRENT REV	ILL J.Sanchez CHK C.Brown ENGR C.Brown AUTH
ITEM NOMENCLATURE ELECT UNIT ASSY		ORIGINAL DATE 84326	

PRESERVATION IAW MIL-P-116

LEVEL A	IIb
LEVEL B	IIb
LEVEL C	III (see note 1)

PACKING AS SPECIFIED BELOW AND BILL OF MATERIALS

LEVEL	SPEC	STYLE	TYPE	CL	VAR	GR
A	PPP-B-601	A	OVERSEAS			
B	PPP-B-636	RSC	CF	WR	SW	V3c
C	PPP-B-636	RSC	CF	DOM	SW	350

	LEVEL A	LEVEL B	LEVEL C
GROSS CU FT	4.88	3.88	3.88
GROSS WT LBS	62	43	43

CLEANING C1 C-1
DRYING D4 D-4
PRESERVATIVE N/A

MARKING IAW MIL-STD-129
SPECIAL MARKING:
A. Mark "SPI 01-156-0302 on Lower Right Area of One Side"
B. Outside Dimensions in Inches Required
C. "Reusable Container – Do Not Destroy"
D. Method II labels req'd for Level A & B packs

	LENGTH		WIDTH		DEPTH	
CTNR I.D.	23½	IN.	19	IN.	13-3/4	IN.
CTNR O.D. "A"	25½	IN.	21	IN.	15-3/4	IN.
CNTR O.D. "B"	23-7/8	IN.	19-3/8	IN.	14½	IN.
CTNR O.D. "C"	23-7/8	IN.	19-3/8	IN.	14½	IN.
ITEM DIM	14½	IN.	11	IN.	6-3/4	IN.

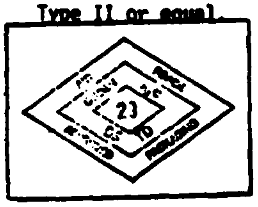
ITEM WT LBS 25.38

CLOSURE INSTRUCTIONS: Level A close I.A.W. PPP-B-601 Para 3.6
Levels B & C close I.A.W. Method 102 of Fed Std. No. 224 and Tables VI or IX of PPP-B-636.

OPENING INSTRUCTIONS: Do not open until ready for use/inspection.
After opening save all cushioning/dunnage for repacking.

NOTES:

1. For Level C delete barrier bag P/N 5, desiccant P/N 6, indicator P/N 7.
2. Level B pack shown on pages 3 & 4.
3. References 9, 10, 11 and 12 may be constructed from one piece fiberboard or laminated to a tolerance of + or - 1/8 inches. If laminated use MMM-A-250. Type II or equal.



SPI No. 01-156-0302

GENERAL DYNAMICS
Fort Worth Division

SPI (Continuation Sheet)

CODE ID: 81755

SPI NO.: 01-156-0302

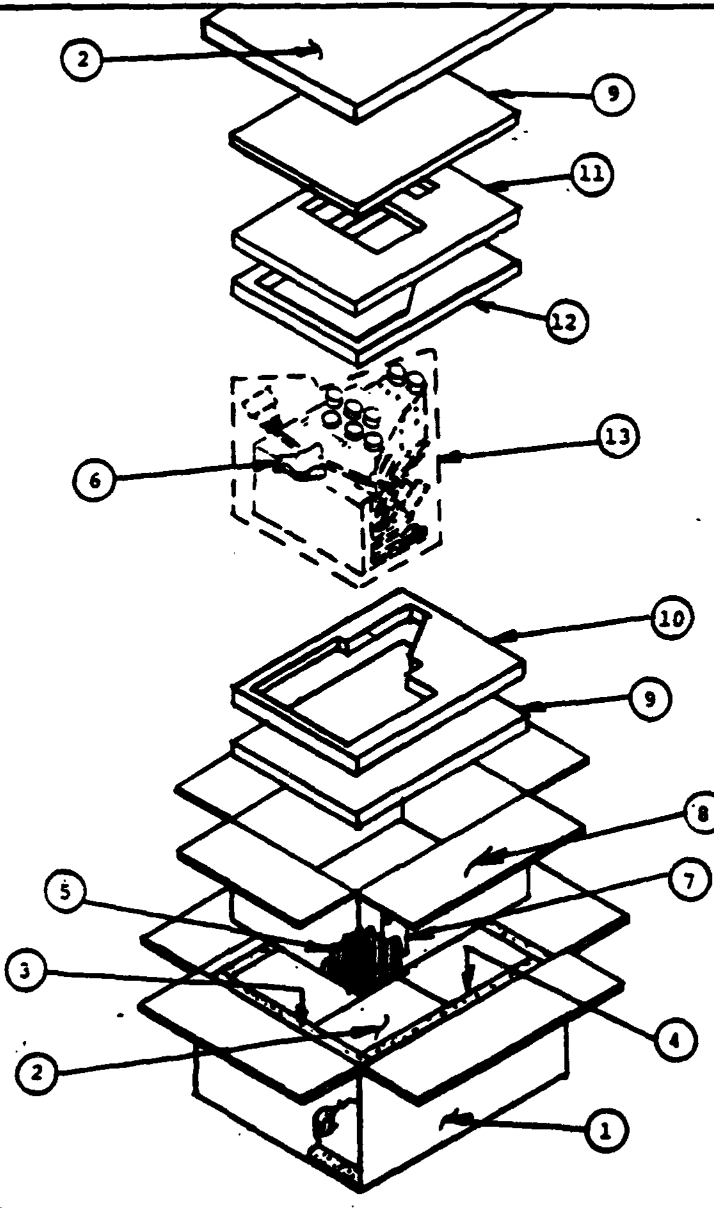
ITEM NOMENCLATURE: ELECT UNIT ASSY

SHEET 2 OF 4

PART NO.	QTY REQD	NOMENCLATURE OR DESCRIPTION	SIZE	MATERIAL SPECIFICATION
.50				
.49				
.48				
.47				
.46				
.45				
.44				
.43				
.42				
.41				
.40				
.39				
.38				
.37				
.36				
.35				
.34				
.33				
.32				
.31				
.30				
.29				
.28				
.27				
.26				
.25				
.24				
.23				
.22				
.21				
.20				
.19				
.18				
.17				
.16				
.15				
.14				
.13	1	Polyvapo	38"x23"x.002"	L-P-378,Ty.I,Cl.1,Gr.B, Fin 1
.12	1	Top cutout	18"x14"x7/8" see detail	PPP-F-320,Ty.CF,Cl.Dom, DW, 200
.11	1	Upper cutout	18"x14"x7/8" see detail	PPP-F-320,Ty.CF,Cl.Dom, DW, 200
.10	1	Bottom cutout	18"x14"x7/8" see detail	PPP-F-320,Ty.CF,Cl.Dom, DW, 200
.9	2	Top/bottom pad	18"x14"x7/8" see detail	PPP-F-320,Ty.CF,Cl.Dom, DW, 200
.8	1	Inner container	18"x14"x8-3/4" I.D.	PPP-B-636,RSC,CF,Dom,SW,350
.7	1	Humidity indicator	Standard	MS20003-2
.6	1	Desiccant	52 units	MIL-D-3464 Type I
.5	1	Barrier Bag	51"x32" sheet size	MIL-B-117,Ty.I,Cl.E,Sc.1
.4	2	Side foam cushion	19½"x8-3/4"x2"	MIL-P-26514,Ty.I,Cl.2,Gr.C
.3	2	End foam cushion	19"x8-3/4"x2"	MIL-P-36514,Ty.I,Cl.2,Gr.C
.2	2	Top/btm foam cush.	23½"x19"x2"	MIL-P-26514,Ty.I,Cl.2,Gr.C
.1	1	Outer container	23½"x19"x13-3/4" I.D.	See packing levels sheet 1

01-156-0302

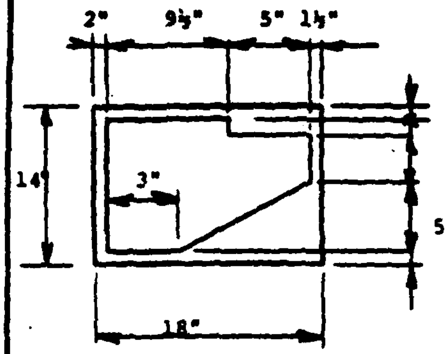
GENERAL DYNAMICS Fort Worth Division SPI (Continuation Sheet)	CODE ID 81755	SPI NO. (TYO) 01-156-0302
ITEM NOMENCLATURE ELECT. UNIT ASSY		SHEET 3 OF 4



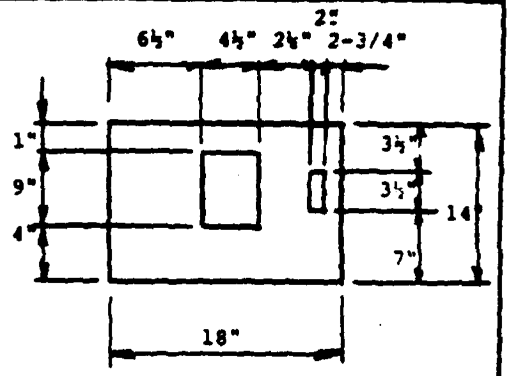
SPI NO. 01-156-0302

GENERAL DYNAMICS
Fort Worth Division
SPI (Continuation Sheet)

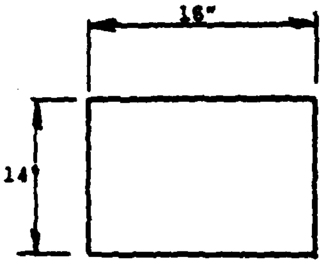
CODE ID	SPI NO. (TPS)	
81755	01-156-0302	
ITEM NOMENCLATURE	SHEET 4 OF 4	
ELECT UNIT ASSY		



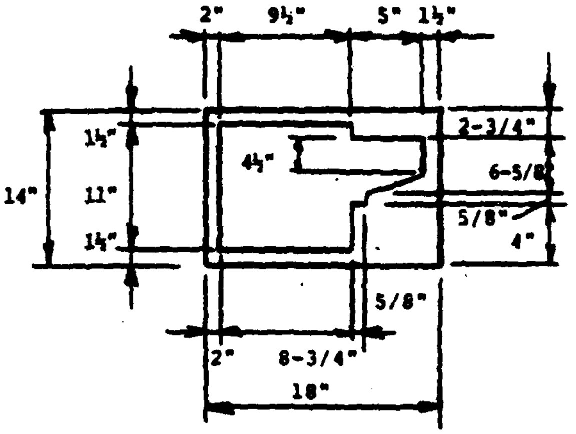
DETAIL PART ⑫



DETAIL PART ⑪



DETAIL PART ⑨



DETAIL PART ⑩

SPI NO. 01-156-0302

GENERAL DYNAMICS *Fort Worth Division* **SPECIAL PACKAGING INSTRUCTIONS (SPI)**	CODE ID 81755	SPI NO. 01-148-6286 SHEET 1 OF 4

PART OR DRAWING NO.	NATIONAL STOCK NO.	CURRENT REV	
16E1535-835, [illegible]	1280011486286[illegible]	A	ILL J. SANCHEZ CHK C. BROWN ENGR C. BROWN AUTH
ITEM NOMENCLATURE ADVANCED CIU		**ORIGINAL DATE** 84325	24 DS TD 87173

PRESERVATION IAW MIL-P-116

LEVEL A	IIb
LEVEL B	IIb
LEVEL C	III (SEE NOTE 1)

PACKING AS SPECIFIED BELOW ~~AND BILL OF MATERIALS~~

LEVEL	SPEC	STYLE	TYPE	CL	VAR	GR
A	PPP-B-601	A	OVERSEAS			
B	PPP-B-636	RSC	CF	WR	SW	V3c
C	PPP-B-636	RSC	CF	DOM	SW	350

CLEANING C-1
DRYING D-4
PRESERVATIVE N/A

	LEVEL A	LEVEL B	LEVEL C
GROSS CU FT	9.06	7.52	7.52
GROSS WT LBS	109	82	82

MARKING IAW MIL-STD-129

SPECIAL MARKING:
A. Mark "SPI 01-148-6286 on Lower Right Area of One Side"
B. Outside Dimensions in Inches Required
C. "Reusable Container – Do Not Destroy"
D. METHOD II LABELS REQ'D FOR LEVELS A&B

	LENGTH	WIDTH	DEPTH
CTNR I.D.	24 5/8 IN.	20 5/8 IN.	24 IN.
CTNR O.D. "A"	26 5/8 IN.	22 5/8 IN.	26 IN.
CNTR O.D. "B"	25 IN.	21 IN.	24 3/4 IN
CTNR O.D. "C"	25 IN.	21 IN.	24 3/4 IN.
ITEM DIM	14 1/2 IN.	10 3/4 IN.	13 1/4 IN.

ITEM WT LBS 57.00

CLOSURE INSTRUCTIONS LEVEL A CLOSE IAW PPP-B-601 PARA. 3.6
LEVEL B OR C CLOSE IAW METHOD 102 OF FED STD. NO. 224 AND TABLES VI OR IX OF PPP-B-636.

OPENING INSTRUCTIONS DO NOT OPEN UNTIL READY FOR USE/INSPECTION. AFTER OPENING SAVE ALL CUSHIONING/DUNNAGE FOR REPACKING.

NOTES:

1. FOR LEVEL C DELETE BARRIER BAG P/N 5, DESICCANT P/N 6, INDICATOR P/N 7.
2. LEVEL B PACK SHOWN ON PAGES 3 & 4
3. TOP LAYER OF FOAM CUSHION LEFT OUT FOR CLARITY (P/N 2)

REVISIONS			
LTR	DESCRIPTION	DATE	APRVD
A	Added a Part No.; Changed Cutout for Part 11.	87142	

SPI No. 01-148-6286

GENERAL DYNAMICS *Fort Worth Division* ***SPI (Continuation Sheet)***	**CODE ID** 81755	**SPI NO.** 01-148-6286
ITEM NOMENCLATURE ADVANCED CIU		**SHEET** 2 **OF** 4

PART NO.	QTY REQD	NOMENCLATURE OR DESCRIPTION	SIZE	MATERIAL SPECIFICATION
.50				
.49				
.48				
.47				
.46				
.45				
.44				
.43				
.42				
.41				
.40				
.39				
.38				
.37				
.36				
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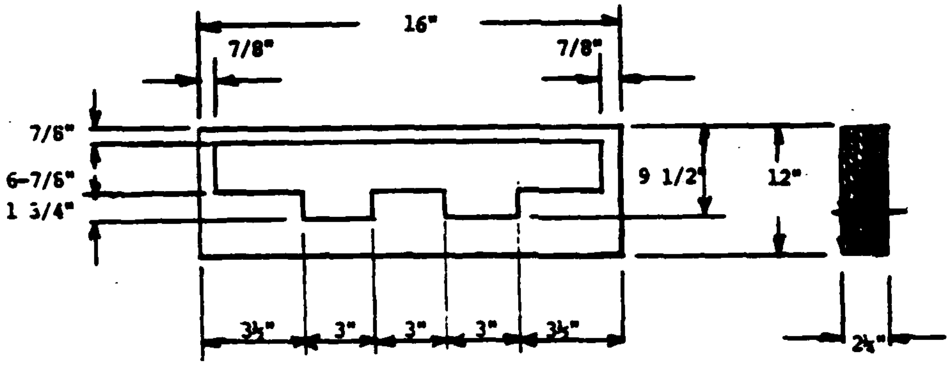
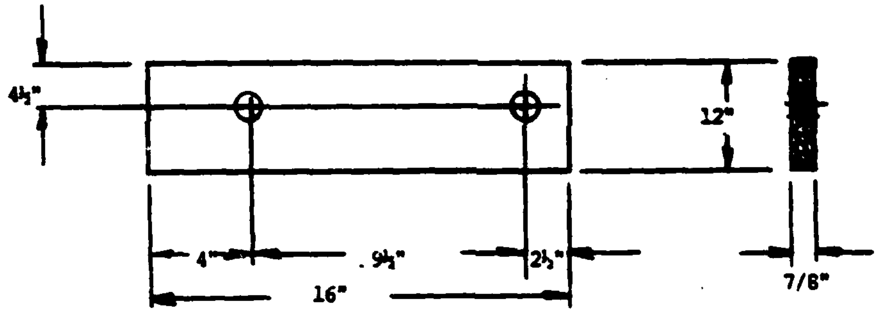
.24				
.23				
.22				
.21				
.20				
.19				
.18				
.17				
.16				
.15				
.14				
.13				
.12	1	Poly,wrap.	52"x31"x.002"	L-P-378,Ty.I,Cl.1,Gr.B
.11	1	Upper cutout	16"x12"x2¼"(See detail)	PPP-F-320,Ty.CF,Cl.DOM
.10	1	Lower cutout	16"x12"x7/8"(See detail)	PPP-F-320,Ty.CF,Cl.DOM
.9	2	Top/btm.pads	16"x12"x7/8"(see detail)	PPP-F-320,Ty.CF,Cl.DOM
.8	1	Inner container	16"x12"x15"I.D.	PPP-B-636,RSC,CF,DOM,SW,350
.7	1	Humidity indicator	standard	MS20003-2
.6	1	Desiccant	80 units	MIL-D-3464 Type 1
.5	1	Barrier bag	61"x37"(sheet size)	MIL-B-117,Ty.I,Cl.E,St.1
.4	2	Side foam cush.	16-5/8"x16"x4"	MIL-P-26514,Ty.I,Cl.2,Gr.C
.3	2	End foam cush.	20-5/8"x16"x4"	MIL-P-26514,Ty.I,Cl.2,Gr.C
.2	2	Top/btm.foam cush.	24-5/8"x20-5/8"x4"	MIL-P-26514,Ty.I,Cl.2,Gr.C
.1	1	Outer container	24-5/8"x20-5/8"x24"I.D.	See packing levels,sheet 1

SPI NO. 01-148-6286

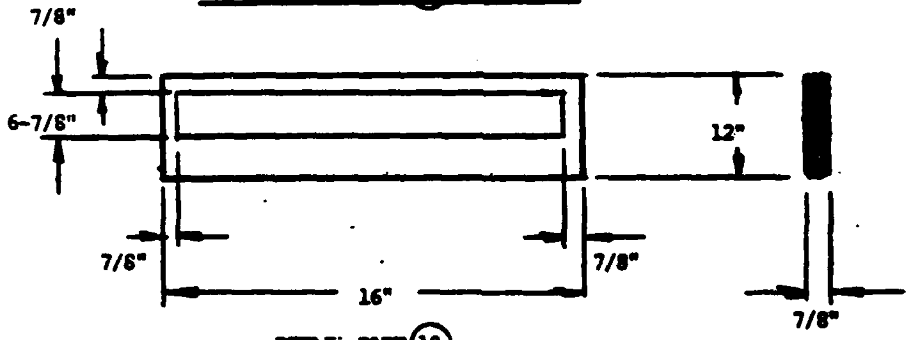
GENERAL DYNAMICS *Fort Worth Division* **SPI (Continuation Sheet)**	**CODE ID** 81755	**SPI NO. (TPO)** 01-148-6286
ITEM NOMENCLATURE ADVANCED CIU		**SHEET** 4 **OF** 4



DETAIL PART ⑪



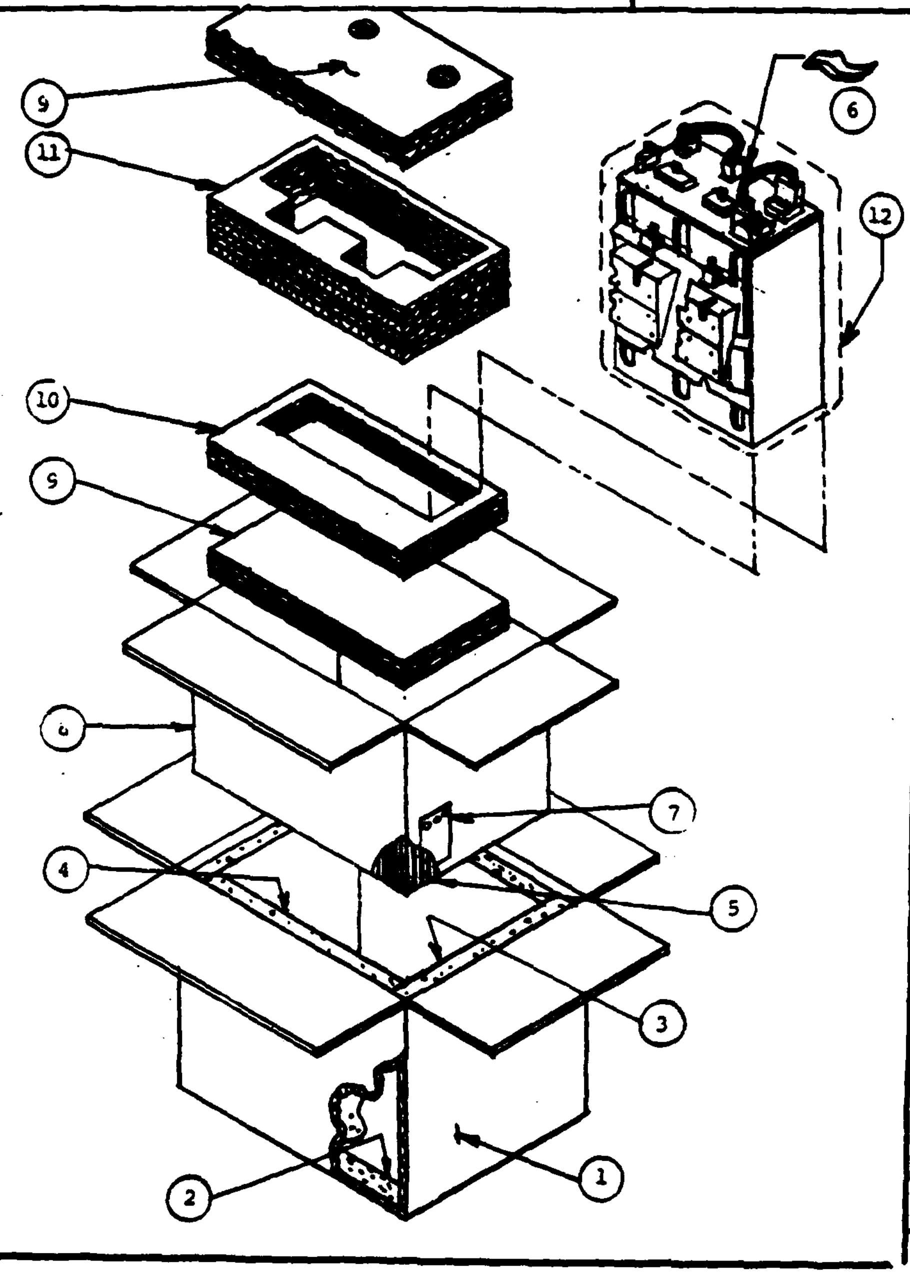
DETAIL PART ⑨



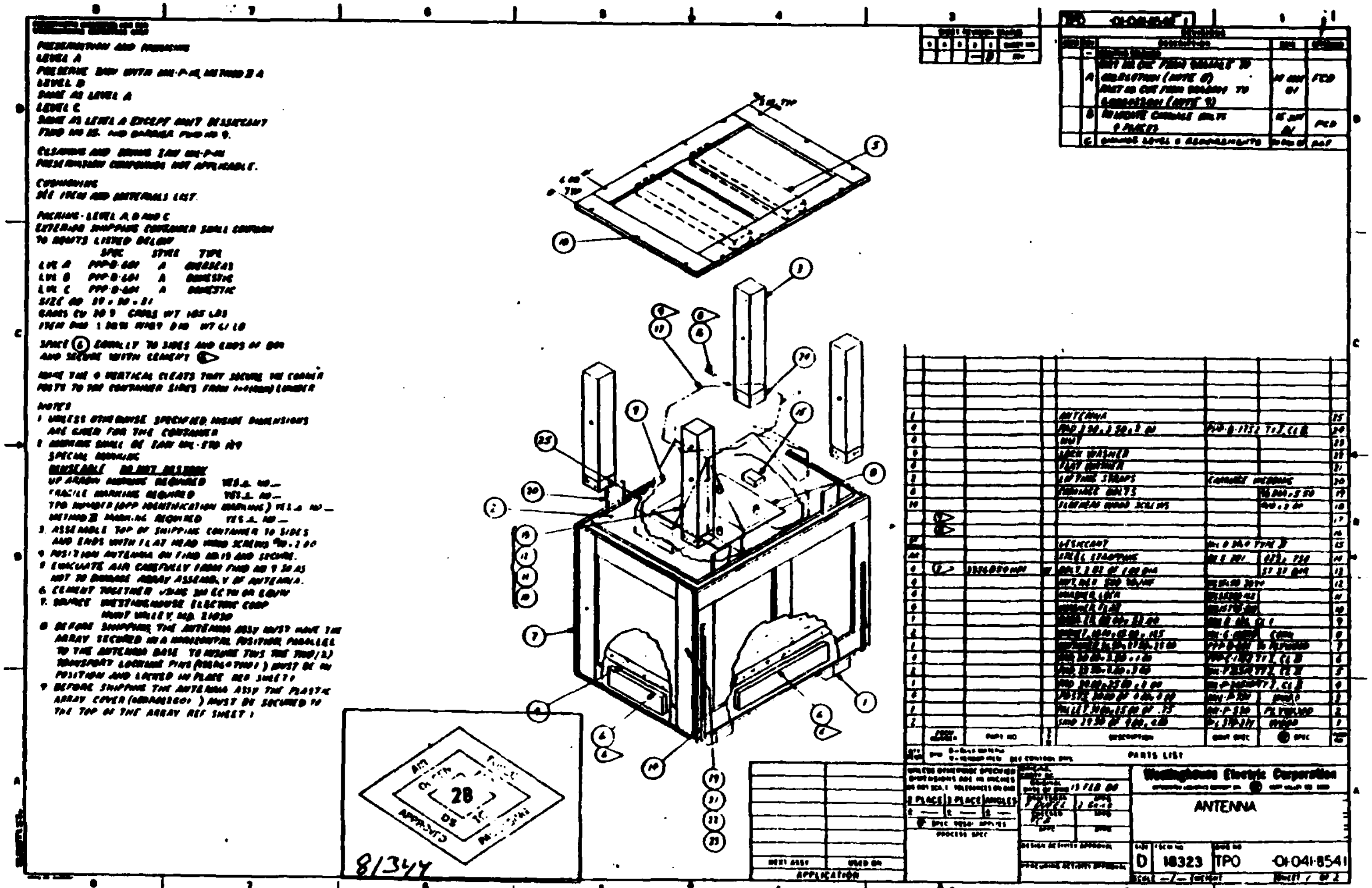
DETAIL PART ⑩

SPI NO. 01-148-6286

GENERAL DYNAMICS *Fort Worth Division* **SPI (Continuation Sheet)**	CODE ID 81755	SPI NO. (TPS) 01-148-6286
ITEM NOMENCLATURE ADVANCED CIU		SHEET 3 OF 4



SPI NO. 01-148-6286



PRESERVATION AND PACKING
LEVEL A
PRESERVE [illegible] WITH MIL-P-116, METHOD II A
LEVEL B
SAME AS LEVEL A
LEVEL C
SAME AS LEVEL A EXCEPT OMIT DESICCANT
FIND NO 15 AND BARRIER FIND NO 9.

CLEANING AND DRYING [illegible] MIL-P-116
PRESERVATION COMPOUNDS NOT APPLICABLE.

CUSHIONING
SEE ITEM AND MATERIALS LIST.

PACKING - LEVEL A, B AND C
EXTERIOR SHIPPING CONTAINER SHALL CONFORM
TO [illegible] LISTED BELOW

	SPEC	STYLE	TYPE
LVL A	PPP-B-601	A	OVERSEAS
LVL B	PPP-B-601	A	DOMESTIC
LVL C	PPP-B-601	A	DOMESTIC

SIZE OD [illegible]
[illegible] CU [illegible] GROSS WT 105 LBS
[illegible]

SPACE ⑥ EQUALLY TO SIDES AND ENDS OF BOX
AND SECURE WITH CEMENT

[illegible] THE 8 VERTICAL CLEATS THAT SECURE THE CORNER
POSTS TO THE CONTAINER SIDES FROM [illegible] LUMBER

NOTES
1. UNLESS OTHERWISE SPECIFIED INSIDE DIMENSIONS ARE GIVEN FOR THE CONTAINER
2. MARKING SHALL BE [illegible] MIL-STD-129
SPECIAL MARKING
REUSABLE DO NOT DESTROY
UP ARROW MARKING REQUIRED YES ⊥ NO —
FRAGILE MARKING REQUIRED YES ⊥ NO —
TPO NUMBER (OPP IDENTIFICATION MARKING) YES ⊥ NO —
METHOD II MARKING REQUIRED YES ⊥ NO —
3. ASSEMBLE TOP OF SHIPPING CONTAINER TO SIDES AND ENDS WITH FLAT HEAD WOOD SCREWS [illegible]
4. POSITION ANTENNA ON FIND NO 19 AND SECURE.
5. EVACUATE AIR CAREFULLY FROM FIND NO 9 SO AS NOT TO DAMAGE ARRAY ASSEMBLY OF ANTENNA.
6. CEMENT TOGETHER USING [illegible] OR EQUIV
7. SOURCE WESTINGHOUSE ELECTRIC CORP
HUNT VALLEY, MD. 21030
8. BEFORE SHIPPING THE ANTENNA ASSY MUST HAVE THE ARRAY SECURED IN A HORIZONTAL POSITION PARALLEL TO THE ANTENNA BASE. TO INSURE THIS THE TWO (2) TRANSPORT LOCKING PINS ([illegible]) MUST BE IN POSITION AND LOCKED IN PLACE REF SHEET 1
9. BEFORE SHIPPING THE ANTENNA ASSY THE PLASTIC ARRAY COVER ([illegible]) MUST BE SECURED TO THE TOP OF THE ARRAY REF SHEET 1

		PART NO		DESCRIPTION		SPEC	
1				ANTENNA			25
4				ROD [illegible]	PPP-B-1152 TY I, CL B		24
4				NUT			23
4				LOCK WASHER			22
4				FLAT WASHER			21
2				LIFTING STRAPS	[illegible]		20
4				CARRIAGE BOLTS		[illegible]	19
10				FLATHEAD WOOD SCREWS		[illegible]	18
							17
							16
AR				DESICCANT	MIL-D-3464 TYPE II		15
AR				STEEL STRAPPING	QQ-S-781	[illegible]	14
4	1	[illegible]		BOLT [illegible]		[illegible]	13
[illegible]				[illegible]	[illegible]		12
[illegible]				[illegible]	[illegible]		11
[illegible]				[illegible]	[illegible]		10
[illegible]				[illegible]	[illegible]		9
[illegible]				[illegible]	[illegible]	[illegible]	8
[illegible]				[illegible]	[illegible]		7
[illegible]				[illegible]	[illegible]		6
[illegible]				[illegible]	[illegible]		5
[illegible]				[illegible]	[illegible]		4
[illegible]				[illegible]	[illegible]	[illegible]	3
[illegible]				[illegible]	[illegible]	[illegible]	2
[illegible]				[illegible]	[illegible]	[illegible]	1

PARTS LIST

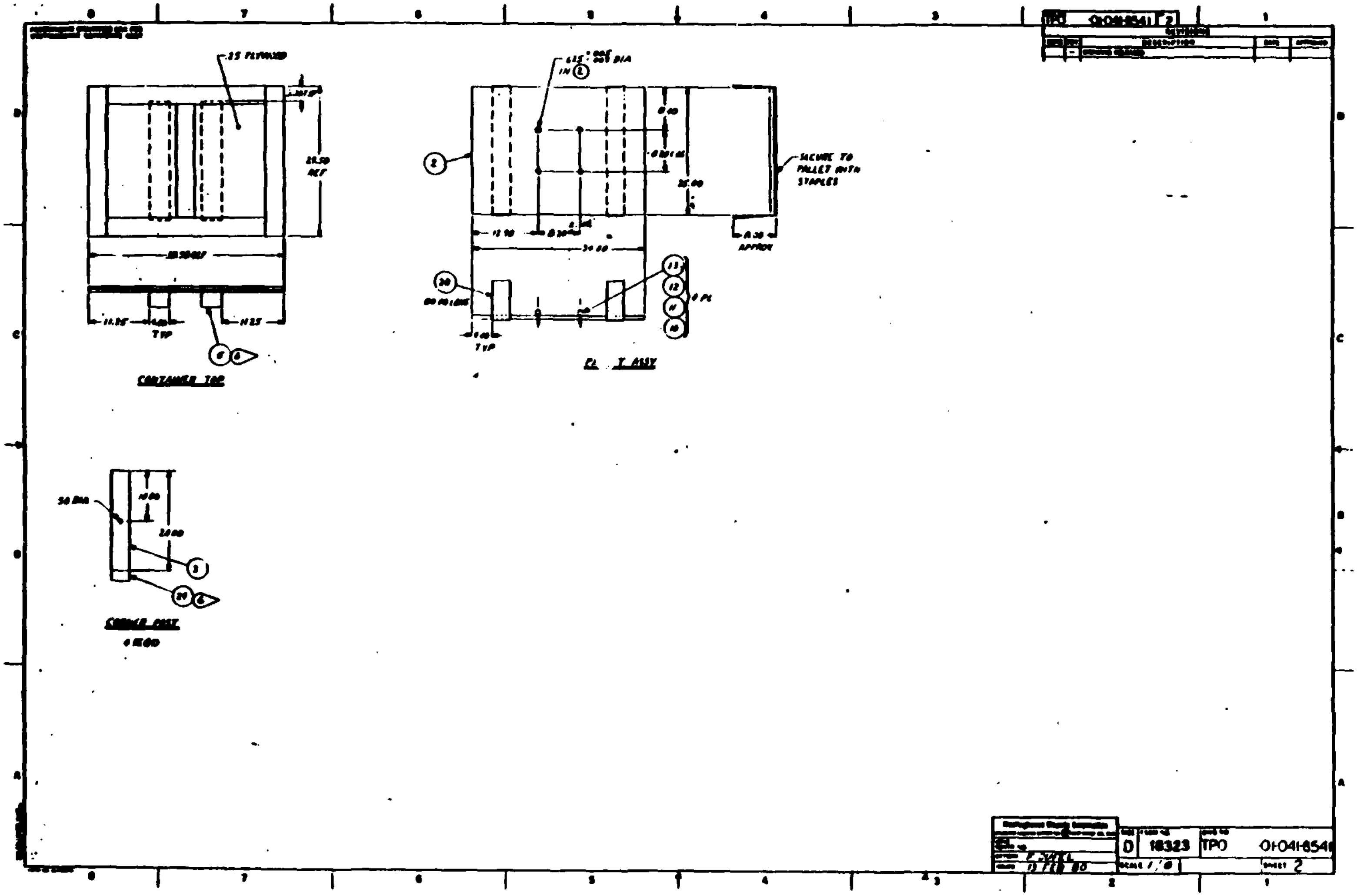
Westinghouse Electric Corporation

ANTENNA

D 18323 TPO 01-041-8541

SCALE —/— SHEET 1 OF 2

APPLICATION


.25 PLYWOOD
23.50 REF
TYP
11.25
6
CONTAINER TOP
.615 DIA
IN 2
2
8.00
25.00
SECURE TO
PALLET WITH
STAPLES
APPROX
12.90
30.00
20
8 PL
13
12
11
10
TYP
T ASSY
50 DIA
10.00
20.00
3
CORNER POST
4 REQD
TPO
01-041-8541
2
D
18323
SCALE 1/8
SHEET 2

SHEET REV. STATUS					
5	4	3	2	1	SHEET NO.
-	-	-	-	A	REV.

DWG NO. 01-132-2680 SH. 1

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APP'D
	-	DRAWING RELEASED	7-1-83	GM
	A	METHOD AND CONTAINER CHANGE	10-6-83	

RB 87065

PRESERVATION AND PACKAGING

LEVEL A
PRESERVE IAW MIL-P-116, METHOD IIa
LEVEL B
SAME AS LEVEL A EXCEPT DOM. SHIPPING CONTAINER IS USED.
LEVEL C
SAME AS LEVEL B EXCEPT UNIT BARRIER BAG AND DESICCANT. MIL-P-116, METHOD III
CLEANING AND DRYING IAW MIL-P-116

PACKING

LEVEL A: MIL-C-26195, TY II, ST A, CL 1
LEVEL B: MIL-C-26195, TY I, ST A, CL 1
LEVEL C: SAME AS LEVEL B
SIZE OD: L 39.39" W 30" D 29"
GROSS CUBE 17.9 GROSS WEIGHT 200 LBS

MARKING

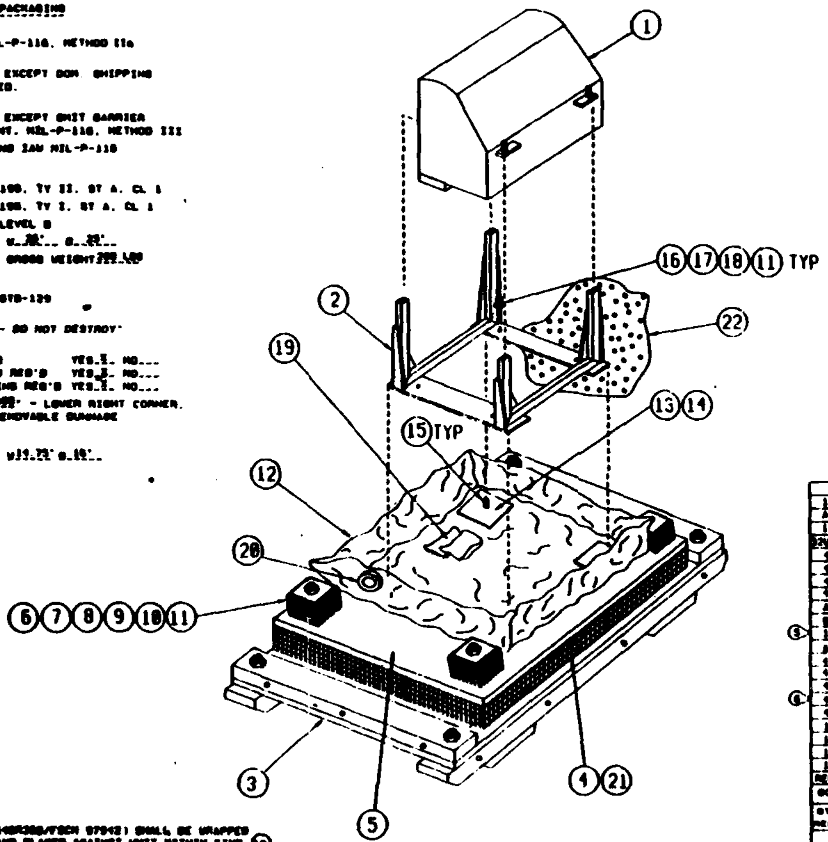
SHALL BE IAW MIL-STD-129
SPECIAL MARKING:
"REUSABLE PACK - DO NOT DESTROY"
ON FOUR SIDES

UP ARROWS REQ'D YES X NO
FRAGILE MARKING REQ'D YES X NO
METHOD II MARKING REQ'D YES X NO

TPD NO. "01-132-2680" - LOWER RIGHT CORNER, ONE SIDE AND ON REMOVABLE DUNNAGE

BARE ITEM DATA

DIMENSIONS L 19.9" W 13.75" D 19"
WEIGHT 110 LBS



NOTES:

1. HANDLE ASSY (3406R360/FSCM 97942) SHALL BE WRAPPED WITH FIND 22 AND PLACED AGAINST UNIT WITHIN FIND 12.
2. CONTAINER CLOSURE AND REINFORCEMENT SHALL BE IAW APPLICABLE SPEC.
3. CAPTIVE SCREWS SECURING UNIT TO MOUNTING FIXTURE 2 SHALL BE LOOSENED PRIOR TO ATTACHING HANDLING FIXTURE (2143009) TO UNIT WHEN UNPACKING.
4. ONLY UNIT SHALL BE LOOSENED FROM CONTAINER BASE, UNLESS REFURBISHMENT IS REQUIRED.
5. FABRICATE BARRIER BAG IAW MIL-E-6060
6. OR EQUIVALENT

QTY REQD	FSCM NO	PART NO	SYM	DESCRIPTION	GOVT SPEC	SPEC	FIND NO
1				WRAP, PROTECTIVE 70X80"	PPP-C-795	CL 1	22
AR				ADHESIVE	MMM-A-120		21
1				HUMIDITY INDICATOR	MIL-I-26860	TY II	20
32UNITS				DESICCANT	MIL-D-3464	TY II	19
4				WASHER, LOCK .375"	MS35338-81		18
4				WASHER, FLAT .375"	AN960-616		17
4				NUT, HEX .375"	MS51972-3		16
4				BOLT, SQ. SHORT NECK .375X2"	FF-B-584	TY I, CL 1	15
AR				ADHESIVE, RUBBER BASE	MMM-A-1617	TY III	14
8				GASKET, CORK 4X4"	MIL-G-12803		13
1				BARRIER, MOIST./VAPOR 70X42"	MIL-B-131	CL 1	12
AR				ADHESIVE, POLYESTER RESIN	MIL-S-22473	GR E	11
4				WASHER, FLAT .375"	AN960-616		10
4				NUT, HEX .375"	MS51972-3		9
4				BOLT, SQ. SHORT NECK .375X8"	FF-B-584	TY I, CL 1, ST A	8
1	1V720	0690092		PLATE, FLOATING PALLET 4X4X.125"	QQ-S-741		7
4				PAD, RECOIL 4X4X2" NOM.	PPP-C-1752	TY I, CL 2	6
1				PALLET, PLYWOOD 28X22X.75"	NN-P-530		5
1				PAD, CUSHIONING 28X22X3"	MIL-P-26514	TY I, CL 2, GR C	4
1				SHIPPING CNTNR 37.5X28.5X29"OD	MIL-C-26195	TY II, ST A, CL 1	3
1	18323	2009021		MOUNTING FIXTURE			2
REF				TRANSMITTER, DUAL MODE			1

SYM: B= BULK MATERIAL V= VENDOR ITEM

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE. TOLERANCES ON DIM.

2 PLACE	3 PLACE	ANGLES
± .30	± -	± - °

ORIG. DATE OF DWG 2 JUNE '83
DRAFTSMAN VERSACAD
CHECKER G. WEYHER
DESIGN ACTIVITIES APPROVAL

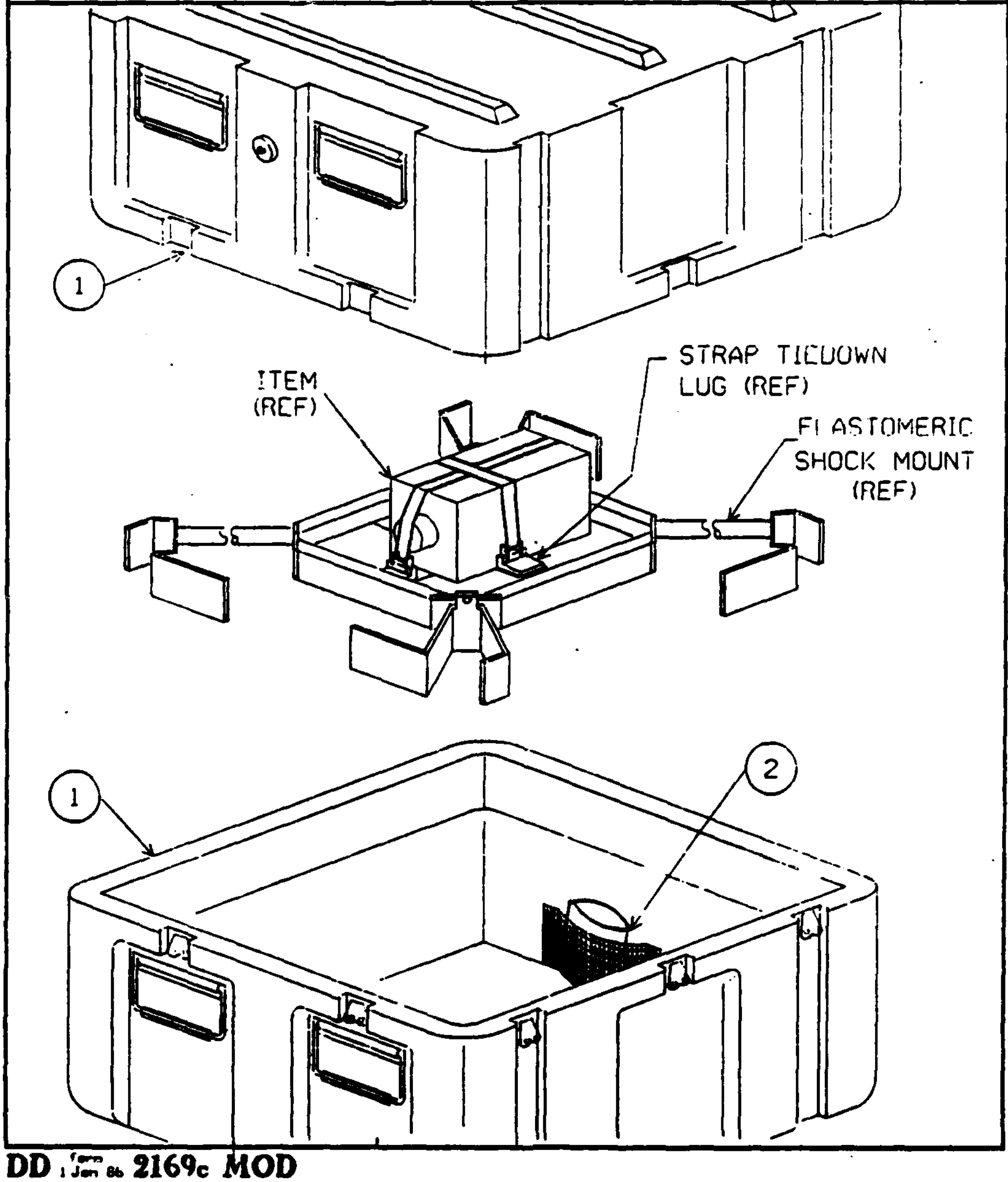
APS-60
NEXT ASSY / USED ON
APPLICATION

Westinghouse Electric Corp.
Integrated Logistics Support Division Hunt Valley, MD

TRANSMITTER, DUAL MODE, PACKAGING DETAIL

SIZE D FSCM NO 18323 DWG NO 01-132-2680
SCALE NONE WGT. 200 LBS SHEET 1 OF 1

SPECIAL PACKAGING INSTRUCTION	CODE ID 97151	SPI NO. / TPD 01-236-5003
ITEM NOMENCLATURE SHIP/STORE CONT, MULTIPURPOSE CNU-429-E		SHEET 2 OF 3



SPI NO. 01-236-5003

SPECIFICATION SHEET
FOR
AIR FORCE
LOW FRAGILITY CONTAINER SYSTEM

Container	Container OD (Inches)	Weight (Empty)	Weight Range (Lbs)	Item Size (Inches) Max/Min	Platform Size I. D. (Inches)	Cost Qty's of 50/100
1	27.5X26X25 8145-01-235-1113	51.5 lbs.	10 to 16.5	10.5X9.75X9.25/ 4X4X5	11 X 12 (Maximum Item Ht=9.25)	$498.80/ 481.85
2	35.25X35.25X30.25 8145-01-235-1112	105.5	12 to 25	21X21X15.75/ 8X6X5	21 X 21 (Maximum Item Ht=15.75)	$685.20/ 662.20
3	35.25X35.25X30.25 8145-01-236-5003	107.0	25 to 54	21X21X15.75 12X6X6.75	21 X 21 (Maximum Item Ht=15.75)	$671.75/ 649.25
4	41.13X37X39.13 8145-01-235-1114	139.5	40 to 91	25X21X20.8/ 15.5X8.75X7.75	23 X 27 (Maximum Item Ht=21.5)	$813.35/ 786.25

FEATURES: Wide application for delicate items.
Low Fragility: 15G protection from -20 degrees F to + 140 degrees F.
Wide weight range: 10 to 91 pounds net weight.
Easy loading platform support.
New design strap tiedown system with stops to prevent side movement.
Durable, rotationally molded plastic cases.
Full method II protection in accordance with MIL-P-116.

Appendix F: Transportation Cost Matrices

Table 22. Costs for Shipments of 100 to 199 Pounds, in Dollars per Pound per Round Trip

ORIGIN BASE	DESTINATION			
	G.D.	W.E.C.	SPERRY	OO-ALC
KUNSAN	4.63	4.67		3.33
MISAWA	4.42	4.46		3.12
SPANGDALM	3.65	2.89		3.23
TORREJON	3.48	3.30		3.26
RAMSTEIN	3.65	2.89		3.23
HAHN	3.65	2.89		3.23
NELLIS	1.68	1.72		0.24
SHAW	1.42	1.24		1.18
LUKE	1.68	1.72		0.34
1	1.68	1.72		0.92
2	5.15	5.19		3.85
3	1.68	1.72		0.38
4	1.42	1.24		1.16
5	1.68	1.72		1.28
6	4.58	4.62		3.28
7	1.24	1.42		1.68
8	1.42	1.24		1.38
9	1.68	1.72		0.40
10	1.24	1.42		1.68
11	1.24	1.42		1.68
12	1.24	1.42		0.96
13	0.92	1.68		1.68
14	1.24	1.42		0.96
15	1.68	0.92		1.72
16	1.24	1.42		1.42
17	1.72	1.72		1.68
18	1.24	1.42		1.68
19	2.47	1.71		2.05
20	1.24	1.42		1.68
21	0.92	1.68		1.68
22	0.92	1.68		0.34
23	1.24	1.42		1.68
24	1.68	0.92		1.72
25	1.68	0.92		1.72
26	1.24	1.42		0.96
27	0.92	1.68		1.68
28	1.42	1.24		1.18
29	3.47	2.71		3.05

G.D. Stands for General Dynamics Corp.
W.E.C. stands for Westinghouse Electric Corp.
OO-ALC stands for Ogden ALC, Hill AFB UT.

(American Airlines, 1987:6-7; HQ AFLC, 1988:5; Dept. of the Air Force, 1987:1-40)

Table 23. Transportation Cost Matrix for Shipments over 200 pounds, in Dollars per Pound per Round Trip

ORIGIN BASE	DESTINATION			
	G.D.	W.E.C.	SPERRY	OO-ALC
KUNSAN	4.59	4.63		3.33
MISAWA	4.38	4.42		3.12
SPANGDALM	3.61	2.87		3.23
TORREJON	3.44	3.26		3.26
RAMSTEIN	3.61	2.87		3.23
HAHN	3.61	2.87		3.23
NELLIS	1.64	1.68		0.24
SHAW	1.38	1.20		1.18
LUKE	1.64	1.68		0.34
1	1.64	1.68		0.92
2	5.11	5.15		3.85
3	1.64	1.68		0.38
4	1.38	1.20		1.16
5	1.64	1.68		1.28
6	4.54	4.58		3.28
7	1.20	1.38		1.64
8	1.38	1.20		1.38
9	1.64	1.68		0.40
10	1.20	1.38		1.64
11	1.20	1.38		1.64
12	1.20	1.38		0.96
13	0.90	1.64		1.64
14	1.20	1.38		0.96
15	1.64	0.90		1.68
16	1.20	1.38		1.64
17	1.68	1.68		1.64
18	1.20	1.38		1.64
19	2.43	1.69		2.05
20	1.20	1.38		1.61
21	0.90	1.64		1.64
22	0.90	1.64		0.34
23	1.20	1.38		1.64
24	1.68	0.90		1.68
25	1.64	0.90		1.68
26	1.20	1.38		0.96
27	1.38	1.20		1.64
28	1.38	1.20		1.18
29	3.43	2.69		3.05

G.D. Stands for General Dynamics Corp.
W.E.C. stands for Westinghouse Electric Corp.
OO-ALC stands for Ogden ALC, Hill AFB UT.

(American Airlines, 1987:6-7; HQ AFLC, 1988:5; Dept. of the Air Force, 1987:1-40)

Table 24. Transportation Cost Matrix for Shipments of 62 pounds, in Dollars per Pound per Round Trip

ORIGIN BASE	DESTINATION G.D.	W.E.C.	SPERRY	OO-ALC
KUNSAN	4.56	3.33		3.33
MISAWA	4.35	3.12		3.12
SPANGDALM	3.58	3.23		3.23
TORREJON	3.67	3.26		3.26
RAMSTEIN	3.58	3.23		3.23
HAHN	3.58	3.23		3.23
NELLIS	1.61	1.61		0.24
SHAW	1.61	1.61		1.18
LUKE	1.61	1.61		0.34
1	1.61	1.61		0.92
2	5.08	5.08		3.85
3	1.61	1.61		0.38
4	1.61	1.61		1.16
5	1.61	1.61		1.28
6	4.52	4.52		3.28
7	1.61	1.61		1.61
8	1.61	1.61		1.38
9	1.61	1.61		0.40
10	1.61	1.61		1.61
11	1.61	1.61		1.61
12	1.61	1.61		0.96
13	1.61	1.61		1.61
14	1.61	1.61		0.96
15	1.61	1.61		1.61
16	1.61	1.61		1.61
17	1.61	1.61		1.61
18	1.61	1.61		1.61
19	1.61	1.61		2.05
20	1.61	1.61		1.61
21	1.61	1.61		1.61
22	1.61	1.61		0.34
23	1.61	1.61		1.61
24	1.61	1.61		1.61
25	1.61	1.61		1.61
26	1.61	1.61		0.96
27	1.61	1.61		1.61
28	1.61	1.61		1.18
29	3.40	3.40		3.05

G.D. Stands for General Dynamics Corp.
W.E.C. stands for Westinghouse Electric Corp.
OO-ALC stands for Ogden ALC, Hill AFB UT.

(American Airlines, 1987:6-7; HQ AFLC, 1988:5; Dept. of the Air Force, 1987:1-40)

Appendix G: Projected LRU Shipments

Table 25. Projected WAC HUD DU Shipments by Year and Base

ORIGIN BASE	YEAR									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997-ON
KUNSAN	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
MISAWA	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
SPANGDAL	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
TORREJON	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
RAMSTEIN	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
HAHN	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
NELLIS	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
SHAW	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
LUKE	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
1	0.0	0.0	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
2	0.0	0.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
3	0.0	0.0	0.0	3.7	3.7	3.7	3.7	3.7	3.7	3.7
4	0.0	0.0	0.0	11.2	11.2	11.2	11.2	11.2	11.2	11.2
5	0.0	0.0	0.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8
6	0.0	0.0	0.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5
7	0.0	0.0	0.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8
8	0.0	0.0	0.0	0.0	11.2	11.2	11.2	11.2	11.2	11.2
9	0.0	0.0	0.0	0.0	3.7	3.7	8.4	8.4	8.4	8.4
10	0.0	0.0	0.0	0.0	2.8	2.8	2.8	2.8	2.8	2.8
11	0.0	0.0	0.0	0.0	2.8	2.8	2.8	2.8	2.8	2.8
12	0.0	0.0	0.0	0.0	0.0	3.7	3.7	3.7	3.7	3.7
13	0.0	0.0	0.0	0.0	0.0	3.7	3.7	3.7	3.7	3.7
14	0.0	0.0	0.0	0.0	0.0	2.8	2.8	2.8	2.8	2.8
15	0.0	0.0	0.0	0.0	0.0	2.8	2.8	2.8	2.8	2.8
16	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8	2.8	2.8
17	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8	2.8	2.8
18	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8	2.8	2.8
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8	2.8
20	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.7	3.7	3.7
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8	2.8
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.7	3.7
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8	2.8
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8	2.8
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8	2.8
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	5.6

Table 26. Projected MLPRF Shipments by Year and Base

ORIGIN BASE	YEAR									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997-ON
KUNSAN	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
MISAWA	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
SPANGDAL	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
TORREJON	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
RAMSTEIN	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
HAHN	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
NELLIS	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
SHAW	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
LUKE	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
1	0.0	0.0	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
2	0.0	0.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
3	0.0	0.0	0.0	3.1	3.1	3.1	3.1	3.1	3.1	3.1
4	0.0	0.0	0.0	9.4	9.4	9.4	9.4	9.4	9.4	9.4
5	0.0	0.0	0.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3
6	0.0	0.0	0.0	6.2	6.2	6.2	6.2	6.2	6.2	6.2
7	0.0	0.0	0.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3
8	0.0	0.0	0.0	0.0	9.4	9.4	9.4	9.4	9.4	9.4
9	0.0	0.0	0.0	0.0	3.1	3.1	7.0	7.0	7.0	7.0
10	0.0	0.0	0.0	0.0	2.3	2.3	2.3	2.3	2.3	2.3
11	0.0	0.0	0.0	0.0	2.3	2.3	2.3	2.3	2.3	2.3
12	0.0	0.0	0.0	0.0	0.0	3.1	3.1	3.1	3.1	3.1
13	0.0	0.0	0.0	0.0	0.0	3.1	3.1	3.1	3.1	3.1
14	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3	2.3	2.3
15	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3	2.3	2.3
16	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3	2.3
17	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3	2.3
18	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3	2.3
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3
20	0.0	0.0	0.0	0.0	0.0	0.0	3.1	3.1	3.1	3.1
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	3.1	3.1
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3	2.3
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	4.7

Table 27. Projected DEEU Shipments by Year and Base

ORIGIN BASE	YEAR									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997-ON
KUNSAN	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
MISAWA	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
SPANGDAL	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
TORREJON	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
RAMSTEIN	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
HAHN	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
NELLIS	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
SHAW	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
LUKE	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
1	0.0	0.0	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
2	0.0	0.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
3	0.0	0.0	0.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6
4	0.0	0.0	0.0	4.9	4.9	4.9	4.9	4.9	4.9	4.9
5	0.0	0.0	0.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2
6	0.0	0.0	0.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3
7	0.0	0.0	0.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2
8	0.0	0.0	0.0	0.0	4.9	4.9	4.9	4.9	4.9	4.9
9	0.0	0.0	0.0	0.0	1.6	1.6	3.7	3.7	3.7	3.7
10	0.0	0.0	0.0	0.0	1.2	1.2	1.2	1.2	1.2	1.2
11	0.0	0.0	0.0	0.0	1.2	1.2	1.2	1.2	1.2	1.2
12	0.0	0.0	0.0	0.0	0.0	1.6	1.6	1.6	1.6	1.6
13	0.0	0.0	0.0	0.0	0.0	1.6	1.6	1.6	1.6	1.6
14	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2	1.2	1.2
15	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2	1.2	1.2
16	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2	1.2
17	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2	1.2
18	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2	1.2
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2
20	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6	1.6	1.6
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6	1.6
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	2.5

Table 28. Projected ACIU Shipments by Year and Base

ORIGIN BASE	YEAR									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997-ON
KUNSAN	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
MISAWA	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
SPANGDAL	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
TORREJON	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
RAMSTEIN	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
HAHN	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
NELLIS	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
SHAW	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
LUKE	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.0	0.0	0.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4
7	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5
9	0.0	0.0	0.0	0.0	0.2	0.2	0.4	0.4	0.4	0.4
10	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
11	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
12	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2
13	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2
14	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
15	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
16	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
17	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
18	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
20	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3

Table 29. Projected ANTENNA Shipments by Year and Base

ORIGIN BASE	YEAR									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997-ON
KUNSAN	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
MISAWA	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
SPANGDAL	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
TORREJON	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
RAMSTEIN	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
HAHN	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
NELLIS	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
SHAW	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
LUKE	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
1	0.0	0.0	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
2	0.0	0.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
3	0.0	0.0	0.0	3.4	3.4	3.4	3.4	3.4	3.4	3.4
4	0.0	0.0	0.0	10.2	10.2	10.2	10.2	10.2	10.2	10.2
5	0.0	0.0	0.0	2.6	2.6	2.6	2.6	2.6	2.6	2.6
6	0.0	0.0	0.0	6.8	6.8	6.8	6.8	6.8	6.8	6.8
7	0.0	0.0	0.0	2.6	2.6	2.6	2.6	2.6	2.6	2.6
8	0.0	0.0	0.0	0.0	10.2	10.2	10.2	10.2	10.2	10.2
9	0.0	0.0	0.0	0.0	3.4	3.4	7.7	7.7	7.7	7.7
10	0.0	0.0	0.0	0.0	2.6	2.6	2.6	2.6	2.6	2.6
11	0.0	0.0	0.0	0.0	2.6	2.6	2.6	2.6	2.6	2.6
12	0.0	0.0	0.0	0.0	0.0	3.4	3.4	3.4	3.4	3.4
13	0.0	0.0	0.0	0.0	0.0	3.4	3.4	3.4	3.4	3.4
14	0.0	0.0	0.0	0.0	0.0	2.6	2.6	2.6	2.6	2.6
15	0.0	0.0	0.0	0.0	0.0	2.6	2.6	2.6	2.6	2.6
16	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6	2.6	2.6
17	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6	2.6	2.6
18	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6	2.6	2.6
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6	2.6
20	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.4	3.4	3.4
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6	2.6
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.4	3.4
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6	2.6
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6	2.6
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6	2.6
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.6
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	5.1

Table 30. Projected DMT Shipments by Year and Base

ORIGIN BASE	YEAR									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997-ON
KUNSAN	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9
MISAWA	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9
SPANGDAL	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9
TORREJON	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9
RAMSTEIN	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9
HAHN	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9
NELLIS	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
SHAW	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9
LUKE	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9
1	0.0	0.0	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9
2	0.0	0.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
3	0.0	0.0	0.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
4	0.0	0.0	0.0	53.9	53.9	53.9	53.9	53.9	53.9	53.9
5	0.0	0.0	0.0	13.5	13.5	13.5	13.5	13.5	13.5	13.5
6	0.0	0.0	0.0	35.9	35.9	35.9	35.9	35.9	35.9	35.9
7	0.0	0.0	0.0	13.5	13.5	13.5	13.5	13.5	13.5	13.5
8	0.0	0.0	0.0	0.0	53.9	53.9	53.9	53.9	53.9	53.9
9	0.0	0.0	0.0	0.0	18.0	18.0	40.4	40.4	40.4	40.4
10	0.0	0.0	0.0	0.0	13.5	13.5	13.5	13.5	13.5	13.5
11	0.0	0.0	0.0	0.0	13.5	13.5	13.5	13.5	13.5	13.5
12	0.0	0.0	0.0	0.0	0.0	18.0	18.0	18.0	18.0	18.0
13	0.0	0.0	0.0	0.0	0.0	18.0	18.0	18.0	18.0	18.0
14	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5	13.5	13.5
15	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5	13.5	13.5
16	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5	13.5
17	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5	13.5
18	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5	13.5
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5
20	0.0	0.0	0.0	0.0	0.0	0.0	18.0	18.0	18.0	18.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.0	18.0	18.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.9
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.9	26.9

Appendix H: Projected Life Cycle LRU Shipments by Base and Total

ORIGIN BASE	WAC HUD	MLPRF	DEEU	ACIU	ANTENNA	DMT
KUNSAN	149	125	66	7	136	719
MISAWA	149	125	66	7	136	719
SPANGDAL	112	94	49	5	102	539
TORREJON	224	187	99	11	205	1078
RAMSTEIN	149	125	66	7	136	719
HAHN	224	187	99	11	205	1078
NELLIS	62	52	27	3	57	299
SHAW	224	187	99	11	205	1078
LUKE	224	187	99	11	205	1078
1	201	168	89	10	184	970
2	34	28	15	2	31	162
3	63	53	28	3	58	305
4	190	159	84	9	174	916
5	48	40	21	2	43	229
6	127	106	56	6	116	611
7	48	40	21	2	43	229
8	179	150	79	9	164	862
9	125	104	55	6	114	602
10	45	37	20	2	41	216
11	45	37	20	2	41	216
12	56	47	25	3	51	269
13	56	47	25	3	51	269
14	42	35	18	2	38	202
15	42	35	18	2	38	202
16	39	33	17	2	36	189
17	39	33	17	2	36	189
18	39	33	17	2	36	189
19	36	30	16	2	33	175
20	52	44	23	2	48	252
21	36	30	16	2	33	175
22	49	41	21	2	44	234
23	36	30	16	2	33	175
24	36	30	16	2	33	175
25	36	30	16	2	33	175
26	34	28	15	2	31	162
27	34	28	15	2	31	162
28	82	69	36	4	75	395
29	67	56	30	3	61	323
TOTAL	3434	2870	1512	164	3138	16535

Appendix I: Life Cycle Shipping Cost Projections

Table 31. Projected Life Cycle Shipping Costs for Current Containers, in Dollars, by Base and LRU

ORIGIN BASE	WAC HUD	MLPRF	DEEU	ACIU	ANTENNA	DMT
KUNSAN	60,845	102,933	14,562	2,788	94,113	555,715
MISAWA	57,042	97,175	13,715	2,626	88,865	524,626
SPANGDAL	44,263	64,783	10,078	1,930	59,155	349,750
TORREJON	89,348	135,297	20,413	3,848	123,760	730,440
RAMSTEIN	59,017	86,378	13,438	2,573	78,874	466,334
HAHN	88,525	129,567	20,156	3,860	118,310	699,501
NELLIS	1,828	7,752	873	171	7,191	41,850
SHAW	32,360	49,252	7,740	1,431	45,341	265,900
LUKE	9,324	30,814	3,633	709	28,537	166,356
1	25,230	40,697	5,483	1,053	37,393	219,715
2	17,597	25,782	3,654	698	23,547	139,190
3	3,474	7,170	783	151	6,611	38,712
4	31,812	41,196	6,163	1,164	37,772	222,405
5	8,776	11,918	1,688	323	10,919	64,345
6	60,041	82,679	11,623	2,219	75,503	446,365
7	11,518	14,068	2,094	410	13,142	75,947
8	37,845	45,099	6,746	1,287	41,253	243,480
9	8,227	11,046	1,365	260	10,118	59,637
10	11,518	13,351	1,971	392	12,471	72,080
11	11,518	13,351	1,971	392	12,471	72,080
12	8,776	10,257	1,467	280	9,373	55,377
13	15,358	17,026	2,464	489	15,896	91,922
14	6,582	7,693	1,100	210	7,030	41,533
15	11,792	12,676	1,848	376	11,827	68,437
16	9,736	11,918	1,725	290	9,405	64,345
17	11,518	11,918	1,725	343	11,127	64,345
18	11,518	11,918	1,725	343	11,127	64,345
19	13,064	13,847	2,038	389	12,620	74,759
20	15,358	15,601	2,300	457	14,836	84,224
21	10,695	11,067	1,602	318	10,332	59,749
22	2,886	3,059	450	86	2,788	16,516
23	10,695	11,067	1,602	318	10,332	59,749
24	10,950	11,337	1,602	326	10,578	61,206
25	10,950	11,337	1,602	326	10,578	61,206
26	5,642	5,980	880	168	5,450	32,285
27	9,873	10,216	1,478	294	9,538	55,153
28	16,951	17,968	2,644	504	16,375	97,003
29	35,824	37,973	5,588	1,066	34,608	205,008
TOTAL	888,274	1,243,169	181,987	34,863	1,139,168	6,711,591

Table 32. Projected Life Cycle Shipping Costs for Proposed Containers, in Dollars, by Base and LRU

ORIGIN BASE	WAC HUD	MLPRF	DEEU	ACIU	ANTENNA	DMT
KUNSAN		103,861	31,119	4,194		689,300
MISAWA		98,050	29,315	3,951		650,738
SPANGDAL		65,367	21,544	2,904		433,825
TORREJON		136,516	42,958	5,790		906,027
RAMSTEIN		87,156	28,726	3,872		578,433
HAHN		130,734	43,088	5,807		867,650
NELLIS		7,822	1,908	257		51,911
SHAW		49,696	15,976	2,153		329,818
LUKE		31,091	7,910	1,066		206,345
1		41,064	11,761	1,585		272,531
2		26,014	7,795	1,051		172,649
3		7,235	1,683	227		48,017
4		41,567	12,997	1,752		275,868
5		12,026	3,604	486		79,813
6		83,424	24,774	3,339		553,665
7		14,194	4,573	616		94,204
8		45,505	14,363	1,936		302,009
9		11,146	2,906	392		73,973
10		13,471	4,371	589		89,407
11		13,471	4,371	589		89,407
12		10,350	3,122	421		68,689
13		17,180	5,464	736		114,018
14		7,762	2,342	316		51,517
15		12,791	4,196	565		84,888
16		12,026	3,233	436		79,813
17		12,026	3,825	516		79,813
18		12,026	3,825	516		79,813
19		13,972	4,338	585		92,730
20		15,741	5,100	687		104,470
21		11,167	3,552	479		74,112
22		3,087	958	129		20,486
23		11,167	3,552	479		74,112
24		11,439	3,636	490		75,919
25		11,439	3,636	490		75,919
26		6,034	1,873	252		40,045
27		10,308	3,278	442		68,411
28		18,130	5,629	759		120,322
29		38,315	11,896	1,603		254,288
TOTAL		1,254,368	389,197	52,455		8,324,954

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VITA

Captain Paul F. Schikora [redacted] [redacted] He [redacted] [redacted] attended the Illinois Institute of Technology, from which he graduated with honors, receiving the degree of Bachelor of Science in Management in December 1981. Upon graduation, he received a commission in the USAF as a distinguished graduate of the AFROTC program. After graduating from Transportation Officer School in August 1982, he was assigned to the First Transportation Squadron, Langley AFB, Virginia. He was then assigned in December 1984 as a Foreign Military Sales Transportation Officer at Detachment 45, AF Contract Management Division, AF Plant Representative Office, Westinghouse Electric Corporation, Baltimore, Maryland, until entering the School of Systems and Logistics, Air Force Institute of Technology, in May 1987.

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Packaging is a critical part of any electronic item's logistics support system. Different packaging options have varying characteristics, including price, weight, durability, shock protection, and ease of opening and closure. Each of these characteristics has a different impact on the packaged item's logistics life cycle costs. ~~(LCC),~~ By analyzing the cost trade-offs between alternative packaging options, a least total cost option can be identified. This thesis

This study compares the LCC of different packaging options for four LRUs from the F-16C/D model aircraft. ~~Two~~ options for each LRU ~~are~~ examined are the current container, either a wooden crate or fiberboard box; and a proposed reusable molded plastic container. The objective was to see if the advantages of the plastic containers could result in sufficiently lower recurring LCC to offset their higher acquisition cost. ~~There were five~~ Study method included: main stages in the study: LCC model development, data collection, cost model application and sensitivity analysis, comparison of results including qualitative factors, and packaging option selection. The model can be applied to similar packaging decisions.

~~The~~ Results show that the proposed container would have a higher total LCC for all four LRUs. Sensitivity analysis was performed and proved the results to be quite insensitive to changes in LRU mean time between failure, ~~(MTBF)~~ the major variable factor in the model. Additionally, formulas for determining the model's LCC break-even point with respect to MTBF and LRU shipment rates were developed and presented. (edc)

The final recommendation of the study is to choose the proposed container for one of the LRUs, based on a small difference in LCC and the qualitative advantages of the proposed container. Recommendations for future research are presented.