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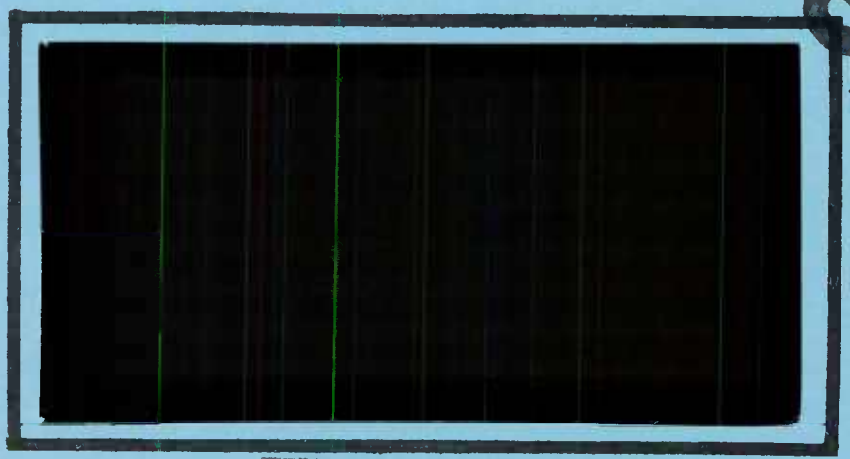
The Commander of Air Force Systems Command stated that the Air Force shall use commercial practices whenever possible. This thesis examines the airlines' criteria in evaluating warranties to determine if these commercial practices can be used by Air Force buying activities. Criteria to evaluate warranties were obtained from the trunk airlines through interviews and a questionnaire. The airlines' rankings of the criteria were compared to rankings by Aeronautical Systems Division (ASD) contracting experts. The results showed that the airlines and the Air Force emphasize different factors in evaluating warranties. The greatest difference was found to be the emphasis placed on cost effectiveness of a warranty by the ASD experts compared to the lack of emphasis on this factor by the airline experts. The results also show that Air Force contracting experts have a false perception of airline practices in evaluating aircraft warranties.

WARRANTIES

Mr. Rosell



DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY (ATC)

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

CRITERIA FOR APPLYING COMMERCIAL AIRCRAFT WARRANTIES IN USAF AIRCRAFT PURCHASES

Jack L. Grubb, Captain, USAF
Thomas O. Sutliff, Captain, USAF

LSSR 37-80

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CRITERIA FOR APPLYING COMMERCIAL AIRCRAFT WARRANTIES IN USAF AIRCRAFT PURCHASES

A Thesis

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

Master of Science in Logistics Management

By

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June 1980

This thesis, written by

Captain Jack L. Grubb

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has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillent of the requirements for the degree of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(CONTRACTING AND ACQUISITION MANAGEMENT MAJOR)

DATE: 9 June 1980

Steven C. Sterling

COMMITTEE CHAIRMAN

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INTRODUCTION

Statement of Problem

In recent years, the Air Force has attempted to use various warranty methods to improve the quality of procured systems and to gain greater commitment of suppliers to product quality. Industry has also made extensive use of warranties, "as an obligation of the seller to the buyer with respect to title, quality, quantity, state, or past or future performability of goods sold or to be sold [2:4]." Because of the potential benefits to the Air Force, General Slay, Commander of Air Force Systems Command (AFSC), has stated that such commercial practices should be incorporated in Air Force procurements (22:1). A need therefore exists to determine the criteria used by the U.S. commercial airlines to evaluate aircraft warranties and to determine if these criteria can be used in Air Force Systems Command aircraft procurements.

Definitions

In order to establish a consistent framework of terms dealing with the subject of government and commercial aircraft warranties, some of the common terms of this subject will be defined for purposes of this thesis.

In this thesis, a contractor is a company or company representative that is selling goods or services to either the government or a purchaser in the civilian marketplace.

A purchase contract is a vehicle through which the contractor and the purchaser agree on the terms of trade. The term "contract" will be used herein to identify a purchase contract. A contract encompasses the following characteristics:

> (1) agreement ("meeting of minds") resulting from an offer and an acceptance; (2) consideration, or obligation; (3) competent parties; and (4) a lawful purpose [14:492].

A warranty is "a contractual obligation that provides incentives for a contractor to satisfy a system's field operational objectives [2:3-21]." While a warranty is a contractual obligation of the contractor, it also specifies the limitations of the contractor's liability. In short, the warranty specifies what the contractor is and is not liable for. A warranty need not be spelled out in the contract. The Defense Acquisition Regulation (DAR) states that "a warranty is a promise or affirmation given by a seller to a purchaser regarding the nature, usefulness, or condition of the supplies or performance of services to be furnished [23:55]."

There are two kinds of warranties found in trade - expressed and implied. While a distinction will be made between these and also in the kinds of expressed warranties

for purposes of definition, it does not imply that these warranties are mutually exclusive. In practice, the differences between warranty types are often obscure. The Uniform Commercial Code (UCC) specifies two aspects of an implied warranty;

> the implied warranty of merchantability, which warrants that the article sold shall be of the general kind described and reasonably fitted for the general purpose for which it is sold, and the implied warranty of fitness for a purpose, which warrants that the goods sold are suitable for the buyer's special purpose [7:31-32].

In the absence of any other statement concerning warranty or guarantee in a contract, the implied warranty is considered to be in effect. The second type of warranty identified in the UCC is the expressed warranty, that is, "any affirmation of fact or promise made by the seller to the buyer and relating to the goods [7:31]."

For purposes of this analysis, the expressed warranties will be further defined into two categories. The first is the commercial warranty which is simply an expressed warranty between a contractor and buyer other than the government. Within this category is the commercial aircraft warranty which is a warranty between an aircraft or aircraft system contractor and a commercial airline. The second type is the Department of Defense (DOD) expressed warranty. The DOD warranty is a warranty used by DOD purchasers in conformance with the DAR. Warranties on aircraft purchased by the Air Force are considered to be a subset of DOD warranties for purposes of this research.

According to the report, "A Study of the Effectiveness of Warranties in Contracts for Military Hardware," there are five types of expressed warranties in procurements. They are: Correction of Deficiencies, Failure Free Warranty (FFW), Reliability Improvement Warranty (RIW), Mean Time Between Failure (MTBF) Guarantee, and Logistics Support Commitment (LSC) (2:5.0-5.5).

Justification

A thesis done at the Air Force Institute of Technology's School of Systems and Logistics in 1975 stated that very little research has been done "to compare commercial airline warranty procedures with those in the Air Force. This area promises to provide a great deal of potential benefits [5:65-66]." Actual benefits to commercial airlines in their use of warranties are substantial. A study done in 1974 stated "three of the larger airlines realized a total combined savings of $31,000,000 from warranty provisions on avionics equipments alone [5:22]."

General Slay, Commander of Air Force Systems Command has directed that Air Force procurement activities use commercial practices in government contracting whenever a potential benefit to the government can be gained (22). In order to determine whether a potential benefit exists, the contracting officer needs criteria upon which to judge the potential benefits of any warranty. A search of the literature indicates that no list of criteria exists to evaluate

the benefits of using a commercial aircraft warranty that are used by the airlines which can be applied to Air Force aircraft procurements (2:I-IV). However, guidance when to include warranties in military acquisition is found in the DAR (See Figure 1).

A need therefore exists to identify a list of criteria which can be used by government contracting officers to determine if benefits can be gained by using commercial techniques in the purchase of aircraft warranties.

Advantages of Warranties

The reason any consumer would desire a warranty is clear; it is a guarantee. It is one weapon that can be used in "the battle [that] has been and is still raging against inferior and bad products [18:21]." The reasons why a warranty is desired by aircraft operators are common to both the airlines and the Air Force.

First, a warranty offers a guarantee that the seller will stand behind their product, that they will assume at least part of the risk should the product fail to perform as the seller claims. Hal Bayer and Robert Speir of Douglas Aircraft Company pointed to the desire of airlines to get the manufacturers to stand behind their product as a motivation for seeking a warranty.

> When a potential airline customer takes heed of the manufacturer's promises of design service life, excellent test results and low maintenance cost, the potential customer is quick to ask us for proportionate assurances defined in recoverable dollars [1:50].

i. Nature of the item and use.
ii. Cost of the Warranty and degree of price competition as it may affect cost.
iii. Criticality of meeting specifications.
iv. Damages to the government which may arise in the event of defective performance.
v. Cost of correction or replacement either by the contractor or another source in the absence of a warranty.
vi. Administrative cost and difficulty of enforcing a warranty.
vii. Ability to take advantage of the warranty, as conditioned by storage time, distance of the using agency from the source, or other factors.
viii. Operation of the warranty as a deterrent against deficiencies.
ix. The extent to which government acceptance is to be based upon contractor inspection or quality control.
x. Whether, because of the nature of the item, the government inspection system would not likely provide adequate protection without a warranty.
xi. Whether the contractor's present quality program is reliable enough to provide adequate protection with a warranty, or, if not, whether a warranty would cause the contractor to institute an effective and reliable quality program.
xii. Reliance on "Brand Name" integrity.
xiii. Whether a warranty is regularly given for a commercial component of a more complex end item.
xiv. Criticality of item for protection of personnel or property, e.g. for flight safety.
xv. The stage of development of the item and the state of the art.
xvi. Customary truth practices.

Figure 1 Factors Used in Determining Use of Warranties by the Air Force. (2:6.1)

The risk should equipment fail to perform in most consumer products is evident, that is, the loss of the investment in the product. In a commercial aircraft, the economic risk is far greater. Should the aircraft fail to perform, the potential loss could include the very survival of the airline itself. The warranty therefore transfers this risk, which is both "an economic and business risk [12:60]."

Another important reason a warranty is desirable is that it is an incentive for greater reliability. During recent years, great attention has been paid to the life cycle cost of a system. It is recognized that the initial cost of an item is but one factor in total cost, that replacement parts and maintenance costs can far outweigh small savings in the initial cost of the case of a poorly built system. In an attempt to limit this risk, the mean time between failure (MTBF) has been warranted. Proponents of warranties argue that savings are realized because "life cycle costs vary inversely with MTBF and vary directly with the average unit repair cost [5:5]."

Therefore, one approach to reduce life cycle costs is to obtain a guarantee for MTBF. This guarantee is an incentive for the contractor to meet the MTBF and to improve the product as new technology becomes available. Early warranties of this type were from the commercial world, that is, they originated in non-military purchases.

> One of the first attempts of a long term service warranty directed at the problem of increasing field MTBF was the Failure Free Warranty concept introduced by the Lear Siegler Company [5:5].

As Dunn and Oltyan pointed out, the term "failure free" was a misnomer because the guarantee did not guarantee no failure. Hence the term Reliability Improvement Warranty (RIW) is used to connote the presently used version of this warranty (5:6).

Another reason a warranty is desired is that it removes "the finality and conclusiveness of acceptance [12:57]." This factor is alleged to be the main value of the warranty for the government.

> The main purpose of a warranty in Government contracts is to remove the finality and conclusiveness of acceptance. In other words, the government gets more time to uncover latent defects [18:45].

Commercial and DOD Warranties on Aircraft Compared

There are several clear differences between the warranties used in airline aircraft procurement and those found in Air Force aerospace procurement. Many of the differences between airline and Air Force procurements center around the differences in the systems they acquire, objectives in their procurements, and the warranties themselves (See Figure 2). These differences will be addressed, in order to analyze the context in which the warranty is either sought and written, or ignored.

	COMMERCIAL	AEROSPACE
1.	Many customers	Single Customer (U.S. Government)
2.	Items fully developed and tested	Items often to be developed and pushing state-of-the-art.
3.	Cost of item usually small in comparison to total value of items sold	Cost of item usually large with respect to total value of items sold
4.	Item in continuous production	Short production run
5.	Normal environment known	Abnormal environment - not always known
6.	Depending upon the product, maintenance systems vary, with household products the maintenance required usually must be accomplished by an authorized dealer; commercial aviation products are maintained under a sophisticated system involving airlines, airplane manufacturers and Government agencies (e.g., FAA, etc).	Government does its own maintenance, supported by Contractor's technical data and field service operations.

Figure 2 Comparison of Warranty Situation for Commercial Products and Aerospace Industry Products [18:44]

Clearly, in many aircraft procurements, the system acquired by the Air Force is for a different purpose than that bought by the airlines. Because of the need to employ the aircraft in combat environments and missions, they often are quite different in design and performance requirements. For example, the KC-10, while similar to the DC-10 has the requirement to be capable of several missions different than that of the commercial version. It must be capable of off-loading and receiving fuel inflight and must be capable of carrying military cargo. Therefore, much of the equipment and the structure must be specially built for these purposes. Further, the aircraft is required to be at the highest present state-of-the-art in its systems. The air refueling system, for example, employs a system that permits refueling of both receptacle and probe and drogue receivers in the same flight, which was not possible in the KC-135. The risk to the contractor in guaranteeing such equipment may be greater than in the commercial version, which uses standard equipment.

Beyond these clear differences in the intended use of the aircraft there is often the need for military aircraft to be operated in combat roles. The potential difference in the atmosphere in which the aircraft is operated places further uncertainty into the possible liability of the contractor. This is because the aircraft may be operated in a manner far different than that envisioned by the

Air Force or the contractor due to military necessity. The potential unknown effects of combat employment therefore add more risk to the contractor in guaranteeing such equipment than in the commercial version.

In the past, the Air Force has done its own maintenance. The airlines use a system in which

> the maintenance required usually must be accomplished by an authorized dealer; commercial aviation products are maintained under a sophisticated system involving airlines, airplane manufacturers and Government agencies (e.g., FAA, etc.) [18:44].

There are also some clear differences in the legal limitations when a government purchaser attempts to buy a product when compared to a commercial buyer. As Ron Chalecki, a contracting officer on the KC-10 project, put it in discussing the KC-10 warranty:

> In the commercial market-place, the competition fight it out by offering their best overall 'deal'. While we recognized that we had to live within the framework of Government rules and regulations [4:1].

Some of the rules Mr. Chalecki referred to are not strictly limitations on clauses or in obtaining the best quality for the lowest price. While the specifics of these limitations are outside the scope of this study, it must be recognized that these limitations do exist in order to understand the context in which the government views a potential purchase. The limitations referred to are those oriented toward socioeconomic goals such as equal opportunity of

minorities and small businesses. These constitute clear limitations placed on government acquisitions that are not placed on the airlines.

> The industrial buyer is free to choose suppliers on the basis of total value . . . . Many laws and executive orders influence government purchasing. A large number of these laws and orders are designed to achieve socioeconomic goals [14:564-565].

Lest the conclusion is drawn that the commercial buyer has a clear advantage in every aspect, it is well to point out that the government has some advantages too:

> The government is a sovereign and as such can determine the conditions for doing business in the government market. The government, for example, regulates the actions of its prime contractors, even to the point of determining the manner in which they do business with their subcontractors [14:549].

Another example of government advantage is the inspection clause, which will be covered under the legal aspects later in this chapter.

The warranties used by the government and the airlines are similar in many respects. As Mr. Chalecki pointed out in his article and Captain C. Brandon Gresham, Jr., confirmed in a recent interview, "there can be a lot of similarities between the correction of deficiency [clause] and the standard commercial warranty [9]."

The inconsistencies between the warranty obtained by the airlines and the government are pointed out by Charles D. Woodruff in his article "A More Critical View of

Warranties and Consequential Damages in Government Contracts." Mr. Woodruff stated that the implied warranty for a particular purpose is not normally covered in the commercial warranty whereas the government warranty clause is aimed at the particular purpose for the item (25:4-5).

The DAR permits the use of the commercial warranty when the rights of the government are not changed. But as Woodruff pointed out, because of the coverage of the standard government clauses, the contracting officer is probably unable to replace the DAR clauses such as the Correction of Deficiency or Warranty of Supply with the commercial warranty.

> The fourth sentence in the paragraph discussing Commercial Item Warranties does permit the Government to adopt the contractor's standard commercial warranty when it is determined by the Contracting Officer that its provisions are not inconsistent with the rights afforded the Government under the clauses in 7-105.7 (a) and (b), or other provisions of the contract. However . . . it is almost inconceivable that a standard commercial warranty would not be inconsistent with the two supply warranty clauses [25:4-5].

Since the commercial warranty covers the performance rather than the specific purpose of the item, as Captain Steven C. Lathrop, instructor of Logistics Management at the Air Force Institute of Technology (AFIT), pointed out, the commercial airline receives a warranty which is far longer in duration and extensive in coverage (13). The unique intended uses, mentioned earlier, therefore have an impact on the warranty coverage.

Because of this problem, the government normally receives a warranty that is of shorter duration than the commercial warranty. Despite the differences in the other aspects, this is the principal difference between the warranty the commercial airlines receive and the one the Air Force receives (9).

The short length of time of coverage in the warranties attained by the government was pointed out as a problem in a recent memorandum which states that "the usual one year or eighteen month period of coverage after acceptance (rather than use of the item) turns out to be insufficient [10:3]." While the length of time covered in warranties attained by the government is normally shorter than those obtained by airlines, greater coverage has been attained by the government, when a warranty similar to a commercial warranty is negotiated in Air Force acquisition. The warranty on the KC-10 is such a warranty.

To gain an idea of the coverage offered on the commercial airlines, Figure 3 shows the length of warranties offered by Douglas on the DC-8, DC-9, and DC-10. Also, by way of comparison, Figure 4 shows the warranty given by Douglas on the KC-10 to show the length of time and extent of coverage that has been obtained when the government pursued a commercial aircraft warranty.

Coverage	DC-8	DC-9	DC-10
1. Defects in material	1 yr/2000 hr.	1 yr/2500 hr.	2 yr/5000 hr. or 3 yr/3000 hr. for components not subject to prior inspection, including pri. struct.
Primary Structure		2 yr/5000 hr.	
2. Defects in design, selection of materials and process of manufacture.	1 yr/2000 hr.	1 yr/2500 hr.	18 mos.
Primary Structure		2 yr/5000 hr.	18 mos.
3. Failure to conform to the detail specification.	1 yr/2000 hr.	2 yr/2500 hr.	2 yr/5000 hr.
Primary Structure		2 yr/5000 hr.	
4. Defects in installation of vendor parts.			2 yr/5000 hr.
5. Performance guarantees			3 mos./400 hr.
6. Warranty labor reimbursement	Direct repair labor only	Direct repair labor only	Yes, except inspection checkout & test effort.

Figure 3 Standard Warranty, DC-8, DC-9, DC-10 (1:53).

Coverage	DC-8	DC-9	DC-10
7. Provide reimbursement at operator's direct labor rate plus 50% for burden			Yes
8. Transportation Costs	Operator pays	Operator pays	DAC pays one way.
9. Recycle warranty period for repair, replacement, correction or redesign			Yes
10. Provide service life policy for primary structure			10 yr/30,000 hr. (pro-rata).
11. Provide service life policy for primary landing gear components.			10 yr/30,000 hr. or 20,000 landings (pro-rata).

Figure 3 (Continued).

KEY PROVISIONS

COVERAGE	TERM
Defects in material and workmanship	60 months or 5000 hours
Defects in installation of vendor parts	60 months or 5000 hours
Defects in failure to conform to specification	60 months or 5000 hours
Defects in design	24 months
Service Life Policy	10 years or 30,000 hours

Figure 4 KC-10 ATCA Warranty and Service Life Policy [15:10].

Legal Aspects

Government supply contracts contain an inspection clause. This inspection clause allows the government the right to examine and test supplies and services "to determine whether they conform to contract requirements [23:7-103.5(a)]." If the government accepts the supplies or services after this inspection and the contract does not contain any warranty provision, the government's acceptance is conclusive except for latent defects, fraud, and gross mistakes (20:148).

A latent defect is a defect which existed at the time of government acceptance but could not be detected by reasonable inspection (8:24). A latent defect can then be defined in terms of "reasonable inspection." For example, if the government were buying shoes,

> a visual inspection would suffice -- an x-ray would not be expected; however, in the examination of welding done on structural steel, an x-ray inspection could be reasonably expected [3:XVI-11].

If the subject of reasonable inspection becomes an issue, it is normally settled by the litigation process.

To obtain relief for a defective item due to fraud, the government must prove "intent to deceive by the contractor in that he misrepresented a material fact and that the government relied upon the misrepresentation [3:XVI-11]." For the government to prove gross mistake, the government must show that the defect is so gross that it should be considered fraud but unlike fraud, the government does not have to prove intent to deceive. In obtaining relief from defects in all these conditions, the burden of proof rests on the government (3: XVI-11).

Unlike government contracts, commercial aircraft contracts do not contain an inspection clause. If defects are discovered after acceptance, the commercial aircraft company does not have to prove that the defect was latent but simply that the defective component is not in accordance with the contract.

In commercial contracts, the aircraft manufacturer specifically excludes any implied warranties (18:57). In the case of Delta Airlines, Inc. vs. McDonnell Douglas Corporation, Delta attempted to recover expenses suffered when the nose gear of a plane purchased from McDonnell Douglas collapsed. The plane was being landed and when the

nose gear collapsed the plane veered off the runway. No one was injured. Delta claimed that McDonnell Douglas was liable because of implied warranty but the court ruled that, since the contract had a specific exclusion of implied warranties, McDonnell Douglas was not liable (18:60).

In government contracts, both the Correction of Deficiencies clause and the Warranty of Supplies clause as defined in the DAR do not exclude implied warranties (18:43). An aircraft manufacturer can be held liable for defective parts under an implied warranty if the government contract contains either one of these two clauses.

While, in many respects, government warranties are different than commercial warranties, the objective in obtaining warranties for commercial aircraft are often similar to government warranty objectives. The question is, therefore, if the criteria used by the airlines to meet these objectives can be used by government contracting officers in evaluating the potential benefits of a commercial aircraft warranty. Our studies indicate that the criteria used in commercial aircraft warranty evaluation have not been identified. Further, the question whether the criteria used by the airlines could be effectively applied to government usage of commercial aircraft warranties has not been addressed.

Objectives

The primary objective of this study is to identify criteria for application of commercial aircraft warranties

in Department of Defense acquisition of aircraft. In order to accomplish this, the following objectives must be met:

1. Develop a list of criteria that are used by the airlines to determine the advantages of a warranty.

2. Evaluate applicability and legality of the airline criteria for use in the Air Force.

Research Hypothesis/Questions

Research Hypothesis (1) The airlines use a homogeneous set of criteria to evaluate warranties.

Research Question (1) Can the airline criteria, if they exist, be legally applied to Air Force aircraft acquisitions?

Research Hypothesis (2) Contracting experts in the Air Force agree with the commercial airline contracting personnel in the order of importance of the criteria used in evaluating warranties.

Research Question (2) Can a list of criteria be developed for application of commercial aircraft warranties in the Department of Defense?

Chapter 2

RESEARCH METHODOLOGY

Overview

The previous chapter provided a background of USAF warranty experience and a comparison of commercial and USAF aircraft warranties. The need to identify the commercial criteria and to determine if such criteria can be used by the Air Force was also discussed. This chapter contains a description of the universe and populations of interest. It also includes operational definitions of variables and the method of data collection. Finally, it contains an explanation of the procedures used in analyzing the data used in the research. In order to facilitate reference to the methodology in answering the research questions/hypotheses, each is addressed separately in this chapter.

Description of Universe

Because this study is limited to the criteria used in evaluating major aircraft purchases, the universe is the major air carriers. More specifically, the universe is composed of the trunk airlines, and the United States Air Force. It should be noted that there is a variety of consumers of aircraft not included in this study because the objective is to determine the criteria used in evaluating the warranties on complex aircraft systems.

Description of the Population of Interest

Our population is the criteria used by contracting officials of the major air carriers. Major air carriers are defined here as the trunk carriers in the continental United States (including Pan American), as defined by the 1979 World Aviation Directory (See Appendix B) (21:70) and the U. S. Air Force. For purposes of comparison, this population contains two subpopulations, the criteria of the trunks and of the Air Force. The criteria used by major carriers are discrete. Conceptually the number of values, that is, the number of criteria, could be infinite. However, to focus on meaningful criteria the criteria are considered to be multiple or having 7-19 discrete values.

Research Hypothesis 1

The airlines use a homogeneous set of criteria to evaluate warranties.

Data Collection. A list of criteria were identified through telephone interviews with airline contracting experts from all ten trunk carriers. This list was then given to Mr. Don Robinson of the ASD Contracting Office, and Captain Steven C. Lathrop of AFIT to review the list for completeness and to offer more succinct ways of stating the criteria.

A questionnaire was then written incorporating the list of criteria in alphabetical order. The instructions for the questionnaire instructed the respondent to rank

order the criteria in order of importance and to include in the ranking any criteria they wished to add in the space provided (See Appendix C).

To validate the questionnaire, it was administered to AFIT Graduate Logistics Class of 1980 students in the Contracting and Acquisition major who had previous contracting experience and to two AFIT faculty members who had contracting experience. Comments on the readability of the instructions and the criteria were solicited from each.

The sampling plan to examine the homogeneity of criteria used by the trunk carriers was to randomly select nine trunk carriers using a computer random number generator. The chief of the contracting division of each of these airlines was then contacted and asked if they would fill out the questionnaire. An alternate airline remained and would have been used if one of the primary contracting chiefs declined to participate.

Identification/Definition of Variables. In collecting data for testing Research Hypothesis 1, nine commercial airline chiefs of contracting were asked to rank order a list of criteria which were used in evaluating aircraft warranties in order of importance. The most important criterion would be given a one and the least important criterion would be given a twelve. The individual criteria are the independent variables and the ordinal rankings of each criterion are the dependent variables. The questionnaire in Appendix D

contains the specific instructions given to each commercial airline contracting person and a list of the criteria used in evaluating aircraft warranties.

Design to Test Research Hypothesis 1. To test Research Hypothesis 1 the Kendall coefficient of concordance W was used to determine if the rankings given to the criteria by the nine commercial airline contracting personnel were the same. The Kendall coefficient of concordance is used to measure the association between a fixed number of rankings from any number of respondents (19:239). When using the Kendall coefficient of concordance, the null hypothesis (H_o) is the rankings of items by respondents are unrelated. In this research the null hypothesis is the rankings given to the criteria used in evaluating warranties by the nine commercial airline contracting personnel are not related. Therefore, the alternate hypothesis (H_1) is the rankings of the criteria by the nine commercial airline contracting personnel are related. To support Research Hypothesis 1 the results of the Kendall coefficient of concordance test must be to reject the null hypothesis (H_o) and conclude the alternate hypothesis that the nine commercial airline contracting personnel agree on the rankings of the criteria for evaluating aircraft warranties.

To evaluate this test an alpha value of .05 was used. This alpha value is the probability of rejecting the null hypothesis as false when the null hypothesis is actually true (16:259, 266).

If a sample size of seven or larger is used, the test statistic W follows a chi-square distribution with N-1 degrees of freedom (19:236). To test the hypothesis a critical chi-square value can be obtained from a statistical table containing chi-square values.

The Kendall W test was performed using the following steps:

1. The null hypothesis (H_o) is the rankings given to the criteria used in evaluating aircraft warranties by the nine commercial airline contracting personnel are not related. The alternate hypothesis (H_1) is the rankings of the criteria by the commercial airline contracting personnel are related.

2. An alpha value of .05 was chosen for the test.

3. The rank order scores were placed in a table having N (12) columns (one for each criterion) and K (9) rows (one for each respondent) (See Appendix G).

4. The Kendall coefficient of concordance W was calculated (See Appendix E).

5. A chi-square value for the ranks (χ^2_{ranks}) was calculated using the following formula:

$$\chi^2_{ranks} = K(N-1)W$$

where

K = number of respondents

N = number of criteria ranked

W = Kendall coefficient of concordance calculated in step 4.

5. The χ^2_{ranks} was compared against the critical value of χ^2 with eleven degrees of freedom obtained from a statistics table. If the χ^2_{ranks} is less than the critical χ^2, then the null hypothesis cannot be rejected. If χ^2_{ranks} is greater than the critical χ^2 the null hypothesis can be rejected. The conclusion is to accept the alternate hypothesis that the nine commercial airline contracting personnel agree on the rankings of the criteria used in evaluating aircraft warranties (19:237).

Criteria Test. The criteria test for Research Hypothesis 1 addresses the question of whether there is agreement on the rank order of criteria used in evaluating warranties by commercial airline contracting personnel. If no agreement exists on the rankings of the criteria by the commercial airline contracting personnel, then the conclusion would be that the commercial contracting personnel do not use a homogeneous set of criteria but each contracting person has their own set of criteria which are used in evaluating an aircraft warranty. If, however, the statistical test shows that the null hypothesis of no agreement in the rankings can be rejected with a 95% confidence level, then the conclusion is that the commercial airline contracting personnel agree on the ranking of the criteria and therefore use a homogeneous set of criteria.

Research Question 1

Can the airline criteria, if they exist, be legally applied to Air Force aircraft acquisitions?

Data Collection and Analysis. Because of the changing nature of acquisition law, an absolute answer to this question could not be found. This is because interpretations of laws vary among experts and in various court decisions.

Recognizing this, a series of interviews with attorneys experienced in government contract law were conducted to determine if they felt there were any problems in employing the airline criteria. Through these interviews, an attempt was made to gather a list of potential legal problems.

A corollary objective in these interviews was to identify the specific regulations or laws which prohibited implementation of these criteria, if any.

Research Hypothesis 2

Contracting experts in the Air Force agree with the commercial airline contracting personnel in the order of importance of the criteria used in evaluating warranties.

Data Collection. The questionnaire used in Research Hypothesis 1 was again used. The sampling plan was to identify a list of experts in aircraft acquisition in ASD. Experts were considered to be Air Force contracting officers presently assigned to ASD with at least five years experience

in Air Force aircraft acquisition. A random selection using a random number generator was made of a list of experts provided by ASD/PMW to obtain a random sample of the expert contracting officers in ASD.

Identification/Definition of Variables. In collecting data for testing Research Hypothesis 2, fifteen USAF contracting officers were asked to rank order the list of criteria used in evaluating warranties in the order of importance. The individual criteria used in evaluating aircraft warranties are the independent variables and the ordinal rankings of the criteria are the dependent variables. The questionnaire letter in Appendix C contains the specific instructions given to the USAF contracting officers and a list of the criteria is found in Appendix D.

Design to Test Research Hypothesis 2. To test Research Hypothesis 2, two statistical tests were used. First, the Kendall coefficient of concordance W was used to determine if the rankings given to the criteria by the USAF contracting officers were the same. If the USAF contracting officers agree on the importance of the criteria used in evaluating warranties, then a comparison can be made between the rankings of the criteria by the commercial airline contracting personnel and the rankings of the criteria by the USAF contracting officers. The second test used was the Spearman coefficient of correlation r_s. This test was used to compare the rankings of the criteria by commercial airline contracting personnel to the rankings by the USAF contracting officers.

The procedure used for the Kendall W test was the same as the test described for Research Hypothesis 1. The null hypothesis (H_o) for this test is the rankings given to the criteria by the USAF contracting personnel are unrelated. The alternate hypothesis (H_1) is the rankings given to the criteria by the USAF contracting officers are related. To continue the test of Research Hypothesis 2, the results of the Kendall W test must be to reject H_o and conclude that the USAF contracting officers agree on the rankings of the criteria.

To evaluate this test an alpha value of .05 was used. Also, since the sample size is greater than seven, a critical chi-square value was used to test the hypothesis (19:236).

The Kendall W test was performed using the following steps:

1. The null hypothesis (H_o) is the rankings of the criteria by the USAF contracting officers are unrelated. The alternate hypothesis (H_1) is the rankings given to criteria by the USAF contracting officers are related.

2. An alpha value of .05 was chosen for the test.

3. The rank order scores were placed in a table having N columns and K rows (See Appendix H).

4. The Kendall coefficient of concordance W was calculated (See Appendix E).

5. A chi-square value for the ranks (χ^2_{ranks}) was calculated using the following:

$$\chi^2_{ranks} = K(N-1)W$$

6. The χ^2_{ranks} was compared against the critical χ^2 value with eleven degrees of freedom obtained from a statistics table. If the χ^2_{ranks} is greater than the critical χ^2, the null hypothesis can be rejected and the conclusion is to accept the alternate hypothesis (19:237).

The second statistical test used in testing Research Hypothesis 2 was the Spearman rank correlation coefficient. This test can be used on ordinal level data to determine if the rank order of two samples are from the same population (19:202).

The null hypothesis for the Spearman test is the rankings given to the criteria by the commercial contracting officers are unrelated to the rankings given to the criteria by the USAF contracting officers. The alternate hypothesis is the commercial contracting officers agree with USAF contracting officers on the rankings of the criteria.

An alpha value of .05 was selected for the test and because the number of criteria was greater than 10 the Student's t statistic was used to test the null hypothesis (19:212). The degrees of freedom for the Student's t is N-2 (19:212).

If the calculated value of the t statistic (t^*) is less than the critical value of the t statistic then the null hypothesis cannot be rejected. If t^* is greater than the critical value of t then the null hypothesis can be rejected and the conclusion would be to accept the alternate hypothesis.

Criteria Test. The criteria test for Research Hypothesis 2 addresses the question of the agreement between the commercial contracting personnel and the USAF contracting officers on the importance of the criteria used in evaluating aircraft warranties. If the Kendall W test results reject the null hypothesis with a 95% confidence level, then the conclusion is the USAF contracting personnel give the criteria the same level of importance. If the Spearman test results reject the null hypothesis, then the conclusion is the commercial airline contracting personnel and the USAF contracting officers give each criterion the same level of importance. If this conclusion can be reached, then the criteria used in evaluating commercial aircraft warranties by commercial airline contracting personnel have the same level of importance as the criteria used by USAF contracting officers.

Research Question 2

Can a list of criteria be developed for application of commercial aircraft warranties in the Department of Defense?

Data Collection and Analysis. Using the criteria rankings developed in Research Hypotheses 1 and 2, a list of criteria in order of importance was compiled. The list was based upon the results of Research Hypothesis 1 and the results of Research Hypothesis 2. The list was presented to Air Force contracting experts using the structured interview technique. Problems in the applicability of these criteria to Air Force aircraft acquisitions were then listed to show which of the criteria are not applicable to Air Force acquisitions and why these criteria are not applicable.

Generalization

The findings for Research Hypothesis 1 were not generalized beyond the population. Similarly, the findings for Research Hypothesis 2 were not generalized beyond the population.

Validity of Measurement Instruments

As mentioned earlier, the measurement instruments for testing Research Hypotheses 1 and 2 were evaluated by experts in the field and graduate students with contracting experience. Further, the statistical tests used and their applicability to the research were coordinated with the statistics department of Air Force Institute of Technology. Comments concerning the validity of the measurement instruments were received, and the measurement instruments were changed as necessary.

List of Assumptions

1. The data gathered for Research Hypotheses 1 and 2 were independently provided by the respondents.

2. Any criteria omitted in the study had no significant impact on the research results.

3. The ordered responses supplied by the respondents reflect the actual order of importance of the criteria in warranty evaluations.

4. Interview respondents interpreted the wording of the criteria in the same manner.

5. For the nonparametric statistical tests, the variables were assumed to have underlying continuity (19:31).

6. The importance of the criteria given by the airline chief contracting officers reflect the order of importance placed by their respective airlines.

Chapter 3

FINDINGS

Overview

This chapter is a presentation of the results of the research procedures presented in Chapter 2 to answer the research hypotheses and questions that were raised in the literature review. Nine corollary findings are also presented. These corollary findings are a result of additional information which was uncovered in the course of this research.

Research Hypothesis 1

The airlines use a homogeneous set of criteria to evaluate warranties.

General. To evaluate Research Hypothesis 1, phone interviews were conducted with all ten trunk carrier airlines to obtain a list of criteria used by the commercial airline contracting personnel. The twelve criteria which were obtained are listed in Appendix D.

A random sample of nine trunk carriers were then asked to rank order the twelve criteria in order of importance. If the commercial airline contracting personnel agree on the level of importance of the criteria, then this would support the hypothesis that the airline contracting

personnel can be treated as a homogeneous group in terms of evaluating warranties. The nine contracting personnel were asked to rank order the list of criteria assigning a one to the criterion which was considered most important and a twelve to the criterion which was considered least important. The rankings obtained from the airline contracting personnel are listed in Appendix G.

Primary finding. The statistical test used to test this hypothesis was the Kendall Coefficient of Concordance W. To provide additional support for Research Hypothesis 1, the Friedman Two-Way Analysis of Variance by ranks test was also used.

The null hypothesis for these tests is the airline contracting personnel do not agree on the rankings of the twelve criteria. The alternate hypothesis is the airline contracting personnel agree on the rankings of the twelve criteria and therefore represent a homogeneous group.

Kendall coefficient of concordance W: To perform the Kendall W Test, the responses from the nine airline contracting personnel were entered into the FORTRAN computer program listed in Appendix N. This computer program calculates the Kendall W value and the chi-square value associated with this calculated Kendall W value. If more than six rankings are obtained the test statistic W follows a chi-square distribution with degrees of freedom equal to the number of criteria minus 1(n-1) (19:236).

The value obtained for the Kendall coefficient of concordance W is 0.23992 and the associated chi-square value is 23.752. Referring to the table of critical chi-square values, it was found that a chi-square value of 23.752 with eleven degrees of freedom has a probability of occurring of 0.02 (19:249). Since the probability of occurrence (0.02) is less than the alpha value (0.05), the conclusion is to reject the null hypothesis and accept the alternate hypothesis that the airline contracting personnel represent a homogeneous group in ranking the twelve criteria.

Friedman Two-Way Analysis of Variance by Ranks Test: The Friedman Two-Way Analysis of Variance (ANOVA) by ranks test can be used for testing whether a number of samples have been drawn from the same population (19:166). In testing Research Hypothesis 1, this test is used to determine if the rankings given to the twelve criteria by the nine airline contracting personnel were randomly assigned.

The null hypothesis (H_o) for the Friedman ANOVA is the rankings assigned to the twelve criteria by the nine airline contracting personnel were random. The alternate hypothesis (H_1) is the rankings are not random and there exist agreement on the rankings of the twelve criteria by the airline contracting personnel. If this test shows that the null hypothesis can be rejected, then the acceptance of the alternate hypothesis would support the finding that the airline contracting personnel are a homogeneous group in their ranking of the twelve criteria.

An alpha value of 0.05 was selected to test the significance of the Friedman Two-Way ANOVA.

The Statistical Package for the Social Sciences (SPSS) system of computer programs was used to test this hypothesis. Sub-program NPAR TESTS was used and the rankings of the criteria were entered (See Appendix L). The output from the program showed a chi-square value 23.752 and a significance level of 0.014. Since the level of significance from the test (0.014) is less than the alpha value (0.05), the conclusion is to reject the null hypothesis and accept the alternate hypothesis that the airline contracting personnel agree on the rankings of twelve criteria in order of importance and therefore represent a homogeneous group.

Research Question 1

Can the airline criteria, if they exist, be legally applied to Air Force aircraft acquisitions?

Interview Results. Interviews were conducted with two attorneys from the Procurement Opinion Division of AFLC and with an attorney who presently teaches contract law at the Air Force Institute of Technology to determine if there are any legal impedements to government officials using the criteria developed through interviews with the airline experts. All three lawyers indicated that no laws or regulations would be violated by using any or all of these criteria to evaluate a warranty. Therefore, the answer to this

research question is that at present there is no known legal restriction to the use of these criteria in government negotiation in evaluating an aircraft warranty.

Research Hypothesis 2

Contracting experts in the Air Force agree with the commercial airline contracting personnel in the order of importance of the criteria used in evaluating warranties.

First Primary Finding. Research Hypothesis 2 was evaluated using two procedures. First, nine ASD contracting experts were asked to rank order the twelve criteria obtained from the commercial airline contracting personnel. These ranks were then tested using the Kendall coefficient of concordance test to ascertain whether the ASD contracting experts could be considered a homogeneous group. If the ASD contracting experts are a homogeneous group in ranking the criteria, then the second procedure is to compare the rankings from the ASD experts with the rankings of commercial airline contracting personnel to determine if the rankings show agreement. This comparison would be done using a Spearman rank correlation coefficient. If agreement is found to exist, then the order of importance of the criteria is the same for the ASD contracting experts and the commercial airline contracting personnel.

The first procedure used in Research Hypothesis 2 is to determine if the nine ASD contracting officers represent

a homogeneous group. The statistical test used in this procedure is the Kendall coefficient of concordance test. To support this result the Friedman Two-Way ANOVA was also used. The null hypothesis for these tests is that the nine ASD contracting officers do not agree on the rankings of the twelve criteria used in evaluating an aircraft warranty. The alternate hypothesis is that the ASD contracting officers agree on the rankings of the criteria and therefore constitute a homogeneous group in ranking the criteria.

Kendall Coefficient of Concordance: To test the hypothesis that the nine ASD contracting officers agree on the rankings of the twelve criteria, the ranks obtained for the criteria were entered into the FORTRAN program listed in Appendix N. The results from the FORTRAN program are a Kendall coefficient of concordance W equal to 0.38565 and the associated chi-square value equal to 38.18. The critical chi-square value with eleven degrees of freedom and a significance level of 0.05 is 19.68 (19:249). If the calculated chi-square value is less than or equal to the critical chi-square value then the decision would be to accept the null hypothesis that there is no agreement of the rankings of the criteria by the ASD contracting officers. Since the results of this test show a calculated chi-square value (38.18) greater than the critical chi-square value (19.68), the decision is to reject the null hypothesis and accept the alternate hypothesis that the ASD contracting officers

agree on the rankings of the criteria and represent a homogeneous group in ranking the criteria in the order of importance.

Friedman Two-Way ANOVA: The Friedman Two-Way ANOVA was used to support the results obtained from the Kendall coefficient of concordance test.

The null hypothesis is there is no agreement between the nine ASD contracting officers on the rankings of the twelve criteria. The alternate hypothesis is the ASD contracting officers agree on the rankings of the twelve criteria. An alpha value of 0.05 was selected to test this hypothesis.

The rankings obtained from the ASD contracting officers for the criteria were entered into the SPSS subprogram NPAR TESTS. The output from this program showed a chi-square value of 38.179 and a significance level of 0.000. Since the significance level obtained from rankings of the ASD contracting officers (0.000) is less than the alpha value (0.05), the conclusion is to reject the null hypothesis and accept the alternate hypothesis that the nine ASD contracting officers agree on the rankings of the twelve criteria. Therefore the ASD contracting officers represent a homogeneous group in ranking the twelve criteria.

Second Primary Finding. Since the results from the first procedure show that the ASD contracting officers are a homogeneous group in ranking the criteria, the second

procedure is to compare the rankings obtained from the commercial airline contracting personnel with the rankings obtained from the ASD contracting experts. This test was conducted using the Spearman rank correlation coefficient. Also, to support this finding, the Kendall rank correlation coefficient was used. The null hypothesis for these two tests is the ASD contracting officers disagree with the rankings of the criteria by the airline contracting personnel. The alternate hypothesis is the ASD contracting officers agree with the rankings of the criteria by the airline contracting personnel. The alpha value for these tests was set at 0.05.

Spearman Rank Correlation Coefficient: To conduct the Spearman rank correlation coefficient test, the twelve criteria obtained from the commercial airline contracting personnel were ranked from one to twelve using the mean ranks of each criterion (See Appendix J). The same procedure was used to rank the criteria from the ASD contracting officers (See Appendix K).

The rankings were input into the SPSS sub-program NPAR CORR (See Appendix M). This sub-program calculated the Spearman rank correlation coefficient and the associated probability. The output from the SPSS program showed a Spearman rank correlation coefficient of 0.3678 and an associated probability of 0.120. Because the calculated probability (0.120) is greater than the alpha value (0.05) set

for this test, the conclusion is to not reject null hypothesis that the ASD contracting experts do not agree with commercial airline contracting personnel in the order of importance of the twelve criteria.

Kendall Rank Correlation Coefficient: The Kendall rank correlation coefficient Tau was used to support the findings from the Spearman rank correlation coefficient. The Kendall Tau will give a measure of the degree of correlation between two sets of ranks (16:214).

To conduct the Kendall Tau test the mean ranks were input into SPSS sub-program NPAR CORR. This sub-program calculates the Kendall Tau value and its associated probability. The output from the SPSS program showed a Kendall Tau value of 0.3512 and an associated probability of 0.057. Because the calculated probability (0.057) is greater than the alpha value (0.05), the conclusion is to not reject the null hypothesis that ASD contracting experts do not agree with the commercial airline contracting personnel on the order of importance of the twelve criteria.

Research Question 2

Can a list of criteria be developed for application of commercial aircraft warranties in the Department of Defense?

Interview Results. In order to evaluate Research Question 2, the list of airline criteria was given to the

ASD experts who had ranked them. These experts were then asked if there were any reasons these criteria could not be used in ASD procurements.

Responses varied widely. Five of the ASD respondents saw no reason why the criteria cannot be used, the others voiced reservations on the applicability of the criteria, two of these voiced reservations on more than two criteria. Most emphasized the difference between the types of equipment purchased by the Air Force and the airlines. This point was summed up by David Vicars, a contracting officer in the Maverick System Program Office (SPO):

> I suspect that you will find that warranties in a commercial environment will vary from the government in many ways. Commercial carriers are usually buying "off the shelf" aircraft that have already been developed while the government is seeking to develop, through R&D, a new product. Therefore, the risks would be perceived from a different point of view on these environments which, of course, is reflected in the warranty priorities [24].

Pete Gagaris, a contracting officer in the Propulsion SPO, voiced similar reservations. He also pointed out that besides this difference, the Air Force emphasizes the quality of the equipment rather than coverage of it. He stated his belief that due to the fact that military aircraft are on the leading edge of technology, it is in the government's best interests to be self-insured (6).

In looking at the specific criteria, the most comments related to the ASD respondents' most important

criterion: the cost effectiveness of the warranty. Ironically, several questioned whether or not it is possible to quantify cost even though they consider it to be the most important criterion. They explained this discrepancy by the fact that cost breakout data is important to get any contract price approved in AFSC.

Further, Mr. Robert Kinderman, a Contracting Officer in ASD, pointed out that actually breaking out the cost of the warranty is difficult. At the same time he said, "cost is not easy to prove, but philosophically, I want to get one (warranty) when someone will guarantee the product [11]."

Mr. Gagaris, Mr. Kinderman and Mr. Miller stated reservations on criterion E, the right to repair parts for reimbursement. All three doubted that this was applicable to Air Force acquisitions as Mr. Gagaris put it, "getting money back is not necessarily good [6]." Mr. Gagaris pointed out that such provisions as the right to repair parts for reimbursement could be difficult to enforce because of the fact that Air Force maintenance personnel are not certified by the Federal Aviation Administration (6).

Mr. Gagaris also stated reservations on the criterion dealing with greater coverage due to a new design, pointing out that it would often be inconsistent with our purchasing methods because "configuration is controlled by the Air Force in aircraft acquisitions whereas the contractor controls it in the commercial arena [6]."

In discussing criterion J, the right to make or buy parts from others for reimbursement if the seller cannot supply them, both Mr. Miller and Mr. Kinderman expressed doubts. Both felt the government would be reluctant to charge contractors on a part because of time and also due to the complicating factor of collateral damage if the replaced part fails damaging other warranted items. Mr. Kinderman also emphasized that this relates to a basic requirement of any purchase, an adequate pipeline of parts must be available. Without this, a warranty is meaningless and will be broken in order to repair or replace a part to keep the aircraft flying (11).

Finally, our respondents were asked if any criteria appeared to be missing in the list provided. Mr. Kinderman was the only respondent to offer a criterion which he felt should be included in evaluating a warranty. He stated it this way: "keep it simple, the shorter the better [11]."

Primary Findings. While a list of criteria can be developed for application of commercial aircraft warranties, it should be emphasized that the criteria, like the warranties, cannot be applied in every instance. Yet a generalized list was developed, in order of importance, for application in DOD acquisition. This list (See Figure 5) is the criteria in order of importance as developed through the responses of the airline experts and the statistical techniques used in Research Hypothesis 1. Based on the

Commercial Airline Criteria Applicable

Rank by Airlines	Criterion Letter	
1	F	The warranty guarantees that the seller will redesign and replace components if they fail with exceptional frequency.
2	A	The length of coverage on aircraft components, measured by Mean Time Between Failure (MTBF)
2	B	The past performance of the seller on warranties *
4	H	The scope of coverage should be increased to include components which historically have problems
6	C	The coverage on particular components is in the most appropriate unit of measure, that is in hours or months or cycles.
7	D	The reliability of the same or similar components presently in service
9	I	The past performance of the aircraft series.
10	L	The coverage on the aircraft offered by the manufacturer compared to that offered by others.
11	K	The warranty is cost effective, that is, the cost of the warranty is less than the savings realized with the warranty *

Criteria Not Applicable

5	E	The warranty permits us to repair parts for reimbursement *
8	G	The coverage of a new design should be greater due to greater risk
12	J	The right to make or buy parts from others for reimbursement if the seller cannot supply them

* Denotes criterion which was ranked by greater than five places apart by airline and ASD experts.

Figure 5 Commercial Airline Criteria Applicable and Not Applicable to Air Force Aircraft Acquisitions

explanation of ASD experts as to why certain criteria should not apply to DOD acquisitions, those criteria, which are not applicable, in the researchers' judgment are found at the end of Figure 5. To aid the reader in isolating those rankings which significantly differ between commercial airline practices and the evaluations of DOD experts, those criteria which are ranked more than five places apart by these groups are followed by an asterisk.

Although, as mentioned earlier, considerable disagreement exists on the cost effectiveness of warranties and the ability to measure it, this criterion is used to some degree by the airlines and was considered the most important criterion by the ASD experts in spite of their reservations on the capability to measure it. For these reasons, the researchers left this criterion on the list but also pointed out that it is the least important of the airline criteria applicable to DOD procurements. Further discussion on this criterion can be found in this chapter under the heading Corollary Finding 5.

Summary of Primary Findings

Twelve criteria were obtained from the commercial airline contracting personnel. The results of Research Hypothesis 1 showed that the nine commercial airline contracting personnel agree on the order of importance of the twelve criteria used in evaluating warranties. A survey of lawyers showed the twelve criteria could be legally applied

in evaluating warranties in the DOD environment. Nine ASD contracting experts also ranked the twelve criteria and agreement was also found within the ASD contracting experts in the order of importance of the twelve criteria. However, the ASD contracting expert's rankings of the twelve criteria did not agree with the rankings from the commercial airline contracting personnel. A list of criteria was developed for use in evaluating warranties based on the rankings from the commercial airline contracting personnel and interviews with ASD contracting experts.

Corollary Findings

The corollary findings are a result of new information surfaced in interviews and as a result of the data received on the questionnaire.

In conducting interviews with airline contracting experts, questions surfaced whose answers might have an impact on the validity of the findings related to the criteria. These questions are reflected in the four questions found at the bottom of the questionnaire (See Appendix D). In the first three questions, a Likert scale was used. A t-test is presented in each corollary finding concerning these questions. The t-test assumes interval level data. The Mann-Whitney U test, using SPSS, was also performed in each test involving these questions, although the results are not presented herein. The results of the Mann-Whitney U test which is a nonparametric test requiring only ordinal

level data, were the same as the t-test results in every case. The last question was simply a yes/no answer, therefore, the data was treated as nominal and no statistical tests were done. Corollary findings 6 through 9 compared the perception of Air Force experts of commercial practices of the airlines with the airlines actual responses.

Corollary Finding 1. This question arose in interviewing the trunk carrier experts, some of whom expressed the belief that there might be a difference between the larger and smaller trunk carriers in the way they approach warranties. Some hypothesized that the smaller carriers tended to go along with the warranties already achieved by the larger carriers in aircraft purchase negotiations. If true, this would mean the criteria supplied by the smaller airlines are rarely, if ever, used. Therefore, the criteria supplied by the larger trunk carriers would be far more important because they had stood the test of actual use. This view is consistent with a common belief that the contractors are reluctant to change coverage on an item because they attempt to standardize their coverage between carriers to make their service program easier to administer.

In order to determine the validity of the belief, that the smaller airlines consider the warranty less negotiable, the following question was included in the questionnaire (See Appendix D):

The aircraft warranty is treated as a negotiable item by your airline.

The t-test was performed using the following steps:

1. The following hypotheses were used to evaluate the data:

H_o: The larger trunk carriers consider the warranty as negotiable as the smaller trunk carriers do.

H_1: The larger trunk carriers do not consider the warranty as negotiable as the small trunks.

2. An alpha value of .05 was chosen.

3. The trunk carriers were divided into two groups based upon total operating revenue and passengers (21:74). The larger four carriers were considered the larger trunks.

4. The test was conducted (See Appendix O).

5. The test resulted in a t of .986 and a t' with N-2 degrees of freedom at alpha of .05 of 2.365. Therefore the null hypothesis that the larger trunk carriers and the smaller trunk carriers consider the warranty as negotiable was not rejected. The results of the test indicate that the smaller trunk carriers do consider the warranty as negotiable as the larger trunk carriers do.

Corollary Finding 2. The same test as the one used in Corollary Finding 1 was used to determine if the ASD experts consider the warranty as a negotiable item as much as the airline experts do.

1. Therefore, the following hypotheses were used:

H_o: The ASD experts consider the warranty to be as negotiable as the airline experts do.

H_1: The ASD experts consider the warranty to be more or less negotiable than the airline experts do.

2. An alpha value of .05 was chosen.

3. The test was conducted in the same manner, using the same formulas as found in Appendix O where the computations for this corollary finding are shown.

4. The test resulted in a t of 1.25335 and a t' with N-2 (16) degrees of freedom at alpha of .05 to be 2.120. Therefore, the null hypothesis that the ASD experts consider the warranty to be as negotiable as the airline experts do was not rejected.

Corollary Finding 3. Again, the same test of difference between means shown for Corollary Finding 2 (See Appendix O) was used. The question was whether or not there was a difference between the airline and ASD view of the cost effectiveness of the warranty.

1. The following hypotheses were used:

H_o: The airline experts and ASD experts view the benefits of the warranty as compared to the price in the same way.

H_1: The airline experts and ASD experts do not view the benefits of the warranty as compared to the costs in the same way.

2. An alpha value of .05 was chosen.

3. The test was conducted in the same manner, using the same formulas found in Appendix O where the computations for Corollary Finding 2 are shown.

4. The test resulted in a t of 1.097 and a t' with N-2 (16) degrees of freedom, of 2.120. Therefore the null hypothesis was not rejected. The ASD experts and the airline experts considered the relationship between warranty costs and benefits in roughly the same manner.

Corollary Finding 4. The same test as the one used in Corollary Findings 1 through 3 was again used to determine if the ASD experts and the airline experts agreed on whether proposal leveling was the most effective way of getting the best coverage on an aircraft warranty.

1. The following hypotheses were used:

H_o: The airline and ASD experts agree that proposal leveling is the most effective way of getting the best coverage on an aircraft warranty.

H_1: The airline and ASD experts do not agree.

2. An alpha value of .05 was used.

3. The test was conducted using the same formulas found in Appendix O where the computations for Corollary Finding 2 are shown.

4. The test resulted in a t of .978 and a t' of 2.12. Therefore, once again the null hypothesis could not be rejected. Therefore, the ASD experts and the airline experts do not disagree on the value of proposal leveling, with 95% confidence.

Corollary Finding 5. This finding concerns the use of proposal leveling in the airlines and ASD. Three points are salient in this issue. They are the results from our question asking the airline and ASD experts if they use proposal leveling and finally the ASD experts' opinions on whether or not the airlines do in fact use this practice.

All nine of the airline contracting experts who were sent a questionnaire answered the question no, that they do not use proposal leveling. In addition, several included comments that such practices are unethical and against company policy. One expert stated an opinion that the practice may be illegal for commercial companies. One photocopied questionnaire was received from a warranty administrator for an airline (In all, two photocopied questionnaires were received from individuals who were not asked to fill them out by the researchers. Their responses were not included in the primary findings). This administrator answered the question yes.

Of the nine ASD experts who responded to the questionnaire, all but one said they did not use proposal leveling.

As explained in Corollary Finding 6, nine Air Force experts were asked to give their perceptions of the airline practices by answering the questionnaire on the basis of how they feel the airlines do business. Of these, six felt the airline do use proposal leveling and three felt the airlines do not use proposal leveling.

Greater insight into the question of the Air Force experts' perception of the airlines' use of proposal leveling was offered by Lt. Col. Pattison, one of the attorneys from the Procurement Opinion Division who was interviewed. Lt. Colonel Pattison stated his belief that the airline experts, especially at higher corporate levels would be reluctant to admit the use of this technique, even though it isn't illegal for them to use it, because it is probably against corporate policy. He felt that the negotiators in the airlines probably do use it. At the same time, he stated that the ASD experts probably would claim that they do not use it because it is against the DAR although the technique is sometimes used by Government engineers during a negotiation (17).

A clear majority of airline and ASD experts responded that they did not use proposal leveling. Further, there is a belief among a majority of Air Force experts questioned that the airlines do use proposal leveling.

Corollary Finding 6. To determine if the ASD contracting experts have an accurate perception of the airline procedures used in evaluating warranties, another sample was taken. Nine Air Force personnel were asked to rank order the twelve criteria in the order of importance they believe the commercial airlines would use. Two of nine original respondents were replaced for this test because two of the original experts were unavailable. These rankings were then tested for agreement to determine if the DOD contracting

personnel were a homogeneous group in their perception of the commercial airline experts evaluation of warranties. This test was conducted using the Kendall coefficient of concordance W. The null hypothesis for this test is the nine Air Force experts' perceptions of the airline ranking of the criteria do not agree. The alternate hypothesis for this test is the nine Air Force experts agree on the rankings and therefore represent a homogeneous group in their perception of the airline's ranking of the twelve criteria. This test was conducted with an alpha value of 0.05.

Kendall Coefficient of Concordance W: The rankings of the criteria obtained from the nine Air Force experts based on their perception of airline rankings were input into the Kendall W computer program (See Appendix N). The output from the program showed a Kendall W value of 0.17224 and an associated chi-square value of 17.05. The critical chi-square with eleven degrees of freedom and a significance level of 0.05 is 19.68 (19:249). Since the calculated chi-square value (17.05) is less than the critical chi-square value (19.68), the null hypothesis that the Air Force experts do not agree on their perception of the airline's rankings can not be rejected. Therefore, the results of this test shows that the nine Air Force experts are not a homogeneous group in their perception of the commercial airline's rankings of the twelve criteria.

Corollary Finding 7. The test between means used in Corollary Findings 1 through 4 was again used. This time a comparison between the means of the responses made by the airline experts and the Air Force experts' perceptions of their responses were made on the following question.

The aircraft warranty is treated as a negotiable item by your airline.

1. The following hypotheses were evaluated:

H_o: The airline experts' view and the Air Force experts' perception of that view on the above question are the same.

H_1: The airline experts' view and the Air Force experts' perception of that view on this question are not the same.

2. An alpha value of .05 was chosen.

3. The test was conducted in the same manner, using the same formulas found in Appendix O, where the computations for Corollary Finding 2 are shown.

4. A t value of 1.397 was calculated and a t' of 2.12. Since the t' is greater than the calculated t the null could not be rejected.

Corollary Finding 8. The test between means described above, using the same steps and formulas was performed with an alpha value of .05. This test was used to determine if the airline experts' opinions and the perception of those opinions held by the Air Force experts are in agreement on

whether or not the price of a warranty is more than offset by the benefits of the coverage. The same hypotheses as shown in Corollary Finding 7 were used.

The results shown in Appendix O included a calculated t of 1.46 which was less than the t' of 2.12 which was needed to reject the null. Therefore the null that there was no difference between the airline experts' opinions and the Air Force experts' perception of that opinion could not be rejected with 95% confidence.

Corollary Finding 9. The test between means was again performed using the same formulas, steps, alpha value, and hypotheses. The question examined was whether or not proposal leveling is the most effective way of getting the best coverage on an aircraft warranty.

The results included a t of 4.545 which is greater than the t' of 2.12 which must be exceeded to reject the null. Therefore, the null was rejected with 95% confidence. This means the Air Force experts perceived the airline experts' beliefs to be different from what they actually were. The interval for this difference indicated the Air Force experts believed the airlines would view proposal leveling to be more beneficial than the airline experts actually did from between 1.9 to 5.2 on the Likert scale.

Summary of Corollary Findings

In the Corollary Findings, the results supported the hypotheses of similarity between airline and ASD

experts' opinions concerning the cost effectiveness of a warranty and whether or not it is negotiable. In both cases the ASD experts' perceptions of the airlines coincided with the airline experts' responses. No evidence was found to support the contention that larger trunk carriers view the warranty to be more negotiable than smaller trunk carriers do.

It was also found that the use of proposal leveling and the experts' perceptions of the effectiveness of it were approximately the same for the airline experts and the ASD experts. However, it was also found that the ASD experts believed the airlines used proposal leveling and falsely believed that the airline experts would consider proposal leveling to be more effective than the airline experts actually did.

Finally, insufficient agreement was found among the ASD experts' perceptions of the airlines' ranking of the criteria to formulate a consolidated list of the ASD experts' perceptions of the airlines.

Chapter 4

CONCLUSIONS

Overview

This chapter contains conclusions derived from the findings in Chapter 3. The objective of this research project was to determine the criteria used by the trunk carriers, in evaluating an aircraft warranty to determine if these criteria can be applied to Air Force aircraft acquisitions when seeking a commercial aircraft warranty, and to determine if ASD contracting experts place a similar emphasis on those criteria when evaluating an aircraft warranty.

The primary findings related to these objectives are presented in this chapter followed by corollary conclusions which were derived from other information developed through the interviews with airline experts and the questionnaire.

Research Hypothesis 1

The airlines use a homogeneous set of criteria to evaluate warranties.

Hypothesis Support. Research Hypothesis 1 was supported. The results of the Kendall W test shown in Chapter 3 indicated a high degree of correlation between the rankings of the criteria given by the airline contracting experts. The established significance of the correlation of 95% certainty was exceeded.

General Conclusions. The primary conclusion derived from Research Hypothesis 1 is that the airlines do evaluate an aircraft warranty in much the same way. By using the mean ranks of the airline experts to find natural breaks in order to group the criteria by importance to the airline experts the list shown in Figure 6 was developed. The clearest break in the means appeared between the top 8 and bottom 4 criteria, thus the least important criteria could be easily discerned.

Research Question 1

Can the airline criteria, if they exist, be legally applied to Air Force aircraft acquisitions?

General Conclusions. As indicated in the previous chapter, interviews with three government lawyers indicated no legal reasons why the airline criteria could not be applied to Air Force aircraft procurements.

Research Hypothesis 2

Contracting experts in the Air Force agree with the commercial airline contracting personnel in the order of importance of the criteria used in evaluating warranties.

Hypothesis Support. This hypothesis was not supported in our research. The ASD contracting experts were found to be a homogeneous group in terms of ranking the criteria. This level of significance for this part of the

Mean Rank	Criteria
2.89	The warranty guarantees that the seller will redesign and replace components if they fail with exceptional frequency.
4.67	The length of coverage on aircraft components, measured by Mean Time Between Failure (MTBF).
4.67	The past performance of the seller on warranties.
5.78	The scope of coverage should be increased to include components which historically have problems.
6.33	The warranty permits us to repair parts for reimbursement.
6.44	The coverage on particular components is in the most appropriate unit of measure, that is in hours or months or cycles.
7.00	The reliability of the same or similar components presently in service.
7.22	The coverage of a new design should be greater due to greater risk.
7.67	The past performance of the aircraft series.
7.89	The coverage on the aircraft offered by the manufacturer compared to that offered by others.
8.56	The warranty is cost effective, that is, the cost of the warranty is less than the savings realized with the warranty.
8.89	The right to make or buy parts from others for reimbursement if the seller cannot supply them.

Figure 6. Airline Criteria Ordered by Mean Rank.

test was greater than 99.9%. This result shows that the ASD contracting experts rank the criteria in the same order.

However, the comparison of the rankings obtained from the ASD contracting experts with the rankings obtained from the commercial airline contracting personnel did not show correlation. A visual inspection of the rankings obtained from the two sources revealed three criteria with a difference in ranking of greater than five ranks. These criteria are listed in Figure 7.

ASD Experts Rank	Commercial Airline Contracting Personnel Rank	Criteria
8	2	The past performance of the sellers of warranties.
11	5	The warranty permits us to repair parts for reimbursement.
1	11	The warranty is cost effective, that is, the cost of the warranty is less than the savings realized with the warranty.

Figure 7. Criteria Which Differ by More Than Five Ranks.

An attempt was made to find correlation between the rankings of the two groups by individually deleting each of the three criteria identified in Figure 7 and recomputing the Spearman rank correlation coefficient. The results of this test are shown in Appendix P. The results of deleting the cost effectiveness criteria showed that with 95%

confidence the ASD contracting experts agree with the commercial airline contracting personnel in ranking the remaining eleven criteria in order of importance. Individual deletion of the other two criteria did not result in correlation.

General Conclusions. The ASD contracting experts do not agree with the rankings obtained from the commercial airline contracting personnel in order of importance of the twelve criteria. Correlation was found to exist if the criteria of cost effectiveness is not included.

It was stated in interviews with the commercial airline contracting personnel that the cost of the warranty is impossible to determine because the warranty is not an optional item. The commercial airline contracting personnel therefore believe that, because cost effectiveness of a warranty is impossible to calculate, the criteria of cost effectiveness is of little importance.

The ASD experts had a different view of cost effectiveness. The ASD experts stated that in purchasing a major weapon system, such as a new aircraft, it is extremely important to justify every element of cost. Therefore, even though the cost of the warranty and the resultant savings are extremely difficult to measure, the contracting officer must be able to show a cost benefit from obtaining a warranty. This may have led the ASD experts to rank the cost effectiveness criteria as the most important criteria in evaluating a warranty.

Research Question 2

Can a list of criteria be developed for application of commercial aircraft warranties in the Department of Defense?

General Conclusions. A list of criteria derived from the airlines applicable to DOD aircraft procurement was presented in Figure 5, page 46. This list is presented in order of the mean of the ranks of the criteria provided by the airlines. Criteria were deleted from this list in light of opinions expressed by the ASD experts interviewed. The list of criteria which were deleted are also shown in Figure 5.

The most significant difference between the airline experts and ASD experts in evaluating a warranty, the cost effectiveness of the warranty, was included in the list of criteria applicable to DOD aircraft procurements, however, its ranking clearly indicates that this is the least important of the criteria listed. If the government is to follow commercial practices more closely in evaluating aircraft warranties then less emphasis on this criterion by acquisition personnel would be appropriate. Further, more emphasis should be placed on past performance of the seller on warranties and if the situation permits, gaining provisions which permit the government to repair parts for reimbursement.

Finally, a complete list of criteria for evaluating an aircraft warranty should include, according to ASD expert Mr. Robert Kinderman, an evaluation of the simplicity of the warranty clauses. This additional criteria seems appropriate in order to avoid costly litigation due to the possibility of ambiguities arising out of complex clauses.

Corollary Conclusions

This portion of the study contains the conclusions for the nine corollary findings described in the previous chapter.

The first corollary finding indicated that there was no significant difference between the larger four trunk carriers experts, and the smaller five trunk carrier experts on the question of whether or not they treat the aircraft warranty as a negotiable item, in fact, all of the airlines except one responded with a 1 for strongly agree with the statement. Only one airline expert, a smaller trunk expert, responded differently to the question. This one expert responded that he strongly disagreed with the statement. Clearly, there was wide agreement among the airline experts, both large and small airlines, that the warranty is treated as a negotiable item by their airlines. At the same time, it should be pointed out that the sample of large and small trunk carriers was very small and results could have easily been effected by only one respondent. Therefore, while there appears to be wide agreement on this question between

the large and small trunk carriers, further study is warranted to add certainty to this conclusion.

In the second through fourth corollary findings the hypothesis could not be rejected that there was agreement between the airline experts' views and the ASD experts' views, on the three questions ranked on a Likert scale from strongly agree to strongly disagree. While the null hypothesis could not be rejected in the three cases, the means of two of the three revealed possible differences had the sample sizes been larger. The average, or mean, response of the airline experts on the first statement, that the aircraft warranty is treated as a negotiable item by their airline, indicated slightly stronger agreement than the response by the ASD experts. On the second statement, that the price of a warranty is more than offset by the benefits of the coverage, the reverse was true. That is, the mean response by the ASD experts indicated slightly more agreement than the responses of the airline experts. Of the three statements, the strongest agreement between ASD experts and airline experts was on whether or not proposal leveling is the most effective way of getting the best coverage on an aircraft warranty. Both groups tended to strongly disagree with the statement.

The fifth corollary finding related to the last question on the questionnaire. Respondents were asked to answer yes or no to the statement "we use the proposal

leveling technique to get a better aircraft warranty". As pointed out in the findings, all primary airline respondents and all ASD respondents but one responded no. The remaining ASD respondent and one unsolicited airline contract administrator responded yes. There was near universal agreement among the respondents that they do not use the technique. On the other hand, when asked their perception of the airlines' practices, most of the Air Force experts expressed their belief that the airlines do use the technique. As previously mentioned, not only is technical leveling against defense regulations, but it is also against corporate policy among the airlines according to the airline respondents. Six of the nine ASD experts felt the airlines do use proposal leveling. Like the "grass is greener" attitude that seems to be reflected in the ASD perceptions of airline practices was the comment by one airline expert expressing his belief that Air Force contracting officers may use the technique but that his airline does not. No evidence was uncovered to indicate that either the airline contracting executives or the Air Force contracting officers violate their respective "company policy" more frequently.

The sixth corollary finding showed that the ASD contracting personnel have an incorrect perception of the commercial airline procedures in evaluating warranties. The results of the Kendall W test presented in Chapter 3 showed the ASD contracting experts do not have a consistent

view of the commercial airline practices. Without a consistent view, a comparison of ASD experts perceptions of the order of importance and the airlines actual rankings would be inappropriate.

The conclusion drawn from this finding is the ASD contracting experts need better information on the commercial airline procedures used in evaluating warranties. If the ASD contracting community is to effectively use commercial practices in evaluating warranties, it is imperative that the ASD contracting community understand the commercial practices.

The results of the seventh and eighth corollary findings show that the ASD experts' perceptions of the commercial airline practices do not significantly differ from the actual commercial airline practices. The ASD experts' perception that the commercial airlines treat the warranty as negotiable is an accurate perception. With the exception of one commercial airline, all respondents felt very strongly that the warranty is a negotiable item. The results of the eighth corollary finding showed no significant difference between the commercial airline contracting personnel and the ASD experts perceptions of the airlines in the area of cost effectiveness. The response to this question reflects the difficulty in measuring the cost effectiveness of the warranty. Both the commercial airline contracting personnel

and the ASD perception fall around the middle of the scale. The respondents did not agree or disagree with the statement that the warranty is cost effective.

The ninth corollary finding showed that there is a misconception with the ASD contracting community that the commercial airlines use proposal leveling. The results of the statistical test presented in Chapter 3 showed that there is a significant difference between the ASD experts' perceptions and the actual commercial airline contracting personnel's response to the question on the effectiveness of proposal leveling. The commercial airline contracting personnel strongly disagreed with the statement and the ASD experts' perception was that the commercial airlines would agree with the statement. This response was supported by the response to the question of whether the airlines use proposal leveling. All nine airline contracting personnel answered this question no and most airlines commented that this procedure is unethical. The ASD experts' perceptions, by contrast, were that proposal leveling is used by the airlines (six of the nine respondents answered yes).

Chapter 5

RECOMMENDATIONS

This chapter contains recommendations of a general nature concerning how commercial practices studied herein can be implemented in Air Force aircraft acquisitions and recommendations for further research.

General Recommendations

The following recommendations are offered:

1. In order for DOD to evaluate aircraft warranties in a manner similar to that of the airlines, the following criteria should be used with the first criterion considered the most important and the last criterion the least important.

A. The warranty guarantees that the seller will redesign and replace components if they fail with exceptional frequency.

B. The length of coverage on aircraft components, measured by Mean Times Between Failure (MTBF).

C. The past performance of the seller on warranties.

D. The scope of coverage should be increased to include components which historically have problems.

E. The coverage on particular components is in the most appropriate unit of measure, that is in hours or months or cycles.

F. The reliability of the same or similar components presently in service.

G. The past performance of the aircraft series.

H. The coverage on the aircraft offered by the manufacturer compared to that offered by others.

I. The warranty is cost effective, that is, the cost of the warranty is less than the savings realized with the warranty.

This ranking differs from that given by ASD experts when they were asked to rank these criteria. This difference was most pronounced in their ranking of three criteria, indicating a particular need for a change in emphasis in these areas when evaluating a warranty. Two of these areas are found in General Recommendations 2 and 3. The other criterion was not considered applicable to government acquisitions for the reasons explained in Chapter 3, Research Question 2.

2. Less emphasis on cost effectiveness of a warranty is needed. The airline experts ranked this criterion 11th out of 12, while the ASD experts ranked this first. As several experts, in both airlines and ASD, pointed out the cost effectiveness of a warranty cannot, at present, be determined. The airlines' solution to this problem seems

to be to decrease the emphasis on the cost of the warranty and to emphasize criteria which are related to the potential benefits of the warranty. In order to follow airline practices in this area, the Department of Defense should do the same.

3. Greater emphasis should be placed on the past performance of the seller on warranties. The airline experts ranked this criterion 2nd while the ASD experts ranked it 8th.

4. A booklet explaining commercial aircraft warranty procedures should be published to assist the contracting officer in following the commercial practices he is expected to follow. This need is indicated by the fact that there is such a wide range of opinion regarding airline practices, that insufficient agreement existed among the Air Force experts questioned for the researchers to ascertain a general perception of the Air Force experts as to what the airline practices are.

5. This study revealed no disadvantage to the government in negotiating an aircraft warranty, than the airlines face in their negotiations, due to the DAR's prohibition on proposal leveling. The airlines, like the government, consider the practice unethical. Therefore no evidence was found to show that this prohibition should be stopped in order to bring the government practices in line with airline practices.

Recommendations for Further Study

The following are offered as areas of further study:

1. This study showed disagreement among Air Force contracting experts as to commercial practices in this field. Further study in commercial practices in warranties and other fields would give acquisition experts a better understanding of commercial practices and how to implement those practices when appropriate.

2. Further study, utilizing larger samples, is needed to confirm initial findings in this study concerning the criteria and methods used by airlines in evaluating and negotiating warranties. Such a study might examine differences in criteria and procedures used by various sizes of airlines including regional airlines. By studying smaller airlines, researchers might be able to investigate if criteria used in evaluating warranties on small aircraft are different than those on larger aircraft.

3. A study to determine criteria to evaluate the benefits of a warranty already in existence to include the operational and cost benefits.

4. A study to evaluate the benefits of commercial aircraft warranties that have been bought in such programs as the KC-10, to identify differences between those warranties and airline warranties and to offer lessons learned.

5. At present, no known algorithm exists which permits the evaluation of the cost and savings from an

aircraft warranty either proposed or in use. Such an algorithm would be of great benefit in justifying a proposed warranty or in learning from past warranties.

APPENDICES

APPENDIX A

INTERVIEW GUIDE NO. 1

1. Date_____

2. Individual Interviewed_____

3. Airline/Office_____

4. What criteria do you use in evaluating an aircraft warranty?

5. Do you know of any other criteria used by other acquisition/contracting officers in evaluating an aircraft warranty?

APPENDIX B

LIST OF UNITED STATES TRUNK CARRIERS

AIRLINE	TOTAL NUMBER OF AIRCRAFT 1978
American	250
Braniff	100
Continental	60
Delta	200
Eastern	236
Northwest Orient	106
Pan Am	94
TWA	208
United	341
Western	79

Note: The numbers of aircraft are provided to indicate the size of the trunk carriers. The aircraft included in the list are Boeing B-707, B-720, B-727, B-737, B-747; McDonnell Douglas DC-8, DC-9, DC-10, DC-9-50; and Lockheed L-1011, L-188. All other airlines, classified as local service carriers, have considerably fewer of these types of aircraft with the exception U. S. Air (Allegheny) which possesses 53 of them. However, Allegheny, due to other factors is not considered a trunk carrier.

APPENDIX C

COVER LETTER FOR QUESTIONNAIRE

REPLY TO
ATTN OF: RTAO: Captain Tom Sutliff and Captain Jack Grubb, AFIT/LS

SUBJECT: Questionnaire on Warranty Criteria

TO:

Dear Mr.

The attached questionnaire concerns warranty procedures and criteria. As we mentioned in our telephone conversation a couple of weeks ago, we're pursuing a degree in Contracting and Acquisition Management and our Master's thesis is concerned with whether or not procedures and criteria used by the airlines in evaluating warranties on new aircraft purchases can be used by the U.S. Air Force.

We're asking that you rank the criteria listed on the next page in order of importance from 1 through 12 that your airline considers when receiving and/or negotiating a warranty on a new aircraft purchase. (Please assign each ranking to only one criterion with 1 being the most important and 12 the least important). We also ask that you answer the questions on your warranty procedures and finally add any comments that you have on warranty criteria and procedures on the back of the questionnaire.

We realize that you may be concerned with the confidentiality of your responses therefore, no mention of any particular airline will be given in any written or oral reports in association with any replies on this questionnaire.

One last request, we'd appreciate it if you'd mail our questionnaire in the enclosed envelope as soon as possible to help us meet our thesis deadline. If you have any questions, please call us at 513-879-3111 or 513-252-9025 collect. Thank you for your assistance with both telephone interviews and this questionnaire.

Yours truly,

2 Atch: Questionnaire
Envelope

Tom Sutliff & Jack Grubb

APPENDIX D

QUESTIONNAIRE

Warranty Criteria Please rank according to importance from 1 to 12

_____The length of coverage on aircraft components, measured by Mean Time Between Failure (MTBF)

_____The past performance of the seller on warranties.

_____The coverage on particular components is in the most appropriate unit of measure, that is in hours or months or cycles.

_____The reliability of the same or similar components presently in service.

_____The warranty permits us to repair parts for reimbursement.

_____The warranty guarantees that the seller will redesign and replace components if they fail with exceptional frequency.

_____The coverage of a new design should be greater due to greater risk.

_____The scope of coverage should be increased to include components which historically have problems.

_____The past performance of the aircraft series.

_____The right to make or buy parts from others for reimbursement if the seller cannot supply them.

_____The warranty is cost effective, that is, the cost of the warranty is less than the savings realized with the warranty.

_____The coverage on the aircraft offered by the manufacturer compared to that offered by others.

Please circle the most appropriate answer on the scale provided from 1 for strongly agree to 7 for strongly disagree.

1 2 3 4 5 6 7 The aircraft warranty is treated as a negotiable item by your airline.

1 2 3 4 5 6 7 The price of a warranty on an aircraft is more than offset by the benefits of the coverage.

1 2 3 4 5 6 7 Proposal leveling* is the most effective way of getting the best coverage on an aircraft warranty.

Yes No

1 2 We use the Proposal leveling* technique to get a better aircraft warranty.

* Proposal leveling: the act of providing a competing contractor with information on the proposal of another competing contractor for the purpose of eliciting a better offer from the first contractor--sometimes called Chinese Auctioning.

APPENDIX E

KENDALL COEFFICIENT OF CONCORDANCE

The following procedure was used to calculate the Kendall coefficient of concordance W (16:237).

1. Sum the rank for each criteria (R_j).

2. Divide the sum (R_j) by the number of criteria ranked (N).

3. Calculate the deviation of each R_j from the mean R_j, square the value and sum.

4. Calculate the Kendall W by taking the value obtained in 3 and dividing by the maximum squared deviations.

$$W = \frac{S}{\frac{1}{12}K^2(N^3-N)}$$

where

$$S = \Sigma \left(R_j - \frac{\Sigma R_j}{N}\right)^2$$

R_j = rank of the j^{th} criteria

N = number of criteria ranked

K = number of respondents who ranked criteria

APPENDIX F

SPEARMAN RANK CORRELATION COEFFICIENT

The following procedure was used to calculate the Spearman rank correlation coefficient r_s (16:212-213).

1. List the rank for each criteria received from the commercial airline contracting personnel beside the rank for the same criteria received from the USAF contracting officers.

2. Calculate the difference (di) between the rank given by the commercial contracting personnel and the rank given by the USAF contracting officers for each rank. Square each difference and sum the squares for each criteria (Σdi^2).

3. Calculate r_s using the following formula:

$$r_s = 1 - \frac{6\Sigma di^2}{N^3-N}$$

where:

di = the difference between ranking for each individual criteria

N = the number of criteria ranked

APPENDIX G

RESPONSES OF THE AIRLINE EXPERTS

RANKS OF THE CRITERIA BY AIRLINE EXPERTS														QUESTIONS				
	A	B	C	D	E	F	G	H	I	J	K	L		A	B	C	D	
Expert 1	6	5	8	10	4	1	3	9	11	7	12	2		1	4	7	2	Expert 1
2	1	6	9	7	8	2	4	5	10	11	12	3		1	4	3	1	2
3	1	5	4	8	3	7	12	9	10	6	2	11		7	7	7	2	3
4	4	5	2	6	3	1	7	8	9	12	11	10		1	5	7	2	4
5	1	6	8	9	5	2	7	4	10	3	11	12		1	2	7	2	5
6	3	9	10	7	6	1	2	5	4	12	8	11		1	5	6	2	6
7	9	1	6	7	10	5	12	8	2	11	4	3		1	1	7	2	7
8	5	3	7	4	12	6	11	1	2	8	9	10		1	5	7	2	8
9	12	2	4	5	6	1	7	3	11	10	8.	9		1	1	7	2	9
Total	42	42	58	63	57	26	65	52	69	80	77	71		15	34	58	18	Total

APPENDIX H

RESPONSES OF ASD EXPERTS

RANKS OF THE CRITERIA BY ASD EXPERTS														QUESTIONS				
	A	B	C	D	E	F	G	H	I	J	K	L		A	B	C	D	
Expert 1	3	2	11	6	7	10	4	5	9	12	1	8		3	1	7	2	Expert 1
2	10	2	8	4	11	1	7	3	5	12	6	9		2	4	6	2	2
3	3	10	4	5	11	8	9	6	7	12	2	1		2	2	4	2	3
4	4	9	3	8	10	2	5	7	11	6	1	12		3	4	7	2	4
5	3	10	2	7	5	4	9	8	6	12	1	11		2	2	5	1	5
6	2	8	1	3	10	5	4	6	7	9	11	12		4	2	6	2	6
7	4	11	5	10	12	1	6	2	9	8	3	7		3	1	7	2	7
8	5	12	6	2	8	3	9	10	7	4	1	11		2	5	3	2	8
9	6	7	4	3	9	2	8	5	11	12	1	10		2	4	5	2	9
Total	40	71	44	48	83	36	61	52	72	87	27	81		23	25	52	17	Total

APPENDIX I

AIR FORCE EXPERTS' PERCEPTIONS OF AIRLINE EXPERTS' RESPONSES

AIR FORCE EXPERTS' PERCEPTION OF HOW THE AIRLINE EXPERTS WOULD RANK THE CRITERIA														QUESTIONS				
	A	B	C	D	E	F	G	H	I	J	K	L		A	B	C	D	
Expert 1	4	5	7	8	11	1	6	10	3	12	9	2		1	1	2	1	Expert 1
2	5	3	4	6	9	8	7	11	12	10	1	2		1	1	3	1	2
3	2	6	10	9	5	4	3	8	7	11	12	1		1	4	1	1	3
4	1	10	8	9	7	5	4	3	11	6	2	12		3	3	6	2	4
5	10	6	8	7	5	2	12	11	4	9	1	3		6	2	2	1	5
6	10	5	9	2	6	11	7	4	1	12	8	3		1	3	6	2	6
7	11	5	12	6	10	4	3	7	2	8	1	9		6	4	1	2	7
8	12	3	2	7	8	9	11	6	5	10	1	4		5	4	3	1	8
9	5	2	6	8	10	3	11	4	12	7	1	9		2	4	2	1	9
Total	60	45	66	62	71	47	64	64	57	85	36	45		26	26	26	12	Total

APPENDIX J

MEAN RANKS OF CRITERIA FROM AIRLINES

Criteria	Mean	Ranking
A	4.67	2
B	4.67	2
C	6.44	6
D	7.00	7
E	6.33	5
F	2.89	1
G	7.22	8
H	5.78	4
I	7.67	9
J	8.89	12
K	8.56	11
L	7.89	10

APPENDIX K

MEAN RANKS OF CRITERIA FROM ASD EXPERTS

Criteria	Mean	Ranking
A	4.44	3
B	7.89	8
C	4.89	4
D	5.33	5
E	9.22	11
F	4.00	2
G	6.78	7
H	5.78	6
I	8.00	9
J	9.67	12
K	3.00	1
L	9.00	10

APPENDIX L

SPSS PROGRAM TO CALCULATE FRIEDMAN TWO-WAY ANOVA

```
RUN NAME        FRIEDMAN TEST FOR THESIS
VARIABLE LIST   A B C D E F G H I J K L
N OF CASES      9
INPUT FORMAT    FREEFIELD
INPUT MEDIUM    CARD
NPAR TESTS      FRIEDMAN = A B C D E F G H I J K L/
READ INPUT DATA
$       SELECT  AIRLINES
FINISH
```

APPENDIX M

SPSS PROGRAM FOR CALCULATING SPEARMAN RANK CORRELATION COEFFICIENT AND KENDALL TAU

```
RUN NAME        SPEARMAN TEST FOR THESIS
VARIABLE LIST   A, B
INPUT MEDIUM    CARD
N OF CASES      12
INPUT FORMAT    FREEFIELD
NONPAR CORR     A WITH B
OPTION          6
READ INPUT DATA
$       SELECT  FILENAME
FINISH
```

APPENDIX N

FORTRAN PROGRAM FOR CALCULATING KENDALL W

```
10      DIMENSION IRANK(15,12)
20      PRINT , "ENTER NUMBER OF JUDGES AND NUMBER OF CRITERIA"
30      READ , K,N
40      DO 100 J = 1,K
50      PRINT , " "
60      PRINT 900,J
70      READ , (IRANK(I,J),I-1,N)
80 100  CONTINUE
90      GRAND = 0.
100     DO 110 I = 1,N
110     TOTAL1 = 0.
120     DO 105 J = 1,K
130     TOTAL1 = TOTAL1 + IRANK(I,J)
140 105 CONTINUE
150     RJ(I) = TOTAL1
160     GRAND = GRAND + TOTAL1
170 110 CONTINUE
180     XMEAN = GRAND / N
190     S = 0.
200     DO 120 I = 1,N
210     S = S + (RJ(I)-XMEAN)**2
220 120 CONTINUE
230     W = (12*S)/(K**2*(N**3-N)
240     CHI = K*(N-1)*W
250     PRINT , " "
260     PRINT , " "
270     PRINT 901,W,CHI
280     STOP
290 900 FORMAT(1X,"ENTER RANKS FOR JUDGE",I3)
300 901 FORMAT(1X,"KENDALL W VALUE IS",F8.5,
310&                 CHI-SQUARED IS",F9.5)
320     END
```

APPENDIX O

T-TEST USED ON COROLLARY FINDINGS 1-4, 7-9

The test used was simply to determine if the difference between the means was greater than 0. Two methods were used in each case to test this and are shown below to assist the reader in understanding the procedure. The calculations for corollary finding No. 1 are shown. The data resulting from the calculation for corollary findings 1, 3 and 4 are also shown.

H_o: $\mu_1 - \mu_2 = 0$ if $t \leq t^1$ accept, if $t > t^1$ reject

H_1: $\mu_1 - \mu_2 \neq 0$

$\alpha = .05$

To find t_1 the following formulas were used:

$$S^2_{1/2} = \frac{\Sigma(x-\bar{x})^2}{N-1} \quad \text{where} \quad X_{1/2} = \frac{\Sigma(x)}{N}$$

Airlines ASD

$\bar{X}_1 = \frac{15}{9} = 1.67$; $\bar{X}_2 = \frac{23}{9} = 2.556$

$\bar{D} = \bar{X}_2 - \bar{X}_1 = .889$

$$S^2_1 = \frac{\Sigma(x-1.67)^2}{8} = 4.0 \qquad S^2_2 = \frac{\Sigma(x-2.556)^2}{8} = .5278$$

$$S^2 = \frac{(\mu-1)S^2_1 + (N_2-1)S^2_2}{N_1 + N_2 - 2} = \frac{(8)(4) + (8)(.528)}{9 + 9 - 2} = 2.2639$$

$$S_{\bar{x}_1-\bar{x}_2}, S(\bar{D}) = \sqrt{\frac{S^2}{N_1} + \frac{S^2}{N_2}} \text{ or } S\sqrt{\frac{1}{N} + \frac{1}{N_2}}$$

$$S_{\bar{x}_1-\bar{x}_2}, S(\bar{D}) = \sqrt{\frac{2.2639}{9} + \frac{2.2639}{9}} = .7093$$

$$t = \frac{(\bar{x}_2-\bar{x}_1)-0}{S_{\bar{x}_1-\bar{x}_2}} = \frac{2.556-1.67-0}{.5299} = 1.2525$$

1.254 or $t < 2.12$ t^1 $\therefore$ cannot reject

Using the information already calculated a 95% confidence interval for the difference can be shown. For the 95% interval, $t(1-\alpha/2; n_1+n_2-2) = t(.975;16) = 2.120$ is used. The confidence interval is $\bar{D} \pm t(.975;16)[S(\bar{D})]$ or $.889 \pm 2.120(.7093)$. Therefore, the confidence interval is:

$$-.6147 \leq \mu_2-\mu_1 \leq 2.393$$

Therefore, with 95% confidence, it can be stated that the mean difference between the ASD and airline responses is between -.615 and 2.393. Clearly, the null hypothesis that they are the same could not be rejected. Results from the corollaries 1-4, 7 and 8, all indicated the null could not be rejected. The following figures were obtained for Corollary Findings 1, 3, 4, 7, 8, and 9 using the same formulas used in Corollary Finding 2.

Corollary Finding 1

Big Airlines	Small airlines
$\bar{x}_1 = 1$	$\bar{x}_2 = 2.2$
$S_1 = 0$	$S_2 = 2.4$
$N_1 = 4$	$N_2 = 5$

$$S^2_{1/2} = 3.29$$

$$S_{\bar{x}_1-\bar{x}_2,S(\bar{D})} = 1.217$$

$$t = .986 \qquad t^1 = 2.365$$

$$-1.533 \leq \mu_2-\mu_1 \leq 3.953$$

Corollary Finding 3

Airlines	ASD
$\bar{x}_1 = 3.777$	$\bar{x}_2 = 2.777$
$S_1 = 2.078$	$S_2 = 1.527$
$N_1 = 9$	$N_2 = 9$

$$S^2_{1/2} = 3.324$$

$$S_{x_1-x_2,S(\bar{D})} = .912$$

$$t = 1.097 \qquad t^1 = 2.12$$

$$-.933 \leq \mu_1-\mu_2 \leq 2.933$$

Corollary Finding 4

Airlines	ASD
$\bar{x}_1 = 6.444$	$\bar{x}_2 = 5.778$

$S_1 = 1.377$ $S_2 = 1.356$

$N_1 = 9$ $N_2 = 9$

$S^2_{1/2} = 1.860$

$S_{\bar{x}_1-\bar{x}_2, S(\bar{D})} = .682$

$t = .978$ $t^1 = 2.12$

$-.78 \leq \mu_1-\mu_2 \leq 2.112$

Corollary Finding 7

ASD Airlines

$\bar{x}_1 = 2.89$ $\bar{x}_2 = 1.67$

$S_1 = 2.2$ $S_2 = 1.414$

$N_1 = 9$ $N_2 = 9$

$S^2_{1/2} = 3.431$

$S_{\bar{x}_1-\bar{x}_2, S(\bar{D})} = .873$

$t = 1.397$ $t^1 = 2.12$

$-.631 \leq \mu_1-\mu_2 \leq 3.071$

Corollary Finding 8

Airlines ASD

$\bar{x}_1 = 3.77$ $\bar{x}_2 = 2.88$

$S_1 = 2.078$ $S_2 = 1.269$

$N_1 = 9$ $N_2 = 9$

$S^2_{1/2} = 1.674$

$S_{x_1-x_2}, S(D) = .61$

$t = 1.46$

$-.4032 \leq \mu_1-\mu_2 \leq 2.1832$

Corollary Finding 9

Airlines	ASD
$\bar{x}_1 = 6.444$	$\bar{x}_2 = 2.889$
$S_1 = 1.377$	$S_2 = 1.9$
$N_1 = 9$	$N_2 = 9$

$S^2_{1/2} = 2.754$

$S_{\bar{x}_1-\bar{x}_2}, S(\bar{D}) = .7822$

$t = 4.545$	$t^1 = 2.12$

$1.897 \leq \mu_1-\mu_2 \leq 5.213$

APPENDIX P

SPEARMAN RANK CORRELATION COEFFICIENT WITH CRITERION K DELETED

Criteria K (The Warranty is cost effective, that is, the cost of the warranty is less than the savings realized with the warranty) was rejected and the remaining eleven criteria were ranked from one to eleven using the mean ranks. The resultant rankings are shown below.

Criteria	ASD Rank	Airlines Rank
A	2	2
B	7	2
C	3	6
D	4	7
E	10	5
F	1	1
G	6	8
H	5	4
I	8	9
J	11	11
L	9	10

The rankings were input into the SPSS program listed in Appendix M. The output showed a Spearman rank correlation coefficient of 0.6788 and an associated significance level of 0.011. The results show that, with better than 95% confidence, the ranks from ASD contracting experts agree with the ranks from the commercial airline contracting personnel when criterion K is deleted.

APPENDIX Q

SOURCES OF EXPERT OPINION FROM THE AIRLINES

Nine airline experts were surveyed by telephone and with the questionnaire relative to the criteria their airlines use to evaluate an aircraft warranty. The airlines were picked by a random number generator on the Create computer. The individuals were found using names provided by Air Force experts and the 1978 World Aviation Almanac. These individuals were querried to ascertain if they were responsible for evaluating aircraft warranties. When appropriate, the researchers were then referred to other personnel in their airlines and so on until the proper individuals were found.

The following are the airline experts are listed below in alphabetical order of their airlines:

American Airlines, Inc.
Attn: Mr. Van Keaney
3800 N. Mingo Rd.
Tulsa, OK.

Braniff Airline, Inc.
World Headquarters
Attn: Mr. Horace Bolding
Post Office Box 61747
Dallas-Fort Worth TX 75261
Dallas, Texas 75261

Delta Airline, Inc.
Attn: Mr. Roy Rucker
Atlanta International Airport
Atlanta, Georgia 30320

Eastern Airlines
Attn: Mr. P. G. Mercer
Miami Int'l Airport
Miami, Fla. 33148

North West Airlines Inc.
Attn: Mr. T. E. McGinnity
Minneapolis-St. Paul Airport
St. Paul, Minn. 55111

Pan-American World Airways
Attn: Mr. Ditchey
P. O. Box 592055
Airport Mail Drop
Miami, Florida 33159

TWA, Inc.
Mr. Wally Callan
Kansas City International Airport
Post Office Box 20367
Kansas City, Mo. 64195

United Airline, Inc.
Attn: Mr. Jerry Pollock EXOPP
P. O. Box 66100
Chicago, Ill. 60666

Western Airline, Inc.
Attn: Mr. Bozarth
6060 Avion Dr.
Los Angeles, CA. 90009

APPENDIX R

SOURCES OF EXPERT OPINION FROM THE AIR FORCE

Nine ASD experts were given the questionnaire to answer in accordance with the design for Research Hypothesis 2. These experts were chosen using a random selection from a list of experts supplied by ASD/PM. The following minimum qualifications were required (1) at least five years experience in major systems procurement at ASD (2) experience in working on an aircraft acquisition. In order to test Research Question 1, three Air Force attorneys experienced in the contracting field were selected according to their availability. In the design to test Corollary Findings 6-8. the experts used in Research Hypothesis 2 were again used with the exception of two individuals who were not available. One additional ASD expert was then selected and one of the attorneys was used to replace the two individuals.

The thirteen Air Force experts used are listed below:

Mr. Carl L. Beehler
Contracting Officer
EF-111A Technical Jamming System SPO
Aeronautical Systems Division (ASSC)
Wright-Patterson Air Force Base, Ohio

Ms. Marjorie Charlton
Contract Negotiator (PCO)/Procurement Analyst
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base, Ohio

Mr. Jack D. Falleur
Chairman, Contract Review Committee
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base, Ohio

Mr. Peter G. Gagaris
Contracting Officer
Contracting Division A
Deputy for Propulsion
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base, Ohio

Mr. Robert S. Kinderman
Director of Contractual Instruments
Deputy for Contracting and Manufacturing
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base, Ohio

Mr. Willie E. Livesay
Contract Negotiator (PCO)
Deputy for Strategic Systems
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base, Ohio

Mr. Christe P. Mengos
Contracting Officer/Contract Negotiator
PELS/RPV SPO
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base, Ohio

Mr. Carroll L. Miller
Contracting Negotiator
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base, Ohio

Lieutenant Colonel Norman S. Pattison
Judge Advocate
Procurement Opinion Division (AFLC)
Wright-Patterson Air Force Base, Ohio

Mr. Donald W. Robinson
Director of Policy and Review
Deputy for Contracting and Manufacturing
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base, Ohio

Mr. Wilmer R. Rollins
Attorney Advisor
Procurement Opinion Division (AFLC)
Wright-Patterson Air Force Base, Ohio

Mr. Paul David Vicars
Contract Negotiator
Maverick SPO
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base, Ohio

Mr. Roy L. Wilgus
Contracting Officer
Contracting Division A
Deputy for Propulsion
Aeronautical Systems Division (AFSC)
Wright-Patterson Air Force Base, Ohio

Dr. Melvin Wiviott
Professor of Procurement Management
School of Systems and Logistics
Air Force Institute of Technology (ATC)
Wright-Patterson Air Force Base, Ohio

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BIOGRAPHICAL SKETCHES

Prior to commissioning, Captain Grubb, a native of Kendallville, Indiana, served as a weather observer at McDill AFB, FL. In 1974, he received his Bachelor of Science Degree in General Engineering from Oklahoma State University through the Airman Education and Commissioning Program. After commissioning he served as a Computer Systems Analyst at Headquarters SAC from 1975 to 1979. After graduation from AFIT, he was assigned to the Phase IV base level computer replacement program at Gunter AFS Alabama as a contracting and acquisition officer.

Captain Sutliff, a native of Lynnfield, Massachusetts, received his BA Degree in Government and English from Norwich University, Northfield, Vermont in 1973. After graduation, he attended Undergraduate Pilot Training at Williams AFB, Arizona. He was then assigned to the 305th Air Refueling Wing at Grisson AFB, Indiana where he served as a KC-135 pilot, from 1974 through 1979. Captain Sutliff received his MA Degree in Political Science from Ball State University, Muncie, Indiana in 1979. After graduation from AFIT, Captain Sutliff was assigned as an acquisition officer to the Aeronautical Systems Division at Wright-Patterson AFB, Ohio.