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AN ANALYSIS OF ACQUISITION LOGISTICS
WITHIN THE NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION

THESIS

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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 Degree of
Master of Science in Logistics Management

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Preface

The purpose of this study was to review past actions and assess current plans for establishing more effective acquisition logistics within the National Aeronautics and Space Administration.

We used unstructured interviews, personal observations, literature reviews, and a survey questionnaire to collect data. The Space Shuttle was reviewed for past actions and the Space Station Freedom was reviewed for current plans. We proposed an acquisition logistics model with which we compare the two programs.

We had a great deal of help with this research. First, we thank Mr. Jim Oldnar, NASA Acquisition Logistics, for his exceptional support. We are deeply indebted to our thesis committee, Professor Richard A. Andrews, Chairman, and Major Jacob V. Simons, Jr., for their guidance, perseverance, and patience. Thanks also to Professor Guy Shane, Major Wayne Stone, and all of the logistics managers of the NASA team who gave us their time and expertise.

Finally, we thank our wives, Olga and Kate. We would never have been able to accomplish this research without their support and understanding.

Brian J. Babin
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Table of Contents

Page

Preface ii

List of Figures v

List of Tables vii

Abstract viii

I. Introduction 1

General Issue 1
Reason for Research 2
Research Questions 3
Scope of Research 4
Definition of Terms 4

II. Historical Review 6

Introduction 6
Review 7
Genesis 7
The Shuttle Program 8
51L 11
Space Station Freedom and Beyond 14
Conclusion 15

III. Methodology 17

Overview 17
Sampling Design 18
Research Design 20
Investigative Question Number One 23
Data Collection 23
Data Analysis 23
Limitations 24
Investigative Question Number Two 24
Data Collection 24
Data Analysis 26
Limitations 27
Investigative Question Number Three 28
Data Collection 29
Data Analysis 30
Limitations 31
Investigative Question Number Four 32
Data Collection 32
Data Analysis 33
Limitations 34
Summary 36

Page

IV. Research Findings 37

Introduction 37
Investigative Question Number One 37
Introduction 37
Findings 38
Investigative Question Number Two 44
Discussion of Unstructured Interview Comments 44
Discussion of Personal Observations . . . 46
Discussion of the Historical Review . . . 48
Synthesis 50
Investigative Question Number Three 53
Introduction 53
Discussion of Unstructured Interview Comments 53
Discussion of Personal Observations . . . 56
Discussion of the Historical Review . . . 58
Discussion of Survey Questionnaire Responses and Comments 58
Synthesis 67
Investigative Question Number Four 69
Introduction 69
Results 69

V. Conclusions and Recommendations 71

Conclusions 71
Recommendations. 73

Appendix A: NASA Logistics Survey Questionnaire 75

Appendix B: Survey Responses and Verbatim Comments . . . 82

Appendix C: Unstructured Interview Comments Applicable to IQ 2 117

Appendix D: Unstructured Interview Comments Applicable to IQ 3 120

Bibliography 129

Vita 132

List of Figures

Figure Page

1. Question One Responses 82
2. Question Two Responses 83
3. Question Three Responses 84
4. Question Four Responses 85
5. Question Five Responses 86
6. Question Six Responses 87
7. Question Seven Responses 88
8. Question Eight Responses 89
9. Question Nine Responses 90
10. Question Ten Responses 92
11. Question Eleven Responses 93
12. Question Twelve Responses 94
13. Question Thirteen Responses 95
14. Question Fourteen Responses 96
15. Question Fifteen Responses 97
16. Question Sixteen Responses 98
17. Question Seventeen Responses 99
18. Question Eighteen Responses 100
19. Question Nineteen Responses 101
20. Question Twenty Responses 102
21. Question Twenty-One Responses 103
22. Question Twenty-Two Responses 104
23. Question Twenty-Three Responses 105
24. Question Twenty-Four Responses 106

Figure		Page
25.	Question Twenty-Five Responses	107
26.	Question Twenty-Six Responses	108
27.	Question Twenty-Seven Responses	109
28.	Question Twenty-Eight Responses	110
29.	Question Twenty-Nine Responses	111
30.	Question Thirty Responses	112
31.	Question Thirty-One Responses	113
32.	Question Thirty-Two Responses	114
33.	Question Thirty-Three Responses	115
34.	Question Thirty-Four Responses	116

List of Tables

Table Page

1. Types of Sampling Designs 18
2. Question Objective Matrix 60
3. Program Review and Assessment Results 70

Abstract

The purpose of this study was to review past actions and assess current plans for establishing more integrated logistics management in NASA. The focus of this study was acquisition logistics, the beginning of the ILS process.

This study includes a historical review of acquisition logistics in NASA's major space programs as well as a review of numerous acquisition logistics models. Logistics managers from the Space Shuttle and Space Station Freedom programs were interviewed, surveyed, and observed to provide evidence of the degree to which these two programs are meeting or have met the objectives of the acquisition logistics model selected as most appropriate.

Findings indicated that the Space Station Freedom, like the Space Shuttle program, is losing support and funding for ILS programs. NASA managers are opting to sacrifice long range cost savings in exchange for lower system development costs.

Recommendations include increased emphasis on educating the management and engineering communities of NASA on the benefits of well supported and funded acquisition logistics programs.

AN ANALYSIS OF ACQUISITION LOGISTICS

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I. Introduction

General Issue

> Logistics management is really no different from any other kind of management. So why, you ask, are we putting so much emphasis on it now and holding this national symposium? There are two quite important reasons: The first is that logistics support is a very significant part of the entire program in terms of dollars. It might run to one-third of the program budget. Consequently, any improvement in logistics management will greatly alleviate an already serious money problem. Secondly, we will all agree, that the logistics portion of the program is often taken for granted, frequently to the detriment of the program as a whole. (von Braun, 1966:2)

This excerpt from the welcome address at the first annual logistics management symposium, 13-14 September 1966, by Dr. Werner von Braun, then NASA Director, George C. Marshall Space Flight Center, introduces the subject of this study and establishes the significance of research concerning logistics. Since before the astronauts of Apollo XI walked on the moon, the President and the Congress of the United States have been urging NASA to find ways to reduce their spending without compromising safety and mission accomplishment (Trento, 1987:95-121). The most evident manifestation of the results of this pressure was the creation of the reusable launch vehicle, the Space Shuttle.

The advent of the Space Shuttle marked a shift in NASA organizational roles from a research and development (R&D) base to an R&D and operations base (Trento, 1987:95-121).

To complement this shift in focus, NASA has been implementing organizational changes aimed at improving efficiency and effectiveness. Many of these changes are in the realm of logistics in an effort to capitalize on what Dr. von Braun could see in 1966. A part of NASA's effort is the adoption of the principles of Integrated Logistics Support (ILS) in an effort to reap benefits in the form of cost savings over the life of the systems that are being developed (Oldner, 1991). In addition, NASA has invited the Air Force Institute of Technology, School of Systems and Logistics, to research logistics topics within the NASA organization. This study is one such effort. Specifically, the intent of this study is to review past actions and make an assessment of current plans for establishing more integrated logistics management within NASA. We have chosen the area of acquisition logistics, the beginning of the logistics process, as the focus of our research. Acquisition logistics is:

> the process of systematically identifying and assessing logistics requirements and alternatives, analysis and resolution of ILS deficiencies, and the management of ILS throughout the acquisition process. (Andrews, 1991:3-R-2)

Reason for Research

NASA has no organization-wide guidance on the conduct of acquisition logistics (Oldner, 1991). At present NASA has nine separate operating locations. Each location establishes local policies and procedures. Each program at a location operates independently of the others. Consequently, each program is managed differently and there is little opportunity for coordinated efforts that could possibly enhance efficiency and effectiveness (Oldner, 1991).

Research Questions

This study has the following charter: to review past actions and assess current plans for establishing more effective acquisition logistics within NASA. To address this need we will consider the following research questions:

1) What actions has NASA taken to achieve acquisition logistics?

2) How appropriate and complete are NASA's plans for improving acquisition logistics?

Our research questions lead to more specific investigative questions. Through interviews, surveys, and observation we will gather the data necessary to describe how acquisition logistics is accomplished on two major NASA systems. Our specific investigative questions are:

1. What do experts suggest as a model for an acquisition logistics program?

2. How has NASA accomplished acquisition logistics in the past?

3. What are NASA's current plans and activities for accomplishing acquisition logistics?

4. How well do NASA's actions and plans fit the model?

Scope of Research

This study will focus on the acquisition logistics activities of two major NASA systems, the Space Shuttle and Space Station Freedom. We intend to compare the programs to current state of the art literature ideals. We chose these systems because of their long term requirements, their manned status, their reusable nature, and their large budgets.

Definition of Terms

The following definitions apply to our research:

1) Logistics - The art and science of management, engineering, and technical activities concerned with requirements, design, and supplying and maintaining resources to support objectives, plans, and operations (Mosher, 1983: 1-9).

2) Integrated Logistics Support (ILS) - a disciplined, unified, and iterative approach to the management and technical activities necessary to:

-- Develop support requirements that are related consistently to readiness objectives, to design, and to each other.
-- Effectively integrate support considerations into the system and equipment design.
-- Identify the most cost-effective approach to supporting the system when it is fielded.
-- Ensure that the required support structure elements are developed and acquired (DoDI 5000.2).

ILS elements subdivide the ILS program into manageable functional areas (Andrews, 1991: 3-R-4). They are:

1. Maintenance Planning
2. Manpower and Personnel
3. Supply Support
4. Support Equipment
5. Technical Data
6. Training and Training Support
7. Computer Resources Support
8. Facilities
9. Packaging, Handling, Storage, and Transportation
10. Design Interface

3) Acquisition Logistics - the process of systematically identifying and assessing logistics requirements and alternatives, analysis, and resolution of ILS deficiencies, and the management of ILS throughout the acquisition process (Andrews, 1991: 3-R-2).

4) Logistics Support Analysis (LSA) - a set and/or composite of systematic analyses conducted to identify, define, and quantify the logistics support concepts, plans, and requirements for a system under development. In simple terms, LSA can be defined as any analysis which results in a decision on the scope and level of logistics support (Andrews, 1991: 3-R-2).

5) Maintainability - a characteristic of design and installation which is expressed as the probability that an item will conform to specified conditions within a given period of time when corrective or preventive action is performed in accordance with prescribed procedures and resources (Mosher, 1983: 1-10).

6) Reliability - the probability that material will operate for a specified period under stated conditions (Mosher, 1983: 1-14).

II. Historical Review

Introduction

This review will provide a historical view of NASA as it relates to major system acquisition. It will also serve as a portion of the answer to the second and third investigative questions. The historical perspective, from NASA's birth to the present, is necessary to provide insight into the focus of the NASA organization as it evolved from a pure research and development (R & D) organization to an R & D and operations organization. We will concentrate on high profile programs such as Apollo, the Shuttle, and Space Station Freedom. The search for information concerning the development of acquisition logistics encompassed telephone interviews with NASA representatives, discussions with Air Force Institute of Technology (AFIT) faculty members, a search of the card catalogs and the stacks of the AFIT library, and automated searches of the Defense Technical Information Center data base, the NASA Recon data base, the Defense Logistics Agency data base, and the Aerospace data base on CD-ROM (AFIT Library). The different sources were searched for topics relating to acquisition logistics in NASA. Since that search yielded very little, the search was expanded to include other elements of ILS such as maintenance planning and design interface issues.

Our review will begin with the genesis of NASA and proceed through the evolution of NASA to the development of the Space Station Freedom. It will include a brief accounting of the focus of NASA in the missions that put men on the Moon, the development of the space Shuttle, the findings of the investigation that followed NASA mission 51L, and finish with some discussion on present day NASA to include the Space Station Freedom. Throughout, we will identify any evidence of supportability issues found in the acquisition or development process (acquisition logistics) of different systems. In the absence of acquisition logistics, we will provide evidence of that absence.

Review

Genesis. NASA was created on the 29th of July, 1958 by the National Aeronautics and Space Act in response to advances in the field of space exploration by the Soviet Union (Advisory Committee on the Future of the U.S. Space Program, 1990: 10). NASA replaced the National Advisory Committee for Aeronautics (NACA) and later the Army Ballistic Missile Agency. The new administration was charged with the "responsibility for planning, conducting, and managing civilian research and development activities in aeronautics and space" (Trento, 1987: 12,7,10). On the 12th of April, 1961, Soviet cosmonaut Yuri Gagarin became the first human to be put in earth orbit. Soon afterwards, on the 25th of May, President Kennedy addressed Congress with the following words (Trento, 1987: 39):

> This nation should commit itself to achieving the goal, before the decade is out, of landing a

man on the moon and returning him safely to earth. No single space project will be more impressive to mankind or more important for the long range exploration of space; and none will be so difficult or expensive to accomplish.

This served as the impetus for the support NASA needed to launch into the Mercury, Gemini, and Apollo programs. The nature of these programs was such that there was little evolution or opportunity for long-term life cycle planning (Lewis, 1990: unk). "Launch vehicles were designed for performance with very little attention given to consideration for support and/or maintainability" (Scholz, 1989: 11-28). In fact, NASA Director Dr. Werner von Braun, in a 1966 speech stated that the NASA of the time was just beginning to understand and manage logistics challenges (von Braun, 1966: 2). Even with an understanding of the issues of ILS, NASA was not planning for any of their systems to be reused or even maintained. Their focus was on taking the necessary R & D steps to get a man on the moon (Oldner, 1991). On the 16th of July of 1969 the astronauts of Apollo 11 embarked on the mission that President Kennedy had given them in 1961. On the 20th of July U.S. Astronaut Neil Armstrong became the first human to set foot on the surface of the moon (Trento, 1986: 86).

<u>The Shuttle Program</u>. Ironically, the day that marked NASA's greatest triumph also marked the beginning of NASA's most troubled period. The nation was at war and with the moon mission accomplished, the public and the government were much less interested in NASA than they had been in the

past decade. In addition, not even NASA had a good idea as to what would come next (Trento, 1987: 88-90). An expected side effect in this new period for NASA was a budget decline. Even though NASA's budget had peaked in 1965, its lowest point came shortly after the final Apollo mission (Advisory Committee on the Future of the U.S. Space Program, 1990: 4).

This decline in interest and in money coupled with the lack of a mission like the one presented by President Kennedy left NASA in an unpleasant position for the development of the Space Transportation System (STS) that would become known as the Space Shuttle (Trento, 1987: 102-107). The idea of reusable launch systems had arisen in the early sixties. The President's Science Advisory Committee recommended studies be made "of more economical ferrying systems, presumably involving partial or total recovery and use" (Scholz, 1989: 2). The decision of President Nixon in 1970 was to proceed with plans to make a shuttle to link the earth with a space station that would be developed later.

NASA developed a variety of proposals for a Space Shuttle. The second stage design was considered the optimum in terms of "routine and economical access to space" because it was fully reusable and was large enough to carry space station modules (Presidential Commission on the Space Shuttle Challenger Accident, 1986: 2). The cost of this design was met unfavorably by Congress and the Office of Management and Budget. At that point, NASA was intent on minimizing development cost to get the Shuttle approved (Presidential Commission on the Space Shuttle Challenger Accident, 1986: 3). Included in the decision making process was an evaluation of liquid rocket motors that potentially offered lower operating costs but were rejected because pricing estimates suggested a lower development cost for the solid rocket motors that were chosen (Presidential Commission on the Space Shuttle Challenger Accident, 1986: 3-4). Possibly, the "one-time-use" nature of NASA's previous programs inhibited their taking a more long-term approach to the Shuttle development (Lewis, 1990: 1). The final configuration for the Space Shuttle was selected in 1972 with the contract for design and development of the Shuttle Orbiter going to Rockwell International Corporation's Space Transportation Systems Division.

In spite of not getting the "optimum" design, NASA did develop an integrated logistics support program for the shuttle. The technical requirements for the program, based on commercial aviation concepts, were contained in Space Shuttle Integrated Logistics Requirements JSC 07700. Volume XII contained logistics requirements in the categories of maintainability, maintenance analysis and planning, operations and maintenance documentation, supply support, spares provisioning, logistics facilities, fuels, gasses, transportation, and handling (Byrnside, 1979: 4). A 1979 study indicates that implementation of requirements and planning was being hampered by funding and problems with the prioritization of ILS tasks (Byrnside, 1979: ii).

NASA declared the Space Shuttle and in effect itself "operational" in 1982 (Presidential Commission on the Space Shuttle Challenger Accident, 1986: 5). Shortly after, in 1983, NASA changed their logistics structure for Shuttle processing and logistics support for facilities and equipment associated with the program (Savage, 1987: 151). The change consisted of making one contractor responsible for processing the shuttle from landing to launch instead of relying on at least six contractors and two NASA facilities other than KSC. The intent of this change, called SPC (shuttle processing contractor), was to reduce the cost per launch of the shuttle by eliminating duplication of management and resources (Savage, 1987: 151).

51L. The space shuttle program's 22nd operational mission, 51L, marked another significant point in NASA's history. Mission 51L, launched on the 28th of January 1986, was the final flight of the Space Shuttle "Challenger." "Challenger's" explosion 73 seconds into its flight launched an unprecedented barrage of investigations into every aspect of the NASA organization. The Report of the Presidential Commission on the Space Shuttle Challenger Accident addresses NASA's "operational" capabilities by suggesting that elements within the shuttle program were not prepared for the "operational era." The report states that for a long time the Shuttle program focused only on the Shuttle's first flight and that when it was time to become "operational," "the same resources that had been applied to one flight had to be applied to several flights concurrently." The report further states that the differences between R & D and operations were philosophical, attitudinal, and practical. The assessment in the report is as follows:

> Elements within the Shuttle program tried to adapt their philosophy, their attitude and their requirements to the "operational era." But that era came suddenly, and in some cases, there had not been enough preparation for what "operational" might entail.

Specifically, the report lists problems with spare parts and personnel, two of the elements of ILS (Presidential Commission on the Space Shuttle Challenger Accident,1986: 170-177).

Since the "Challenger" accident there have been numerous studies into NASA and into the evolution of the Space Shuttle into a more operational type vehicle. Among the studies are, "STS Evolution" by Stan Lewis of Rockwell International and "Shuttle Evolution for the 1990's" by Charles Teixeira and Charles Mallini of NASA. Both reports suggest a new strategy or a "new perspective to long term requirements" (Lewis, 1990: unk;12:1-24). Both studies reference conventional aviation programs as models for the evolution of the shuttle to become more operationally capable. Another key aspect of both reports is the consideration of support issues for the rest of the planned life of the Shuttle Program.

Another Rockwell report discusses the key areas in which new technologies could improve shuttle launch times (Baker, 1987: 36). This report suggests that a number of design factors, such as providing system service panel interfaces on the exterior of the vehicle and eliminating unique hardware, could be improved on the shuttles to allow quicker turnarounds. In addition, the present launch facilities are said to not be optimal for shuttle processing because NASA maximized the use of existing sites when fielding the shuttle (Baker, 1987: 42).

NASA has increased emphasis on logistics functions and is creating or modifying programs and directives to carry out acquisition logistics in developing programs (Oldner, 1991). One such directive is "Maintainability Program Requirements for Space Systems." This handbook describes the development of a maintainability and maintenance planning program. The objective of this program is to:

> promote a design that will be affordable and easy to maintain in its operational environment within the framework of the mission objectives. To be successful, maintainability (and reliability) must be addressed early in both the engineering and requirements setting processes to cultivate a delicate balance between performance, reliability, maintainability, and program cost constraints (both developmental and operational). This approach is intended to foster a close relationship between the engineering and logistics activities until consumption rates can be determined from operational use. (Lisk, 1989: 1)

Space Station Freedom and Beyond. As NASA works to make the Shuttle more "operational" and to improve the logistics programs that are in place, they are also in the process of developing the Space Station Freedom in conjunction with a host of international partners. The support for the development of the Space Station Program was given in a December 1990 "Report of the Advisory Committee On the Future of the U.S. Space Program" (Advisory Committee On the Future of the U.S. Space Program, 1990: 29). The Space Station Program Definition and Requirements document, Section 4, Part 2: Space Station Integrated Logistics Support Requirements states the following purpose:

> to establish the requirements necessary to implement the objectives of the Space Station Integrated Logistics Support (ILS) Program and set forth the concepts that shall govern all activities providing logistics for the Space Station Freedom Program. (NASA, 1991: 1-1)

A related document, the "Space Station Program Requirements: Integrated Logistics Support Function Control Document," contains definitions and explanations of the components and concepts of ILS with directives in each of the key ILS areas (NASA, 1991: 12-30).

Finally, NASA's Space Exploration Initiative (SEI) already includes an ILS program for the missions that will return to the Moon and eventually proceed to Mars (Thurman, 1991: 1). The push for ILS in SEI is greater than in previous programs because of the length of time that the mission will take and because of the communication link delays that will result. Loren A. Thurman in a paper entitled "Supportability to "Mars...And Beyond,"" states that SEI:

> means the end to routine treatment of supportability. Further, it must be understood to mean the collective realization of a legitimate Logistics Engineering input as part of a concerted, Concurrent Engineering effort. The absence of a common bridge of communication between the traditional engineering world and the traditional "logistics world" must not be the cause of future Lunar or Mars related hardware to be operationally deficient! The issue of supportability is far more than just "spare parts."

Conclusion

NASA was developed in 1958 primarily as a research and development type organization. The organization thrived during the sixties in response to a stated mission of putting men on the moon by the end of the decade. NASA was able to use the support of the nation and a massive budget to reach their goal by July of 1969. Following the lunar landing NASA faced a marked drop in support, financially and otherwise. Budget constraints and an absence of a clear goal left NASA in a difficult position in developing the next step in space exploration. Pressures that started during the Apollo program and were later stressed by President Nixon led NASA to develop a reusable launch vehicle. The development of the new system, the space shuttle, was marked by pressure to keep development costs to a minimum. An acquisition logistics program was started for the shuttle but much of it was never implemented because of budget constraints. Many of the reports that followed the Space Shuttle "Challenger" accident of 1986 indicate that NASA and the shuttle may not have been ready to become "operational." Moreover, there are specific references to some of the elements of ILS that might have been planned better during the shuttle's acquisition. NASA has implemented different programs to enhance their overall logistics support including a maintenance and maintainability planning program designed to improve acquisition logistics. Finally, NASA has launched an all-out ILS based acquisition logistics plan for the development of Space Station Freedom and is including ILS in the plans for SEI.

The absence of acquisition logistics for most of the organization's life can be explained by the presence of a research and development orientation, short life expectancy of programs in the early years, and budget constraints. The later years may exhibit an organizational deficiency in the area of long term system planning or a low level of appreciation for the benefits of ILS. However, the literature in the area of acquisition logistics is limited and the rest of this study will support and/or refute portions of this review.

III. Methodology

Overview

The purpose of this study was to review past actions and assess current plans for establishing more effective acquisition logistics within NASA. To answer IQ number one, "What do experts suggest as a model for an acquisition logistics program?", an extensive literature review was conducted. The Space Shuttle program was the subject for the review of past actions in NASA for the purpose of answering investigative question (IQ) number two; "How has NASA accomplished acquisition logistics in the past?" The Space Station Freedom program was the subject for the assessment of current plans in NASA for the purpose of answering IQ number three; "What are NASA's current plans and activities for accomplishing acquisition logistics?" Our fourth IQ, "How well do NASA's actions and plans fit the model?", was answered by comparing the answers to IQs two and three with the answer to IQ one. NASA organizational structure includes three formal tiers, Level I, Level II, and Level III. Level I encompasses headquarters activities and functional areas. Level II includes primarily program management from a macro perspective. Level III comprises the activities and functional areas within the space centers. This study concentrated on Level III, the space center tier, to gather data reflecting the results, or lack thereof, of NASA acquisition logistics programs. Level III was selected based on the desire of this research team, and the research sponsor, to review past actions and assess current plans for establishing more effective acquisition logistics within NASA at the operational, or center level.

Sampling Design. Answering the investigative questions required the gathering of data from a subset of the complete NASA population. Therefore, it was necessary to choose a method of identifying an appropriate sample. The sampling technique selected for this study was based on the requirements of the project, its objectives, and the funds available. The different approaches to sampling may be classified by their representation basis; probability or nonprobability, and the element selection techniques; unrestricted or restricted. This classification is illustrated in Table 3-1.

Table 1

TYPES OF SAMPLING DESIGNS (Emory, 1991: 244)

	Representation Basis	
Element Selection	Probability	Nonprobability
Unrestricted	Simple random	Convenience
Restricted	Complex random	Purposive
	Systematic	Judgement
	Cluster	Quota
	Stratified	Snowball
	Double	

Probability sampling is based on the concept of random selection - a controlled procedure that assures that each population element is given a known nonzero chance of selection. In contrast, nonprobability sampling is nonrandom. That is, each member does not have a known nonzero chance of being included. An unrestricted sample is taken when each sample element is drawn individually from the population at large. All other forms of sampling are categorized as restricted sampling (Emory, 1991: 245).

This research team nonrandomly selected each member of the sample from the population of Level III logistics managers at the three centers we were able to visit. No effort was made to limit the sample to only NASA employees, since both NASA and contractor personnel perform as logistics managers. This sample was a restricted sample since cost and time constraints prevented contact with the entire population of logistics managers at all NASA centers. Therefore, restricted nonprobability sampling was the basis of the sampling design for this research.

Within the nonprobability category, we selected the purposive sampling method. A purposive sample is a nonprobability sample that conforms to certain criteria (Emory, 1991: 275). We selected this method because the research emphasis on acquisition logistics at the center level imposes certain criteria on the desired sample. Within purposive sampling, judgment sampling was used. Judgement sampling occurs when a researcher handpicks purposive sample members (Emory, 1991: 275). In this research sample members were handpicked to conform to the criterion of being a logistics manager associated with the space shuttle program, the space station program, or of an agency associated with those programs.

Research Design. This section discusses the approach used to select the research design for this study. This research design will form the baseline perspectives for answering the IQ's. Research design is a complex concept that may be viewed from at least eight different perspectives (Emory, 1991: 139).

1. The degree to which the research problem has been crystallized (the study may be either exploratory or formal).

2. The method of data collection (studies may be observational or survey).

3. The power of the researcher to affect the variables under study (the two major types of research are the experimental and the ex post facto).

4. The purpose of the study (research studies may be descriptive or causal).

5. The time dimension (research may be cross-sectional or longitudinal).

6. The topical scope - breadth and depth - of the study (a case or statistical study).

7. The research environment (most business research is conducted in a field setting, although laboratory research is not unusual; simulation is another category).

8. The subjects' perceptions of the research (do they perceive deviations from their everyday routines).

Although this study did have some degree of exploration prior to the final choice of design, the goal of formal research is to answer research questions posed (Emory, 1991: 140). Therefore, this research was viewed as a formal study based on the stated purpose. The method of data collection included both primary and secondary data sources. Primary sources consisted of both monitoring and interrogation processes. The secondary data source was the literature review. The monitoring process was observational study, in which the research team inspected logistics activities without attempting to elicit responses from anyone. The interrogation processes involved personal interviews, survey questionnaires, and survey comments.

From the perspective of researcher control of variables, this study used an ex post facto design. The research team had no control over the variables in the sense of being able to manipulate them, and desired to only report past and present activities in the area of acquisition logistics. The purpose of the research related to the research design is to provide a descriptive study of acquisition logistics within NASA. The time dimension of this study was cross-sectional, with data collected only once at one point in time.

The topical scope of this research was primarily case study. This provides the benefit of allowing multiple sources of data which permits cross-verification of evidence and possible avoidance of response error, or reported data differing from actual data. The research environment selected was field study, due to the desire to study NASA logistics under normal conditions. We believe the subjects' perceptions of this research did not affect responses, since opinions, rather than behavior were solicited.

We selected field study, a study taking place under actual environmental conditions, as most appropriate for gathering data because it allowed us to collect data with a number of different methods. To gain understanding and insight into logistics operations related to space programs, site visits were conducted at NASA centers directly involved in the space shuttle and space station programs. Three centers were visited; Lewis Research Center (LeRC), Cleveland, Ohio; Johnson Space Center (JSC), Houston, Texas; and Kennedy Space Center (KSC), Cape Canaveral, Florida. The number and location of site visits was based on budgetary restrictions, time limits, and level of involvement with the space shuttle and space station programs. LeRC was selected as the first center visited because of its proximity to our academic location (Dayton, Ohio) and our desire to test our proposed methodology before expending the energy, time, and money necessary to visit JSC and KSC.

During the visits, surveys were administered, unstructured interviews were conducted, and personal observations were noted. Participants in every aspect of this research effort were assured of anonymity, and reported data was formatted to prevent association with any particular individual or location. Survey respondents were encouraged to write additional comments directly on the survey to clarify their answers, or state their opinions in their own words. The following paragraphs explain these activities in greater detail.

Investigative Question Number One

IQ number one; "What do experts suggest as a model for an acquisition logistics program?" was approached by conducting an extensive literature review for the purpose of identifying a comprehensive, widely accepted acquisition logistics model.

Data Collection. The search for information concerning an acquisition logistics model included discussions with AFIT faculty members, a search of the card catalogs and the stacks of the AFIT library, and automated searches of the DTIC data base, the NASA Recon data base, the DLA data base, and the aerospace data base on CD-ROM (AFIT library). These data sources were searched with keywords such as acquisition, acquisition logistics, models, logistics models, and acquisition logistics models.

Data Analysis. The data analysis used for IQ number one was limited to data gathered from the literature review. Preliminary analysis of the data from the literature review involved examination for common themes and opinions. Further analysis focused on whether specific objectives of acquisition logistics were common to several models for the purpose of selecting or constructing one general model.

Limitations. We recognized several limitations in our selected methodology to answer IQ number one. The possibilities of biased model selection and arbitrary conclusions appear to be the most significant. Biased model selection was overcome by the process of comparisons across several models. Also, AFIT faculty members and NASA logistics managers made significant inputs to final model selection through personal discussion and review. Arbitrary conclusions were mitigated by careful review and comments by AFIT faculty, NASA headquarters logistics personnel, and Level III logistics managers.

Investigative Question Number Two

We answered IQ number two; "How has NASA accomplished acquisition logistics in the past?" with a combination of data from the unstructured interviews, personal observations, and literature review.

Data Collection. Two methods of communication were used to collect primary source data: unstructured personal interviews and personal observation. The interviews were used to gain a clearer understanding of the ways that NASA structure, policies, and procedures support or inhibit the execution of acquisition logistics. We started the interviews with personal greetings and discussion concerning the duties and responsibilities of the individual participants. Questions from interviewees concerning the purpose, scope, and output of this study were answered openly. The intent of using such an unstructured format was to allow interviewees to raise issues they felt important, and improve researcher comprehension of the NASA and contractor logistics operations. Significant effort was made to establish credibility with each subject, to enhance communication regarding the issues raised. The most evident strength of this approach lies in the non-threatening aspect of such conversation when the respondent is assured of anonymity (Emory, 1991: 323-324). Several interviewees indicated they "enjoyed the opportunity to speak their mind." This process allowed interviewees to provide specific data related to acquisition logistics in NASA's past, which formed the basis for IQ number two.

Site visits presented ample possibilities for direct observation of acquisition logistics related to NASA's past. JSC and KSC, perhaps more than any other NASA locations, are immediately identified with the space shuttle. KSC serves as the site of shuttle launches, while JSC functions as mission control. Our personal observations at both locations served to balance perceptions from the literature review and interviews. During these site visits, NASA provided nearly unrestricted access to whatever activity this team desired to view. Direct physical evidence, such as the existence of facilities and support equipment, provided information regarding the objectives of integrated logistics support and their impact on shuttle acquisition logistics.

We collected secondary source data through the literature review. We focused our efforts on data related to acquisition logistics on past NASA programs. The Historical Review in Chapter Two served as the literature review for this IQ. Chapter Two contains the information regarding the secondary source data.

Data Analysis. We approached data analysis as an effort involving two major topics. The first was data preparation, which included the processes of editing and typing. The second was preliminary analysis, which involved breaking down, inspecting, and rearranging data to start the search for meaningful descriptions, patterns, and relationships (Emory, 1991: 450). Our initial editing was accomplished during the site visits. Notes were transcribed in an effort to eliminate acronyms, and outbriefs were conducted to follow up on major questions to validate preliminary field results. Upon return to our academic location, central editing was completed. Notes were transcribed to a typewritten format, and interview comments were compiled by subject area.

Preliminary analysis of the data from the personal interviews, personal observations, and literature review involved comparison of data from the three sources, and examination for common themes and opinions. We previously defined acquisition logistics as " the process of systematically identifying and assessing logistics requirements and alternatives, analysis and resolution of integrated logistics support (ILS) deficiencies, and the management of ILS throughout the acquisition process " (Andrews, 1991: 3-R-2). Therefore, further analysis focused on whether the specific activities comprising acquisition logistics were in evidence on the space shuttle program. The data gathered through the unstructured interviews, personal observations, and literature review provide sufficient background to answer IQ number two; "How has NASA accomplished acquisition logistics in the past?"

Limitations. We recognize several limitations in our selected methodology to answer IQ number two. The possibility of biased results from the personal interviews stems from sampling error, nonresponse error, and response error (Emory, 1991: 327). We believe our restrictive nonprobability sampling design was adequate since this study was limited to logistics managers at three locations, and was not intended to be generalized to a population parameter. Nonresponse error was not a factor in this research due primarily to the field study method used. Research team schedules were flexible enough to allow for availability of all selected logistics managers. Response error for interview comments was reduced by careful transcribing of notes, and routine discussion between team members regarding the exact responses given.

We also recognized the possibility for bias in observational data collection. However, since we performed direct personal observation involving facilities, support equipment, supply support, technical data, and the remaining elements of ILS, any existing bias was regarded as having minimal effect on data collection. Other limitations recognized included the inability to recreate the exact organization, personnel, and acquisition logistics program in effect during space shuttle development for an accurate assessment. However, background discussion during the unstructured interviews established that some of our subjects had high experience levels and involvement with early space shuttle logistics. This largely mitigates these limitations.

Finally, all elements of logistics in NASA are not under the control of logistics managers. For instance, the traditional ILS elements of maintenance training and design interface are managed outside of NASA logistics functions. We feel that using three data sources to obtain an accurate picture of space shuttle acquisition logistics helped minimize this difficulty.

Investigative Question Number Three

We answered IQ number three; "What are NASA's current plans and activities for accomplishing acquisition logistics?" with a combination of data from the unstructured interviews, personal observations, literature review, survey questionnaire response analysis, and verbatim survey comments.

Data Collection. The data collection used for IQ number three was much like that used for IQ number two. The unstructured interviews, personal observations, and literature review were conducted as described for IQ number two. However, the perspective taken while gathering this data for IQ number three differed from that of IQ number two. Specifically, data for IQ number three related to action in progress for Space Station Freedom, or plans in the process of either development or enactment. Discussions during the interviews often resulted in unexpected insights, reinforcing the need for anonymity and non-attribution. Two additional methods were used to collect primary source data, survey questionnaires and verbatim survey comments. The survey questionnaire is shown in Appendix A.

The survey questions were constructed to address the objectives of ILS given in the Definition of Terms section in Chapter One. Acquisition logistics was defined in Chapter One as the process of systematically identifying and assessing logistics requirements and alternatives, analysis and resolution of ILS deficiencies, and the management of ILS throughout the acquisition process. Since the definition of acquisition logistics emphasizes ILS, this research team concluded gathering data related to the objectives of ILS would yield meaningful insight into NASA acquisition logistics.

The first ten questions on the survey collected background data of the respondent to establish age, education, experience, and job position. The remaining twenty-four questions collected data reflecting the opinion of the respondent regarding the objectives of ILS. All responses were numeric, with a seven point Likert scale (strongly disagree = 1 to strongly agree = 7) used for the twenty-four opinion questions. Several drafts of the survey questionnaire were reviewed by graduate students, faculty members, and our thesis committee chairman. Numerous suggestions regarding question format, wording, and content were incorporated into the final instrument.

Survey questionnaires were administered, on a purely voluntary basis, to Level III logistics personnel from the sample described in the overview. As noted previously, comments were encouraged to clarify answers or state personal opinions. Out of a total of 45 surveys distributed, 39 were returned in useable condition, for an 86.66% response rate.

Data Analysis. The data analysis used for IQ number three was similar to that used for IQ number two, except survey questionnaire responses were entered into a SAS data base, processed for frequency distributions, and formatted into bar graphs to provide clear representation of response patterns and trends. Responses were not identified by location to preserve anonymity. Comments written by respondents were also extracted and compiled by question number. Comments were associated with corresponding tables and graphs to add further emphasis to, or possibly refute, survey results.

Our personal observations at all three locations both complemented and clarified personal interview, literature review, and survey questionnaire data. NASA provided exceptional access to acquisition logistics activities and plans related to the space station program. Personal observation significantly enhanced this study by allowing direct observation of plans in the process of execution.

These observations were then used to support or refute data collected from other primary and secondary sources. As an aggregate effort, the data taken from the unstructured interviews, personal observations, literature review, survey questionnaire analysis, and verbatim survey comments provided the information necessary to answer IQ number three; "What are NASA's current plans and activities for accomplishing acquisition logistics?"

Limitations. In addition to the general limitations given for IQ number one, we recognize other limitations in our selected methodology to answer IQ number three. Survey questionnaires have several weaknesses. The major weakness is that the quality of information secured depends heavily on the ability and willingness of respondents to cooperate. Respondents may not have the knowledge sought or even have an opinion on the topic of concern. In those cases, it is difficult for researchers to know how true or reliable the answers are. Respondents may interpret a question or concept differently from what was intended by the researcher. Finally, a respondent may intentionally mislead the researcher by giving false information. The methodology selected for this research mitigates these weaknesses by relying on several data sources to enable cross-verification and cross-validation of data collected, rather than relying solely on survey results.

Investigative Question Number Four

IQ number four; "How well do NASA's actions and plans fit the model?" was answered by comparing the answer to IQ number one with the answers to IQ number two and IQ number three.

Data Collection. We constructed a matrix of the model identified in IQ number one in order to display our findings. We considered several types of ordered matrices, and selected the site-ordered descriptive matrix for this study. A site ordered descriptive matrix contains first-level descriptive data from all sites, but the sites are ordered according to the main variable(s) being examined, so that one can see differences among high, medium, and low sites. Thus it puts in one place the basic data for a major variable(s), across all sites (Miles et al, 1984: 160). Miles used the term "site" by preference, to indicate a bounded context where one is studying something. But "site", according to Miles, is equivalent to "case", in the sense of "case study" (Miles et al, 1984: 151). This type of matrix appears to adequately serve our purpose by comparing two cases, the space shuttle and space station programs, to an acquisition logistics model. The model was broken into objectives based on the sub-areas from the definition of ILS. The matrix consisted of the objectives of ILS listed on the vertical axis of the table with one row corresponding to each objective. One aggregate column for the space shuttle and one for the space station were listed on the horizontal axis. The next section describes methods used to enter findings into the matrix.

Data Analysis. Since our study's purpose was not the production of causal inferences, confirmatory data analysis was not required (Emory, 1991: 469). Therefore, we utilized an exploratory data analysis approach to complete the matrix. Exploratory analysis is a perspective and set of techniques used to search for patterns, clues, and evidence with emphasis on visual presentations and graphical techniques over summary statistics (Emory, 1991: 469). Data analysis as described in the methodology for IQs two and three identified both similarities and differences between the space shuttle and space station acquisition logistics processes. Further, both programs were evaluated through exploratory data analysis; that is, comparison across all the sources of research data for common themes, patterns, or evidence. These findings were then compared to the ideal process represented by the model. Based on the findings from IQs one and two, each matrix location was marked plus

(+), zero (o), or minus (-) to indicate the degree to which the program included the specific model objective. A plus (+) indicates the program clearly addresses the objective. A zero (o) indicates the program addresses the objective to some degree. A minus (-) indicates the program provided little, if any, evidence of the particular objective. This evaluation resulted in answering IQ number four; "How well do NASA's actions and plans fit the model?"

Limitations. This research team recognized several bias limitations in our selected methodology to answer IQ number four. The archetypical ones include the following (Miles et al, 1984: 230):

> (1) the holistic fallacy: interpreting events as more patterned and congruent than they really are, lopping off the many loose ends of which social life is made
>
> (2) elite bias: overweighing data from articulate, well-informed, usually high-status informants (interviewees) and under representing data from intractable, less articulate, lower status ones
>
> (3) going native: losing one's perspective or one's "bracketing" ability, being coopted into the perceptions and explanations of local informants (interviewees).

It's useful to note that each of these three biases corresponds, respectively, to one of the three major judgmental heuristics identified by researchers: "representativeness," "availability," and "weighing" (Miles et al, 1984: 230).

In order to mitigate the effects of bias and improve research validity, we used the following testing or confirming tactics (Miles et al, 1984: 230-242):

(1) checking for representativeness: the research methods employed included multiple primary and secondary data sources, collected at three sites, for two major programs. Therefore, we believe the data adequately represent acquisition logistics within NASA.

(2) checking for researcher effects: we made significant effort to establish rapport with all individuals contacted, and clearly explained the intent of our research. Anonymity was assured for all respondents and interviewees. Also, we feel the effect of two graduate students gathering data related to two nationally supported space programs likely poses little threat to either individuals or organizations well acquainted with hosting government and foreign dignitaries.

(3) triangulating: we collected data from multiple sources, at multiple sites, from two programs. Each researcher performed separate literature reviews for different investigative questions. We suggest this process strengthens the validity of the data gathered and resulting analysis.

(4) weighing the evidence: we weighted personally observed data more strongly in our analysis due to assumed consistency of any existing bias. We believe the process of comparing data from different sources described in the first three steps of our efforts to mitigate bias further support this approach.

(5) making contrasts/comparisons: we used this test throughout our research effort. Data was either falsified or supported by similar data from other primary and secondary sources. We suggest this process improves both the reliability and validity of our data.

(6) replicating a finding: we made every effort to test emerging patterns within a program at one site during the following site visits. We suggest this process adds validity to both analysis and findings.

(7) looking for negative evidence: at the outset of our research, we felt NASA personnel would attempt to minimize any potential negative aspect of acquisition logistics. We responded to this possibility by concerted effort to find negative evidence to refute our preliminary analysis. Any bias toward positive findings is likely mitigated due to this effort.

(8) getting feedback from informants: we used this test to further support or refute our study. When several data sources seemed to suggest a common theme or trend, we questioned key logistics managers to ask their opinion. If the data was acknowledged and not refuted, we assumed the data provided an accurate assessment.

Summary

This chapter described the research methodologies used to answer each of the investigative questions. Sampling design, research design, data collection, and data analysis have been presented for each IQ. Possible limitations have been identified, and actions taken to reduce the effect of those limitations on the research described. Chapter IV will present the results of our research effort based on the guidance provided by this chapter.

IV. Research Findings

Introduction

The purpose of this chapter is to present discussion of the data collected to answer our investigative questions. Each investigative question will be restated and the data pertinent to that question will be addressed by collection method. A synthesis of the data will follow the data presentation. The discussions and synthesis will address the model that will be identified in IQ 1. In each case, we will give our assessment of how the answer will fit into the matrix of IQ 4, the objective will be stated, and the data will be synthesized into an answer for the question. The final section, Investigative Question Number Four, will integrate the answers of the first three investigative questions into a matrix.

Investigative Question Number One

Introduction. This section provides the findings from the literature review conducted to answer IQ number one, "What do experts suggest as a model for an acquisition logistics program?" We established three model requirements to provide acceptable internal validity, or the ability of a research instrument to measure what it is purported to measure. In this case, we wanted the model to adequately represent the objectives of acquisition logistics. First, the model must adequately encompass the models of logistics experts identified during our literature search. Second, the model must specify the sequence of events necessary for effective acquisition logistics. Third, the model should reflect acquisition logistics from a macro, or program perspective.

Findings. Our search did not reveal such an existing model. Therefore, publications by such recognized logistics experts as Blanchard, Bowersox, and Stock and Lambert were reviewed for the purpose of compiling their points of view into an acquisition logistics model suitable for the purposes of this study. Our initial efforts consisted of arbitrary selection of elements of logistics common to a majority of the authors and construction of a basic model for this study.

We began the process of building a common model with the following checklist (Blanchard, 1986: 201).

System Design Review Checklist

General
1. System Operational Requirements Defined
2. Effectiveness Factors Established
3. System Maintenance Concept Defined
4. Functional Analysis and Allocation Accomplished
5. Logistics Support Analysis Accomplished
6. Logistics Support Operation Plan Complete

Logistics Support Elements
(Requirements known and optimized for)
1. Test and Support Equipment
2. Supply Support (Spare/Repair Parts)
3. Personnel and Training
4. Technical Data (Procedures)
5. Facilities and Storage
6. Transportation and Handling

Our efforts continued with comparison of the Blanchard checklist to characteristics of leading edge logistics organizations (Bowersox, 1989: v). Commonality did exist to a limited degree, but we did not yet recognize a useful model.

Leading edge logistics organizations:

- Exhibit an overriding commitment to customers
- Place a high premium on basic performance
- Develop sophisticated logistical solutions
- Emphasize planning
- Encompass a significant span of functional control
- Have a highly formalized logistical process
- Place a premium on flexibility
- Commit to external alliances
- Invest in state-of-the-art information technology
- Employ comprehensive performance measurement

We compared Blanchard's and Bowersox's ideas to the following measurements of effective logistics organizations (Stock et al, 1987: 628-629). Commonality remained, but not across all three authors' efforts. We then continued our comparison with several other authors, for the purpose of developing a simple majority of common characteristics.

Measuring the Effectiveness of the Logistics Organization

1. Flexibility-willingness to tackle unusual problems, try out new ideas.
2. Development-personnel participate in training and development.
3. Cohesion-lack of complaints, grievances, conflict.
4. Democratic supervision-subordinate participation in work decisions.
5. Reliability-completion of assignments without checking.
6. Delegation-delegation of responsibility by supervisors.

7. Bargaining-negotiation with other units for favors, cooperation.
8. Results emphasis-results, not procedures, emphasized.
9. Staffing-personnel flexibility among jobs, backups available.
10. Cooperation-responsibilities met and work coordinated with other units.
11. Decentralization-work decisions made at low levels.
12. Conflict-conflict with other units over responsibility and authority.
13. Supervisory backing-supervisors back up subordinates.
14. Planning-waste time avoided through planning and scheduling.
15. Productivity-efficiency of performance within unit.
16. Support-mutual support of supervisors and subordinates.
17. Communication-flow of work information.
18. Initiation-initiate improvements in work methods.
19. Supervisory control-supervisors in control of work progress.

Our efforts to construct an adequate model continued with the following acquisition logistics checklist (Allen, 1986: 18-28). For purposes of clarity, only the headings are presented here. The full text of this checklist represents an extremely detailed audit of the acquisition logistics process. Therefore, while this model arguably includes the bulk of the previous models, this research team decided against using it due to the general, descriptive nature of our study contrasted with the detailed program data requirements of the model.

Acquisition Logistics Checklist

General
A. Management/Organizational Issues
B. System Operational Requirements
C. Planning

D. Life Cycle Cost
E. Contractual Requirements
F. Source Selection Criteria

Integrated Logistics Support (ILS) Elements
A. Maintenance Planning
B. Reliability and Maintainability
C. Technical Data
D. Personnel and Training
E. Facilities
F. Support and Test Equipment
G. Supply Support
H. Package, Transportation, and Handling
I. Logistics Support Resource Funds
J. Logistics Management Information

Since we now recognized an extremely comprehensive model would not serve our purposes, we compared the following model with previous models (Palguta et al, 1987: 66). Our intent remained to find a simple model which addressed acquisition logistics from a macro perspective.

> ILS is a disciplined, unified, and iterative approach to the management and technical activities necessary to:
>
> A. Integrate support considerations into system and equipment design.
> B. Develop the support requirements.
> C. Acquire the required support.
> D. Provide the required support during the operational phase at minimum cost.

We felt this model approached our requirements to a large degree, but did not specify the appropriate sequence of events for a program. As an example, it may prove challenging to integrate support considerations into system and equipment design (A.), before developing the support requirements (B.) that must be integrated. We continued our efforts with another model (Hosmer, 1986: 1):

ILS will:

1. Influence Space Station on-orbit and ground systems design from a logistics supportability standpoint to enhance inherent support and reduce support costs.

2. Identify and optimize logistics support resources required to maintain the Space Station on-orbit and ground systems in a satisfactory operational condition.

3. Identify and optimize logistics support resources acquisition and utilization throughout the Space Station program operational life.

We carefully compared and contrasted this model with the previous models and found this model did not meet our requirements. The sequence of events appeared logical, except determining support requirements was apparently implicit instead of explicit. However, due to different word choices and terminology used by the various experts, common elements were limited and this research team felt building an obviously arbitrary model did not provide an appropriate degree of rigor. Reconsideration of the definition of acquisition logistics given in Chapter One and restated below resulted in our selected model (DoDI 5000.2, 1991).

> Acquisition logistics is the process of systematically identifying and assessing logistics requirements and alternatives, analysis and resolution of ILS deficiencies, and the management of ILS throughout the acquisition process.

Intuitive analysis of this definition suggested acquisition logistics is the performance of ILS during the acquisition process. Based on this assumption, the model for acquisition logistics used for this study was the definition of ILS from Chapter One restated below.

> Integrated logistics support is a disciplined, unified, and iterative approach to the management and technical activities necessary to:
>
> - Develop support requirements that are related consistently to objectives, to design, and to each other.
>
> - Effectively integrate support considerations into the system and equipment design.
>
> - Identify the most cost-effective approach to supporting the system when it is fielded.
>
> - Ensure that the required support structure elements are developed and acquired.

This model satisfies the essential requirements established by the research team. First, the model (ILS definition) adequately encompasses the models of logistics experts identified during our literature search. Second, the model (ILS definition) specifies the sequence of events necessary for effective acquisition logistics. Third, the model (ILS definition) reflects acquisition logistics from a macro, or program perspective. For example, developing requirements should be accomplished before integrating support considerations. Similarly, identifying the most cost-effective approach to supporting the system when it is fielded may prove quite difficult before accomplishing the first two activities. Finally, developing and acquiring the required support structure elements before accomplishing the three previous activities may result in a costly, ineffective system due to rework. We believe this definition serves as an effective answer to IQ number one; "What do experts suggest as a model for an acquisition logistics program?"

Investigative Question Number Two

How has NASA accomplished acquisition logistics in the past?

Discussion of the Unstructured Interview Comments.

Appendix C contains the unstructured interview comments applicable to the Space Shuttle Program or the era of Shuttle development.

ILS Objective One: Develop support requirements that are related consistently to objectives, to design, and to each other.

Our interviews confirmod that this objective was addressed during the development of the Space Shuttle. The Space Shuttle had an ILS plan based on an Air Force document. Included in the plan was a maintenance contract that allowed the contractor, American Airlines, to share in the approval of designs. We also know from the interviews that this program was cut because of budget constraints.

The interviews further revealed that Rockwell International, Shuttle Depot maintenance contractors, are pursuing the ongoing task of gaining certification on all of the parts of all four shuttles (all four shuttles are different). This certification process requires the contractor to obtain the technical data, the drawings, the materials, the tools, and the expertise to repair, refurbish, recreate, or contract for most any part on any of the shuttles. The process is often hampered by the inconsistencies of the data that the contractors can recover. It is evident from the interviews that stricter requirements on the information and resources necessary to maintain the Shuttles would help the certification process. However, it is not clear if the lack of commonality of technical data, drawings, tools, etc. is the result of the cuts in the ILS package or because of loose requirements.

ILS Objective Two: Effectively integrate support considerations into the system and equipment design.

The logistics managers that we spoke to indicated that logistics did not have a well defined method of affecting design. The role of logistics in design matters is described as a lobbying effort that requires the logistician to employ extraordinary means to impact a design. One manager suggested that the design engineers feel that designing for support is "gold-plating." Other managers indicated that engineers are given logistics as an "other assigned duty" and as a result do not have the expertise and the time (because of primary duties) to function as a logistician.

ILS Objective Three: Identify the most cost effective approach to supporting the system when it is fielded.

We failed to elicit comments that clearly indicated the variety or nature of alternative cost effective approaches developed for Shuttle design. We know that the driver for cost considerations was getting the system funded and as a result development costs were minimized. This is often counter to the philosophy of ILS.

ILS Objective Four: Ensure that the required support structure elements are developed and acquired.

Our interviews revealed that this objective was not met. The fact that the maintenance contract for American Airlines was not funded and the fact that Rockwell is going through a certification process for Shuttle parts processing are indicative that support structure elements were not acquired up front. While we do not know how extensive and appropriate the plans were for this objective, we were told that funding cuts prevented the acquisition of the required support structure elements.

Discussion of Personal Observations. In the course of our field visits we were able to personally see existing facilities and equipment which indicated the existence of acquisition logistics in the space shuttle program. The following are some of those items:

-- The WETAF: Astronauts use this water tank to practice procedures. Astronauts are on-orbit maintainers.

-- Mock-ups: again astronauts use mockups for procedures training.

-- Launch pads A and B represent ground equipment/facilities that had to exist before the first shuttle launch.

-- Three shuttle rehab facilities complete with fixtures and tooling are used to prepare shuttles for launch.

-- The vehicle assembly building (VAB) is used to mate the shuttle with the main fuel tank and solid rocket boosters. The shuttle could not fly without this facility.

-- A 747 is maintained and elaborate lifting systems are in place to transport the shuttle. This had to be in place before the shuttle became operational.

-- Massive track vehicles take the Shuttle, fuel tank, and solid rocket boosters from the VAB to the launch pad over a specially reinforced and designed roadway.

ILS Objective One: Develop support requirements that are related consistently to objectives, to design, and to each other.

We feel that it is unlikely that any of these items could have been developed and deployed in time for the Shuttle to launch without some requirements being levied. Most of the items listed had to exist before the Shuttle(s) became operational. Most of the items have a great deal of interface with the Shuttle so that requirements are critical. We did not talk to anyone that may have played a role in the development of these facilities and pieces of equipment because they do not belong to what NASA considers their logistics community.

ILS Objective Two: Effectively integrate support considerations into the system and equipment design.

We do not know what impact support considerations had on Shuttle design with regard to the facilities and equipment we observed on our visits. Since many of these support elements serve a single purpose, it is evident that their design was completely derived for the system.

ILS Objective Three: Identify the most cost effective approach to supporting the system when it is fielded.

Because we failed to talk to people responsible for fielding the support elements that we observed, we cannot comment on what alternatives were presented for them.

ILS Objective Four: Ensure that the required support structure elements are developed and acquired.

It is this objective that we feel this category of data best represents. As we stated for ILS Objective One, many of these support elements had to exist before the Shuttle became operational.

Discussion of the Historical Review. Chapter II, the Historical Review, serves as the literature review for this IQ.

ILS Objective One: Develop support requirements that are related consistently to objectives, to design, and to each other.

Like our interviews, the literature review indicates that the shuttle program had an ILS package that had stated requirements for many aspects of logistics. One article lists the JSC requirements document number and the areas that were covered (Byrnside, 1979: 4).

ILS Objective Two: Effectively integrate support considerations into the system and equipment design.

The literature review contains several sources that suggest that the Space Shuttle was not ready to become operational (Presidential Commision on the Space Shuttle Challenger Accident, 1986: 170-177) and has a turnaround time that will not support mission goals (Baker, 1987: 42). The problem, as indicated in the literature, is that the shuttle was not designed for support and that the support concept for the program was lacking. We could not gather enough information to fairly judge whether these problems would have been negated had the ILS plan been funded and fully implemented.

ILS Objective Three: Identify the most cost effective approach to supporting the system when it is fielded.

The data supports the idea that this was accomplished but not implemented. Different sources identify more than one design for the Shuttle and indicate that the eventual design involved many compromises to supportability. One source indicates that the "optimum design" of the shuttle was not selected because of the development cost (Presidential Commission on the Space Shuttle Challenger Accident, 1986: 2). The focus for NASA was to make sure the program got funding by minimizing development cost.

ILS Objective Four: Ensure that the required support structure elements are developed and acquired.

The literature suggests that this item was considered but not implemented. As indicated in objective one, there were requirements documents and plans for developing the support for the shuttle. The Byrnside article describes the implementation of ILS as inconsistent and incomplete (Byrnside, 1979: ii). Most of what has become Shuttle support for processing was developed after the Shuttle became operational. The Shuttle Processing Contractor was created because NASA felt that managing all of the original equipment manufacturers (OEM) was not as cost effective as having one prime handle Shuttle processing from landing to launch (Savage, 1987: 151). NASA had gone to OEMs as a support plan when the maintenance contract was cut from the budget.

Synthesis. Objective one: Develop support requirements that are related consistently to objectives, to design, and to each other.

We rate this objective (O). All of our sources agree that requirements were established for the Space Shuttle program. An interviewee points out that the ILS package for the Space Shuttle was based on Air Force Regulation 4100.35M. In addition, this interviewee states that the original package contained a maintenance contract that included design interface. Our historical review states that requirements documents were developed and implemented and our observations indicate that some requirements had to be put forth for the different training aids, facilities, and support equipment to be developed before the shuttle was launched.

Our research was not detailed enough to determine whether the requirements were indeed "consistent with objectives, to design, and to each other." We included information from reports that criticized the Shuttle program for some problems that might be caused by requirements not being consistent with objectives, design, and each other, but feel the cutting of the different aspects of the ILS program could also cause the problems that were criticized.

Objective two: Effectively integrate support considerations into the system and equipment design.

We rate this objective (-). Our data suggests that this objective was met in some cases and not in others. Our interviews and portions of the historical review suggest that supportability considerations were not always an integral part of system design. One interviewee says that when there was a maintenance contractor in the early going maintainability did have some impact on Shuttle design. Another interviewee suggests that logistics did not and does not have a formal interface with design and thus any changes to design are lobbying efforts.

Our historical review contains a great deal of critique concerning the Shuttle's turnaround time and readiness to enter an "operational" environment. One article suggests that new technology may allow design changes to improve shuttle turnarounds (Baker, 1987: 36). The authors have both worked on military aircraft much older than the Shuttle that were fielded with many of the so called "new technologies."

On the other side of the issue are our personal observations. Our observations are based on our reasoning that because certain facilities and support equipment existed before the Shuttle became operational that some process must have determined the requirements. We feel all of the items listed in the Personal Observation section indicate some integrated effort on the part of the Shuttle program to ensure that the vehicles could be launched, recovered, returned to a Shuttle processing facility, processed, and relaunched. As a result, we feel that some portion of objective two was met.

Objective three: Identify the most cost-effective approach to supporting the system when it is fielded.

We rate this objective (0). This objective was attempted. The historical review and the interviews support the idea that an ILS program had been set up and partially implemented for the Space Shuttle. NASA based their original maintenance scheme on commercial aviation and a maintenance contract was let with American Airlines. A recurring theme in our research is the idea that as the budget was cut, so were the ILS tasks. This indicates that the decision makers in the organization either felt that ILS was not the most cost effective approach, had insufficient understanding of the life cycle cost basis of ILS, or were too concerned with getting the project funded to worry about down-stream costs. A prevalent attitude is that of "getting the rubber on the ramp and develop support later."

Objective Four: Ensure that the required support structure elements are developed and acquired.

We rate this objective (0). In terms of support structure in the form of facilities and support equipment, the Shuttle program had a great deal of success at meeting this objective. We have discussed the Shuttle processing facilities, the launch pads, the mobile launch vehicle, and other support elements that were in place before the Shuttle made its first flight.

However, much of the present logistics support concept for the Shuttle has been created and purchased since the shuttle became operational. The SPC, the Shuttle Depot, and much of the maintenance data tracking and spares support was developed after the Shuttle had been launched. This is indicative of a failure to develop and acquire support structure. It is important to note that this structure may not have had to be created after the fact if the original ILS package would have survived budget cuts.

Investigative Question Number Three

Introduction. This question will be addressed in the same format as IQ two except that this question additionally includes survey questionnaire results and comments.

Discussion of Unstructured Interview Comments. Appendix D contains the unstructured interview comments that relate to Space Station Freedom or current NASA operations.

Objective one: Develop support requirements that are related consistently to objectives, to design, and to each other.

The interviewees were all familiar with the requirements and the requirements documents. Some managers felt that requirements are arriving too late. Some managers feel that without a definition of tasking that this objective is difficult to meet. In fact, we encountered a number of people who were familiar with the DOD who felt that NASA does not have the structure or the expertise to implement an ILS program. One interviewee states, "In the DoD the user defines what is needed and the infrastructure supports the input of needs and design requirements. NASA is trying to implement a logistics program without the infrastructure to support it."

Objective two: Effectively integrate support considerations into the system and equipment design.

The interview comments state that logistics has no formal influence on design. Like the shuttle program, logistics is considered to be a lobbying effort. Logistics is said to be "something to be considered after the system is developed." One manager discussed how he had brought an issue he felt was important to an astronaut so that the astronaut would get interested and help get the supportability based issue into design. An issue that is also prevalent is the idea that budget cuts are threatening more and more of the program and thus the designs are changing -- logistics is seen as a costly complication. Another issue that arose involved the design of certain mirror image parts so that they were not interchangeable. The logistics managers tried to get this corrected but were unsuccessful.

An exception to the previous comments is the payload/SSF interface. Although one of our interviewees said that Shuttle interface was not part of SSF design, we found that the interface is based on requirements prepared by the Payload section of KSC. We were not able to determine if the Level II contractor was managing all of the interactions, but there were several comments about Level II ineffectiveness.

Objective three: Identify the most cost-effective approach to supporting the system when it is fielded.

Our discussions indicate that the turmoil and environment of constant change are plaguing this area. Cutbacks are causing restructuring and redesign. This, coupled with comments that logistics is not a part of the design process or gets involved when it is too late to have an impact suggests that the idea of minimizing development cost by postponing logistics issues is again part of the NASA program process.

Furthermore, some of our interviewees suggest that the LSA, the process of developing cost trade off models, was not actually accomplished or conducted improperly.

Objective Four: Ensure that the required support structure elements are developed and acquired.

This objective is not being met because of budget cuts. Our interviews point to cutbacks that caused the different centers to be responsible for designing, building and supporting their own hardware. Commonality, maintenance, paper tech data, and depot maintenance have been deleted from the SSF program. Spares money will not be available until 1995 -- the spares plan is to produce spares at lead time before MTBF. One interviewee summarized by saying, "in the beginning the lessons of the Shuttle program were used but the budget cuts got them."

Discussion of Personal Observations. In the course of our field visits we were able to observe indicators of the existence and status of acquisition logistics in the SSF program. Some of them are as follows:

-- On Orbit maintenance technical data.
-- Program definition and requirements documents.
-- LSA Process Requirements.
-- ILS Function Control Documents.
-- WP Logistics Program Documents.
-- SSF Support Facility.
-- Mock ups.
-- Integration Documents from Level II.
-- Payload Integration.

ILS Objective One: Develop support requirements that are related consistently to objectives, to design, and to each other.

As indicated, we have seen SSF requirements documents. The SSF 30000 series documents are the requirements documents for the SSF program. Level II is cited as "responsible for the development of an ILS program to support the ground and flight elements of the SSFP which meets the requirements and policy set forth by Level I." Responsibilities are outlined for different centers and a collection of the elements of ILS are addressed (some of the 10 that we identify are combined).

Objective two: Effectively integrate support considerations into the system and equipment design.

Probably the most notable aspect of design integration that we witnessed involved visiting payload integration. The Space Station will begin its life as Shuttle payload. As a result, the payload integrators have given a number of Shuttle bay configuration options to the design engineers of the different work packages.

One of the negatives in this process is the management of databases. Each work package has its own and presently can not update any other. This may also cause interface problems with astronauts if some form of overlay or integration program is not developed.

Objective three: Identify the most cost-effective approach to supporting the system when it is fielded.

SSP 30527 contains the Logistics Support Analysis Process Requirements for SSF. The introduction of this document states that LSA is "a method by which logistics personnel interface with design engineers and conduct trade studies to determine the most economic mix of system/equipment reliability, supportability, and maintainability." This is evidence that this objective was attempted.

Objective Four: Ensure that the required support structure elements are developed and acquired.

One indicator of the acquisition of support structure for the SSF is the processing facility being built at KSC. Another aspect is the on-orbit technical data that is being developed. The on-orbit technical data will be maintained on computers and the astronaut will gain access through a terminal.

Discussion of the Historical Review. The literature review for this IQ was presented in the Historical Review in Chapter II. The Historical Review was conducted at the beginning of our research and yielded very little information on SSF. We did find some SSF requirements documents that are relevant at face value as indicators of the existence of all of the objectives of ILS (NASA, 1991: 1).

Discussion of Survey Questionnaire Responses and Comments. Appendix B contains the Survey comments and graphical representation of the Survey Responses. We grouped our survey questions to fit the ILS objectives of our model. To accomplish this grouping, we determined individually how we would classify each question and then compared our ideas. We agreed on most of the classifications without debate, and the remaining questions were discussed until consensus was reached. Some questions were related to more than one category, but we purposely restricted each question to one category for purposes of brevity and clarity. The first ten questions on the survey collected background data of the respondents to establish age, education, experience, and job position. The responses showed that the logistics managers surveyed were highly experienced both within NASA and in their profession. The expert status of the group improves the face validity of the responses. We will address the remaining 26 questions by ILS objective. The matrix (Table 4-1) on the following page displays question numbers related to each objective.

ILS Objective One: Develop support requirements that are related consistently to objectives, to design, and to each other.

Objective one will be addressed based on responses to question numbers 13, 17, 19, 20, 22, and 23.

The responses to question 13 indicate guidance provided for developing logistics support requirements needs significant improvement, with a majority of respondents negatively assessing existing guidance.

The responses to question 17 reflect the importance logistics managers attach to planning for support requirements. Significantly, nearly 90 percent of the respondents strongly agreed that logistics planning is

Table 2

QUESTION OBJECTIVE MATRIX

Question	Obj 1	Obj 2	Obj 3	Obj 4
11				X
12		X		
13	X			
14				X
15			X	
16				X
17	X			
18				X
19	X			
20	X			
21		X		
22	X			
23	X			
24			X	
25		X		
26		X		
27			X	
28			X	
29			X	
30		X		
31				X
32			X	
33		X		
34				X

crucial to the success of current and future NASA programs. In fact, all respondents moderately to strongly agreed on the crucial nature of logistics planning.

The responses to question 19 suggest logistics training and professional development are not emphasized within NASA. Over 55 percent of respondents slightly to strongly disagreed that NASA routinely offered such training. Developing logistics support requirements without training in current methods and approaches could prove difficult.

The responses to question 20 indicate over 35 percent of the logistics managers surveyed felt they were not involved in planning ILS for NASA. Since developing support requirements is the first step of ILS, apparently at least 35 percent of the respondents believe they do not affect this activity.

The responses to question 22 show widely varied assessment of NASA Management Instructions (NMIs) regarding the development of logistics support requirements. Survey comments indicate NMIs may be unenforceable. With over 30 percent of respondents moderately to strongly disagreeing that NMIs provide adequate guidance, while over 20 percent neither agree nor disagree, strengthening NMI content and applicability appears appropriate.

The responses to question 23, with over 40 percent of respondents moderately to strongly disagreeing, while nearly 30 percent neither agree nor disagree, clearly indicates the current NASA system for developing logistics support requirements is not considered effective.

Objective two: Effectively integrate support considerations into the system and equipment design.

Objective two will be addressed based on responses to question numbers 12, 21, 25, 26, 30, and 33.

Question 12 asked respondents if NASA selects only experienced, qualified individuals to work as logistics managers. Since all respondents were logistics managers, we were somewhat surprised when over 40 percent selected slightly to strongly disagree, with over 20 percent strongly disagree. If logistics managers are not experienced and qualified, how are they to effectively integrate support considerations into the system and equipment design?

On question 21, responses indicate over 35 percent of the logistics managers surveyed felt they were not involved in executing ILS for NASA. Since integrating support considerations into the system and equipment design is the second step of ILS execution, apparently at least 35 percent of tho respondents believe they do not affect this activity.

Responses to question 25 indicate NASA centers can improve coordination of logistics support requirements with each other, a finding also supported by verbatim survey comments.

Question 26 clearly indicates logistics managers within NASA have overcome the lack of guidance and organization support noted previously. Over 75 percent of respondents slightly to strongly agreed that centers seem to use varied methods for developing program logistics support requirements. These varied methods seem to result in more effective integration of support considerations into system and equipment design due to different requirements between each work package.

Question 30 asked respondents if NASA had one person "in charge" of logistics. Over 55 percent strongly disagreed with this statement, indicating that NASA does not have one person "in charge" of logistics in the opinion of our respondents. Without such a person, NASA may experience difficulty effectively integrating support considerations into system and equipment design, due to the lack of a point of contact for questions regarding logistics related to design from a system or program perspective.

Responses to question 33 indicate over 40 percent of respondents do not feel they are routinely involved in configuration changes to NASA systems. This leads to the finding that effective integration of support considerations into system and equipment design may not be accomplished due to such a lack of involvement of logistics managers.

Objective three: Identify the most cost-effective approach to supporting the system when it is fielded.

Objective three will be addressed based on responses to question numbers 15, 24, 27, 28, 29, and 32.

Question 15 asked if no changes are necessary in the management approach to acquisition logistics. Nearly 30 percent of respondents strongly disagreed, with over 55 percent choosing to slightly or strongly disagree. In concert with question 11 in objective four, question 15 suggests management of acquisition logistics should change by emphasizing ILS during system development and acquisition, which may identify the most cost-effective approach to supporting a system when it is fielded.

Question 24, which addresses Vision 21, The NASA Strategic Plan, resulted in over 60 percent of responses in the neither agree nor disagree category regarding the impact of Vision 21. Survey comments suggest Vision 21 was not widely read, a finding supported by question 9, reflecting a decided lack of strategic plan communication within NASA. Also, within the Vision 21 document, the words "logistics" and "logistics support" do not appear, which conflicts with the responses to question 17 rating logistics as "crucial" to NASA success.

Responses to questions 27 and 28 demonstrate continuing confusion within NASA regarding baseline logistics support concepts. Reusable systems such as the space station, the focus of this survey, should have resulted in opposite response groupings between questions 27 and 28. The spread of responses within the two questions suggests a requirement for clarification of support concepts. Attempting to identify the most cost-effective approach to supporting the system when it is fielded may prove extremely difficult without a clear logistics support concept. Verbatim survey comments seem to support this finding.

Question 29, asking whether significant differences exist between the logistics support concepts used for the space shuttle and space station programs, also reflects confusion regarding logistics support concepts within NASA. Since both the space shuttle and space station are reusable systems requiring on-orbit support, this question might have resulted in responses being grouped on the disagree side of the scale. However, as one verbatim survey comment states, "Space Transportation System logistics were cut and had to be worked after the fact. Space Station Freedom appears headed in the same direction." Identifying the most cost-effective approach to supporting the system without definite logistics support concepts for the space station may prove this statement correct.

On question 32, over 75 percent of respondants slightly to strongly agreed that the NASA logistics system requires change to support long term programs. Since both the space shuttle and space station programs presently have projected 30 year life cycles, they would seem to qualify as long term programs. Identifying the most cost-effective approach to supporting a 30 year program will obviously yield significant long term savings.

Objective Four: Ensure that the required support structure elements are developed and acquired.

Objective four will be addressed based on responses to question numbers 11, 14, 16, 18, 31, and 34.

Question 11 asked if NASA emphasized ILS during systems development and acquisition. Over 40 percent of respondents slightly to strongly disagreed, with nearly 25 percent strongly disagreeing. If NASA does not emphasize ILS during systems development and acquisition, it may prove difficult to ensure the required support structure elements are developed and acquired.

Question 14 asked if respondents felt their supervisor understood their job. Over 50 percent strongly agreed, with over 80 percent between slightly to strongly agree. Possibly, if NASA supervisors do understand subordinates' jobs, they can better ensure that the required support structure elements are developed and acquired.

When asked if they had the authority necessary to do their jobs, 60 percent of respondents to question 16 selected moderately to strongly agree. Counter to other findings, this suggests logistics managers feel they have the authority to ensure that the required support structure elements are developed and acquired.

Question 18 asked logistics managers if the logistics posture of NASA had improved compared to when they joined the organization. Over 70 percent of the respondents selected slightly to strongly agree, with over 20 percent strongly agree. This supports the finding that respondents feel NASA has improved with regard to ensuring that the required support structure elements are developed and acquired.

Responses to question 31, with over 70 percent of respondents moderately to strongly agreeing, indicates a need for NASA organization-wide guidance concerning logistics. Perhaps such guidance would eliminate the confusion discussed earlier and result in ensuring that the required support structure elements are developed and acquired.

Responses to question 34, regarding logistics managers maintaining consistent interface with their customers, seems to indicate that respondents feel interface is maintained. Over 55 percent of the responses were from slightly agree to strongly agree.

<u>Synthesis</u>. Objective one: Develop support requirements that are related consistently to objectives, to design, and to each other.

We rate accomplishment of this objective a (0). Support requirements have been developed and exist. However, our interviews and surveys indicate that there are problems with the requirements and how they are being managed. There is also a lack of guidance and training available in support of developing requirements. Some of the problem areas that were presented to us may be indicative of the cutbacks to the program and not necessarily the fault of the original objectives.

Objective two: Effectively integrate support considerations into the system and equipment design.

We rate this objective a (0). We found that the Payload function of KSC was providing the requirements that the SSF must meet to be transported as Shuttle payload. However, NASA does not consider Payload a logistics function.

Logistics, as defined and designated by NASA, influence on design is not supported in NASA. Logisticians are having to resort to lobbying and "looking over shoulders" to get involved with the design process. However, on occasion, NASA logisticians have been successful. The surveys indicate that the logistics community feels that this objective is crucial to mission accomplishment and that NASA wide guidance would help.

Objective three: Identify the most cost-effective approach to supporting the system when it is fielded.

We rate this objective a (-). The best summation of the data that we collected for this objective is that accomplishing this objective is difficult. Requirements are not what they should be, the program is not working from a statement of need, and budget cuts are causing decision makers to make hard decisions that include cutting program development costs by deleting ILS tasks.

The only support for the idea that this is being accomplished is the existence of LSA documents. However, these too were criticized for not being adequate.

Objective Four: Ensure that the required support structure elements are developed and acquired.

We rate this objective a (-). Much like the shuttle program, this objective has been addressed but is losing ground with every budget cut. Some support elements, like the facility being built at KSC, suggest that there are successes. However, spares and many other aspects of support for the SSF are being pushed back because of budget cuts -- the result will be that this support will have to be recreated at a much higher cost later, compared to cost during development.

Investigative Question Number Four

Introduction. This IQ will consist of simple graphical representation (Table 4-2) of the answers to the first three investigative questions. The purpose of this question and this representation is to assess not only how each program met the objectives of ILS, but also how those two programs compare.

Results. ILS programs were attempted and are being attempted on the Space Shuttle and Space Station Freedom programs. The Space Shuttle requires more visible support than does SSF, thereby providing more evidence of success at acquisition logistics. However, NASA decision makers have felt it necessary to cut logistics programs from the development process in both cases leaving the acquisition logistics incomplete. As a result, we find all aspects of acquisition logistics in both programs have been adversely affected.

Table 3

PROGRAM REVIEW AND ASSESSMENT RESULTS

	Shuttle	Station
ILS Objective One: Develop support requirements that are related consistently to objectives, to design, and to each other.	0	0
ILS Objective Two: Effectively integrate support considerations into the system and equipment design.	-	0
ILS Objective Three: Identify the most cost-effective approach to supporting the system when it is fielded.	0	-
ILS Objective Four: Ensure that the required support structure elements are developed and acquired.	0	-

V. Conclusions and Recommendations

Conclusions

The National Aeronautics and Space Administration is confronted by a significant problem in its declining budget and diminishing public support. We addressed this problem by answering the research questions: What actions has NASA taken to achieve acquisition logistics? How appropriate and complete are NASA's plans for improving acquisition logistics?

A significant part of this research was the selection of an ILS definition as a model for the acquisition logistics process. We used this model, taken from DoD instruction 5000.2, to compare and contrast acquisition logistics actions for the Space Shuttle and the Space Station Freedom programs. The Space Shuttle was the focus for a review of past actions taken by NASA to achieve acquisition logistics. The Space Station Freedom program was the focus for our assessment of NASA's current plans and activities for improving acquisition logistics.

We produced a matrix composed of the acquisition logistics model objectives compared to both the Space Shuttle and Space Station Programs. Our ratings were based on a scale of (+), (0), and (-). We conclude from the matrix (the data that supports the matrix) that neither program clearly addresses the intent of the objectives of our acquisition logistics model. Conversely, we found evidence to support the idea that programs did or do have credible ILS plans that, if carried out, would meet the objectives of an ILS program. These findings are the basis of our conclusions.

We answered the first research question, "What actions has NASA taken to achieve acquisition logistics?" with the results of the comparison of the Space Shuttle program to the objectives of the ILS objectives we selected as our model. NASA developed an ILS structure and program for the Space Shuttle. The program was not implemented in its entirety because many segments fell victim to budget cutbacks. What was implemented was in accordance with the objectives of an ILS program with the exception that some logistics issues do not easily influence design in the NASA organization.

We answered the second research question, "How appropriate and complete are NASA's plans for improving acquisition logistics?" from our comparison of the Space Station Freedom program to the DoD ILS objectives. Our assessment is that NASA's plans are not appropriate. None of the objectives of ILS were rated a (+). All of the objectives are being addressed to some degree. However, the plans and the application of those plans are only understood and supported in the logistics community, not by NASA as an organization. The entire organization has to understand and support ILS for it to be implemented successfully.

Recommendations

NASA has several options available to improve acquisition logistics. Our recommendations will focus on two areas: training and implementation of ILS.

It is our perception that training offers the greatest potential for improving acquisition logistics within NASA. While we feel it is necessary that everyone who performs logistics, or any job, should be given the training that is appropriate, the areas of greatest need are outside of the logistics arena. Logistics training outside of the logistics arena will improve the NASA system in two ways. First, training which addresses logistics concepts will help break communication barriers caused by a lack of understanding of logistics terminology. We do not feel that the "common language" needs to be in logistics or engineering language -- just accepted in both communities. For example "acquisition engineering" and "supportability engineering" work just as well as acquisition logistics as long as the concepts are the same. Second, as non-logistics disciplines begin to understand the benefits of a well thought out, supported, and funded acquisition logistics program, the task of integrating support considerations into system development should become easier.

Even with an appreciation of the benefits of ILS, NASA managers are faced with the challenge of continuing budget reductions. The up-front cost of ILS is often consciously traded for reduced development costs. Supportability is left to be developed when the system has not been designed for support and the creation of support elements has become more expensive. Unless the funding environment changes to support and reward life cycle planning, acquisition logistics will probably continue to not be fully implemented.

As space missions go longer and farther, the need for supportable systems continues to increase. As a result, the priority of logistics issues must improve. Level I NASA managers will have to reconsider whether supportability issues can be sacrificed -- on an extended mission the astronauts are the logisticians.

Finally, we recommend that there be further research in the area of logistics in NASA. We feel that a cost analysis of the creation of support elements after the Shuttle became operational would give some insight into just what an implemented ILS plan may have saved over the Shuttle's life cycle. Ideally, the cost analysis would cover the cost of working around non-supportable design as well as the cost of modifications, spares, recreating technical data, and other support capabilities.

Appendix A: NASA Logistics Survey Questionnaire

NASA LOGISTICS
SURVEY QUESTIONNAIRE

ANSWERS WILL BE MADE DIRECTLY ON THE QUESTIONNAIRE.
IDENTIFY ADDITIONAL COMMENTS BY QUESTION NUMBER.
RESPONDENTS ARE ASSURED OF TOTAL ANONYMITY.

PART I

BACKGROUND INFORMATION

This section of the survey contains several items dealing with personal characteristics. This information will be used to obtain a picture of the background of the "typical logistician."

1. Your age?

    1. Less than 25
    2. 26 to 35
    3. 36 to 45
    4. 46 to 55
    5. 56 to 65
    6. More than 65

2. Your area of study for each educational level obtained?

    Area of Study?

    1. Less than a Bachelor's Degree
    2. Bachelor's Degree
    3. Some graduate work
    4. Master's Degree
    5. Doctoral Degree
    6. Post-Doctoral Research

3. Total months in this organization?

    1. Less than 6 months
    2. More than 6 months, less than 12 months
    3. More than 12 months, less than 24 months
    4. More than 24 months, less than 36 months
    5. More than 36 months, less than 48 months
    6. More than 48 months.

4. If your present position is in a logistics/logistics related job with NASA, select from the list below the area most closely associated with that job.

    1. Maintenance
    2. Packaging, handling & distribution
    3. Supply support
    4. Design/systems engineering
    5. Configuration management
    6. Contracting
    7. Test & evaluation
    8. Training
    9. Marketing
    10. Quality assurance
    11. Research & technology
    12. Other (specify)

5. Total months in your present position?

1. Less than 6 months
2. More than 6 months, less than 12 months
3. More than 12 months, less than 24 months
4. More than 24 months, less than 36 months
5. More than 36 months, less than 48 months
6. More than 48 months

6. How would you characterize your job experience related to your present position with NASA?

1. Highly experienced in present position.
2. Somewhat experienced in present position.
3. Neither experienced nor inexperienced.
4. Somewhat inexperienced in present position.
5. Highly inexperienced in present position.

7. If your past position was in a logistics/logistics related job (whether or not employed with NASA), select from the list below the area most closely associated with your past position.

1. Maintenance
2. Packaging, handling & distribution
3. Supply support
4. Design/systems engineering
5. Configuration management
6. Contracting
7. Test & evaluation
8. Training
9. Marketing
10. Quality assurance
11. Research & technology
12. Other (specify)

8. How would you characterize your job experience related to your past position with NASA?

1. Highly experienced in past position.
2. Somewhat experienced in past position.
3. Neither experienced nor inexperienced.
4. Somewhat inexperienced in past position.
5. Highly inexperienced in past position.
6. Past position NOT with NASA.

9. I have read the NASA strategic plan titled Vision 21.

1. Yes
2. No

10. In my opinion, the terms Integrated Logistics Support (ILS) and Acquisition Logistics (ACQ LOG) are:

1. Interchangeable
2. Equivalent in practical application
3. ILS is a subset of ACQ LOG
4. ACQ LOG is a subset of ILS
5. Other (specify)
6. Don't know
7. Don't use these terms in my job
8. NASA uses other terms that have similar meaning (specify)

For the remainder of this survey, the following definitions apply:

Integrated Logistics Support - a disciplined, unified, and iterative approach to the management and technical activities necessary to:

- Effectively integrate support considerations into the system and equipment design.

- Develop support requirements that are related consistently to readiness objectives, to design, and to each other.

- Ensuring that the required support structure elements are developed and acquired.

- Identifying the most cost-effective approach to supporting the system when it is fielded.

Acquisition Logistics - the process of systematically identifying and assessing logistics requirements and alternatives, analysis and resolution of ILS deficiencies, and the management of ILS throughout the acquisition process.

PART II

ORGANIZATIONAL INFORMATION

Listed below are a series of statements that represent beliefs that individuals might have about the company or organization for which they work. Use the following rating scale to indicate your own beliefs about the particular organization for which you are now working.

1 = Means you strongly disagree with the statement.
2 = Means you moderately disagree with the statement.
3 = Means you slightly disagree with the statement.
4 = Means you neither agree nor disagree with the statement.
5 = Means you slightly agree with the statement.
6 = Means you moderately agree with the statement.
7 = Means you strongly agree with the statement.

11. This organization places great emphasis on integrated logistics support during systems development and acquisition.

12. This organization selects only experienced, qualified individuals to work as logistics managers.

13. This center provides excellent guidance, particularly written guidance, for developing logistics support requirements.

14. My immediate supervisor understands my job.

15. No changes are necessary in this organization in the management approach to acquisition logistics.

16. I have the authority necessary to do my job.

17. Logistics planning is crucial to the success of current and future NASA programs.

18. The logistics posture of NASA has improved compared to when I joined the organization.

19. NASA routinely offers training and/or professional development courses in logistics.

PART III

PROGRAM INFORMATION

Listed below are a series of statements that represent beliefs that individuals might have about the program(s) they work. Use the following rating scale to indicate your own beliefs about the particular program(s) you are now working.

1 = Means you strongly disagree with the statement.
2 = Means you moderately disagree with the statement.
3 = Means you slightly disagree with the statement.
4 = Means you neither agree nor disagree with the statement.
5 = Means you slightly agree with the statement.
6 = Means you moderately agree with the statement.
7 = Means you strongly agree with the statement.

20. I am directly involved in planning Integrated Logistics Support (ILS) for NASA.

21. I am directly involved in executing ILS for NASA.

22. Existing NASA Management Instructions (NMIs) provide adequate guidance for developing program logistics support requirements.

23. The current NASA system for developing program logistics support requirements is effective.

24. Vision 21, the NASA strategic plan, will have a significant and positive impact on the way NASA plans logistics support for future systems.

25. The nine major NASA centers (Goddard, Lewis, Johnson, etc) routinely coordinate logistics support requirements with each other.

26. The centers seem to use varied methods for developing program logistics support requirements.

27. The NASA baseline logistics support concept is designed for "one-time use" systems.

28. The NASA baseline logistics support concept is designed for "reusable" systems.

29. Significant differences exist between the logistics support concepts used for the STS/Shuttle and the SSF Programs.

30. NASA has one person "in charge" of logistics.

31. NASA would benefit from written organization-wide guidance concerning logistics.

32. The NASA logistics system requires change to support long term programs.

33. NASA logistics managers are routinely involved in configuration changes in NASA systems.

34. NASA logistics managers maintain a consistent interface with their customers, relevant to systems logistics matters.

THIS COMPLETES THE SURVEY

WE WOULD LIKE TO EXPRESS OUR APPRECIATION TO YOU FOR TAKING YOUR VALUABLE TIME TO RESPOND. YOUR EFFORTS WILL HELP PROVIDE AN ACCURATE DESCRIPTION OF THE PRESENT LOGISTICS POSTURE WITHIN NASA. AS A REMINDER, TOTAL ANONYMITY WILL BE MAINTAINED REGARDING YOUR ANSWERS.

PLACE THIS SURVEY IN THE STAMPED, SELF-ADDRESSED ENVELOPE PROVIDED AND DROP IT IN THE MAIL BOX.

Appendix B: Survey Responses and Verbatim Comments

The following are the responses and comments from our survey questionnaire. Each question is stated followed by comments and graphical representation of the percentage of participants selecting each answer.

1. Your age?

    1. Less than 25
    2. 26 to 35
    3. 36 to 45
    4. 46 to 55
    5. 56 to 65
    6. More than 65

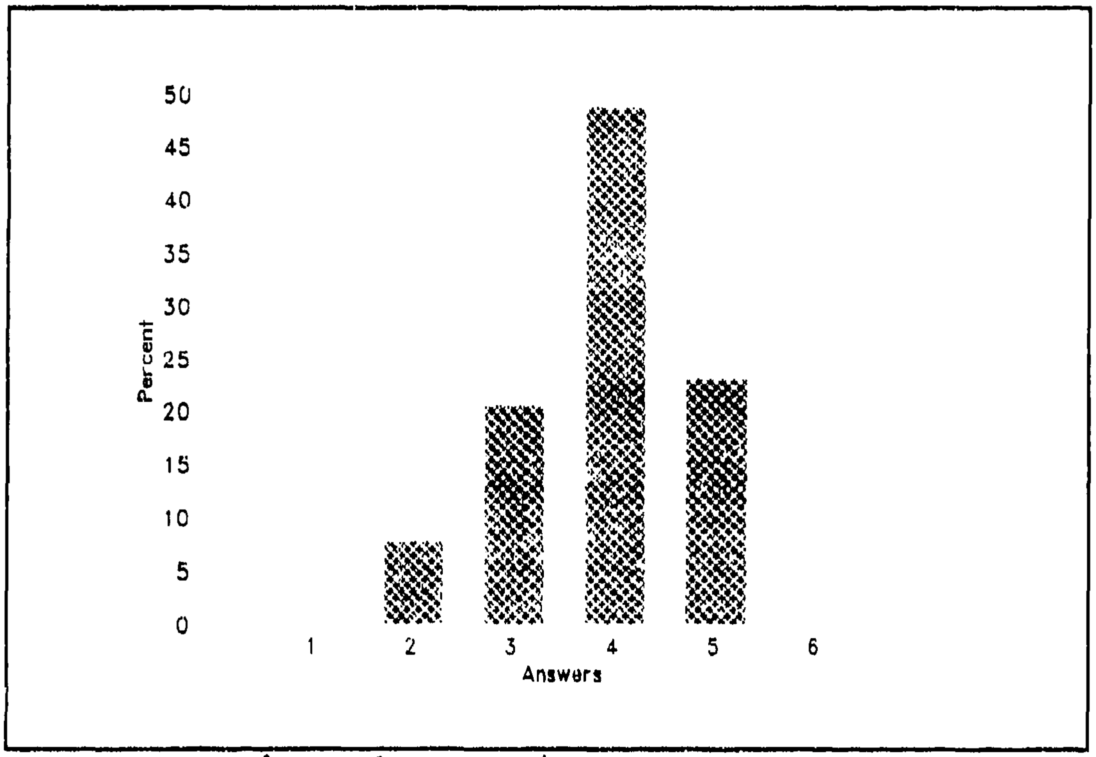

Figure 1. Question One Responses

2. Your area of study for each educational level obtained?

Area of Study?

1. Less than a Bachelor's Degree
2. Bachelor's Degree
3. Some graduate work
4. Master's Degree
5. Doctoral Degree
6. Post-Doctoral Research

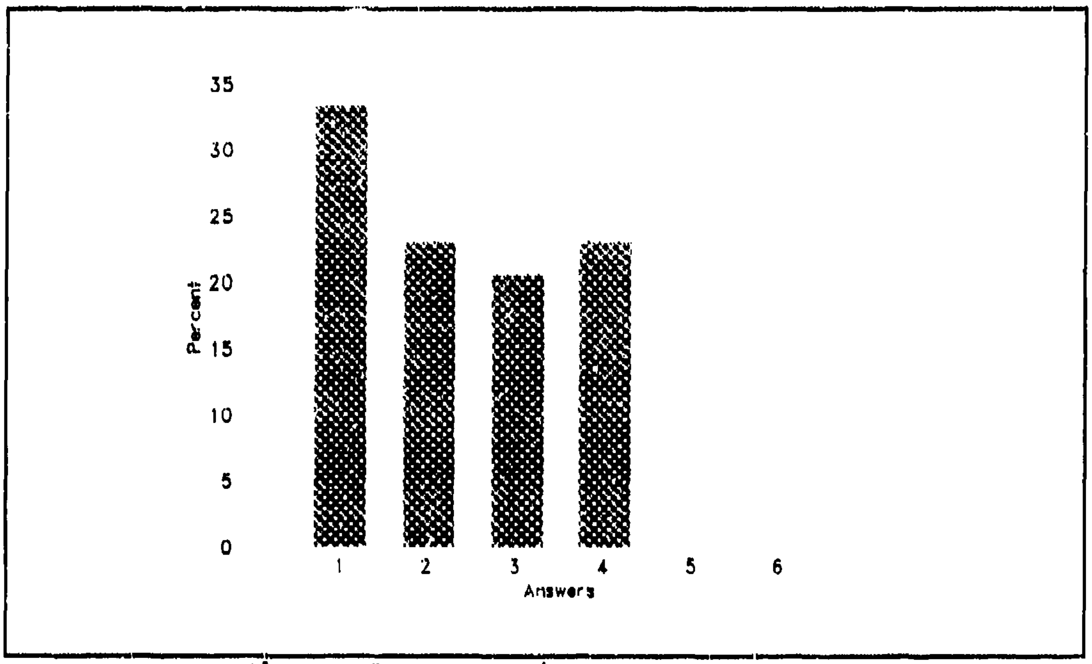

Figure 2. Question Two Responses

3. Total months in this organization?

1. Less than 6 months
2. More than 6 months, less than 12 months
3. More than 12 months, less than 24 months
4. More than 24 months, less than 36 months
5. More than 36 months, less than 48 months
6. More than 48 months.

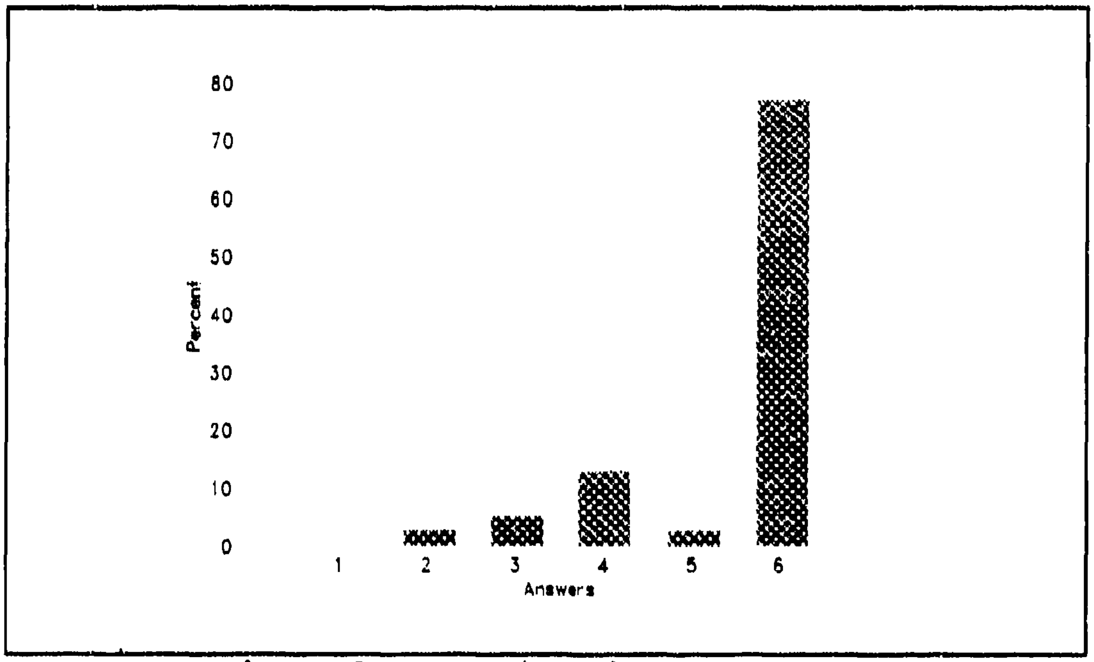

Figure 3. Question Three Responses

4. If your present position is in a logistics/logistics related job with NASA, select from the list below the area most closely associated with that job.

1. Maintenance
2. Packaging, handling & distribution
3. Supply support
4. Design/systems engineering
5. Configuration management
6. Contracting
7. Test & evaluation
8. Training
9. Marketing
10. Quality assurance
11. Research & technology
12. Other (specify)

Comment(s): "All of the above. NASA has a very limited logistics
staff and as such we have to cover the total spectrum of acquisition logistics."

"I'm in a (DELETED) office, so we deal with all of the above."

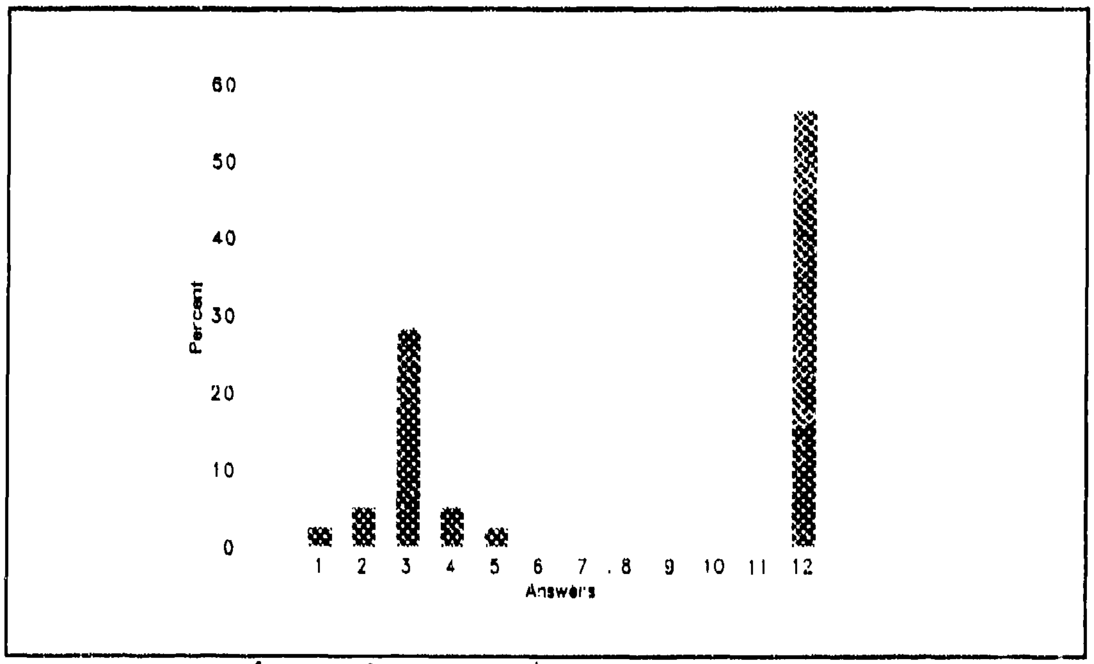

Figure 4. Question Four Responses

5. Total months in your present position?

1. Less than 6 months
2. More than 6 months, less than 12 months
3. More than 12 months, less than 24 months
4. More than 24 months, less than 36 months
5. More than 36 months, less than 48 months
6. More than 48 months

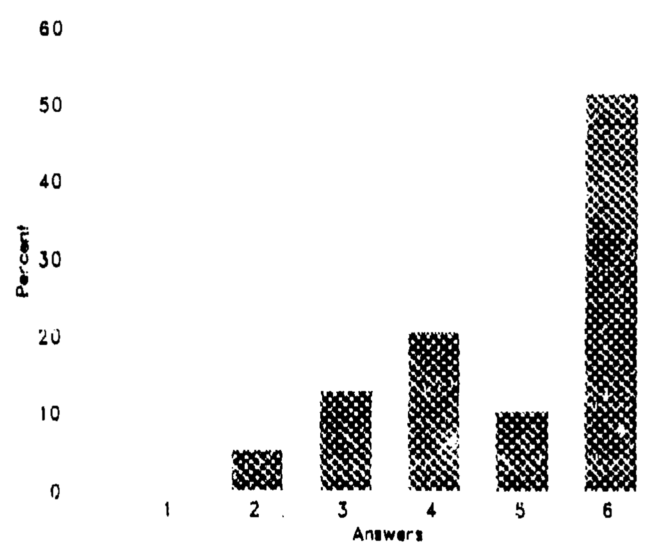

Figure 5. Question Five Responses

6. How would you characterize your job experience related to your present position with NASA?

1. Highly experienced in present position.
2. Somewhat experienced in present position.
3. Neither experienced nor inexperienced.
4. Somewhat inexperienced in present position.
5. Highly inexperienced in present position.

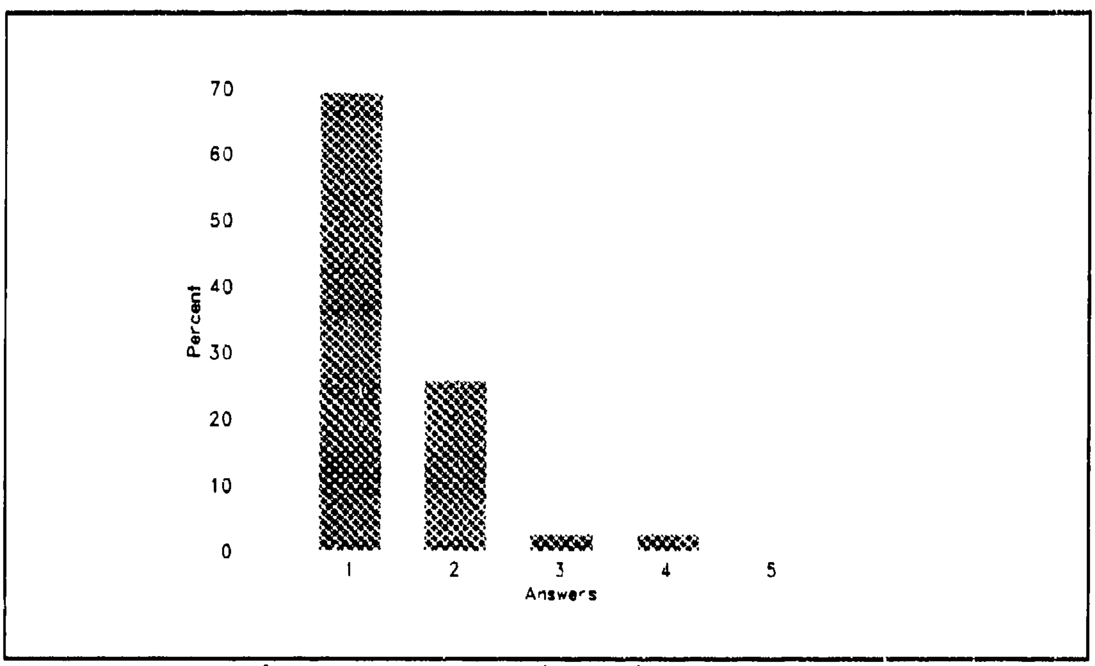

Figure 6. Question Six Responses

7. If your past position was in a logistics/logistics related job (whether or not employed with NASA), select from the list below the area most closely associated with your past position.

1. Maintenance
2. Packaging, handling & distribution
3. Supply support
4. Design/systems engineering
5. Configuration management
6. Contracting
7. Test & evaluation
8. Training
9. Marketing
10. Quality assurance
11. Research & technology
12. Other (specify)

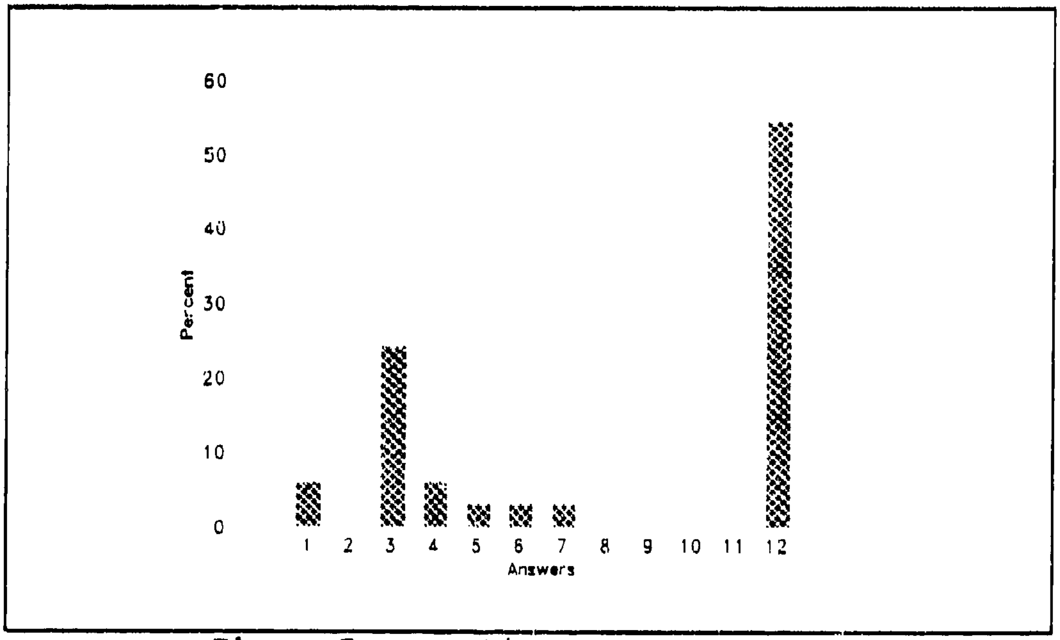

Figure 7. Question Seven Responses

8. How would you characterize your job experience related to your past position with NASA?

1. Highly experienced in past position.
2. Somewhat experienced in past position.
3. Neither experienced nor inexperienced.
4. Somewhat inexperienced in past position.
5. Highly inexperienced in past position.
6. Past position NOT with NASA.

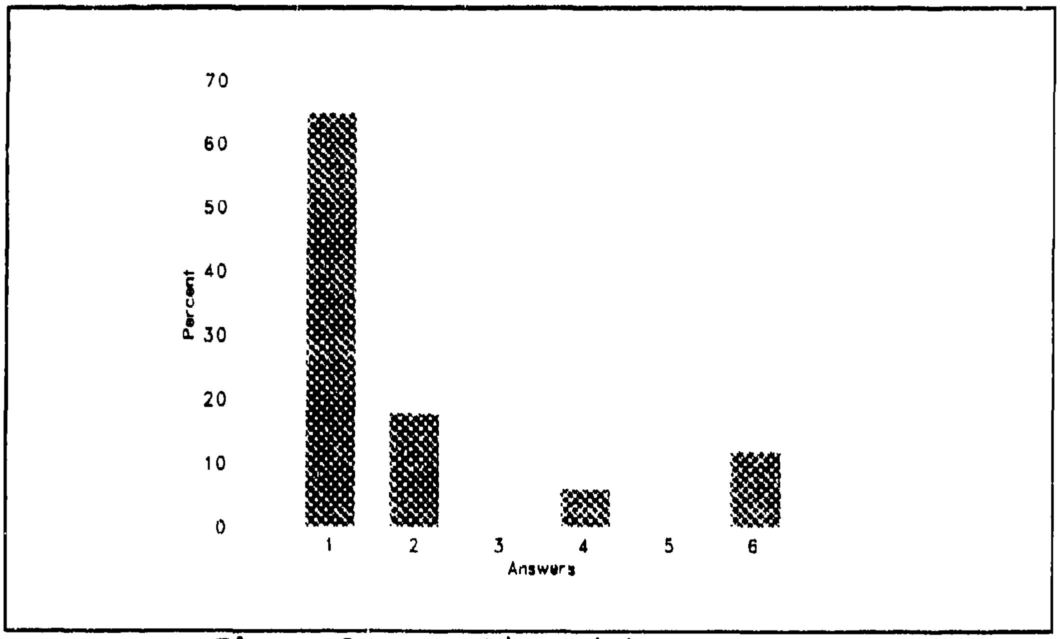

Figure 8. Question Eight Responses

9. I have read the NASA strategic plan titled Vision 21.

1. Yes
2. No

Comment(s): "Vision 21 was not distributed to the staff."

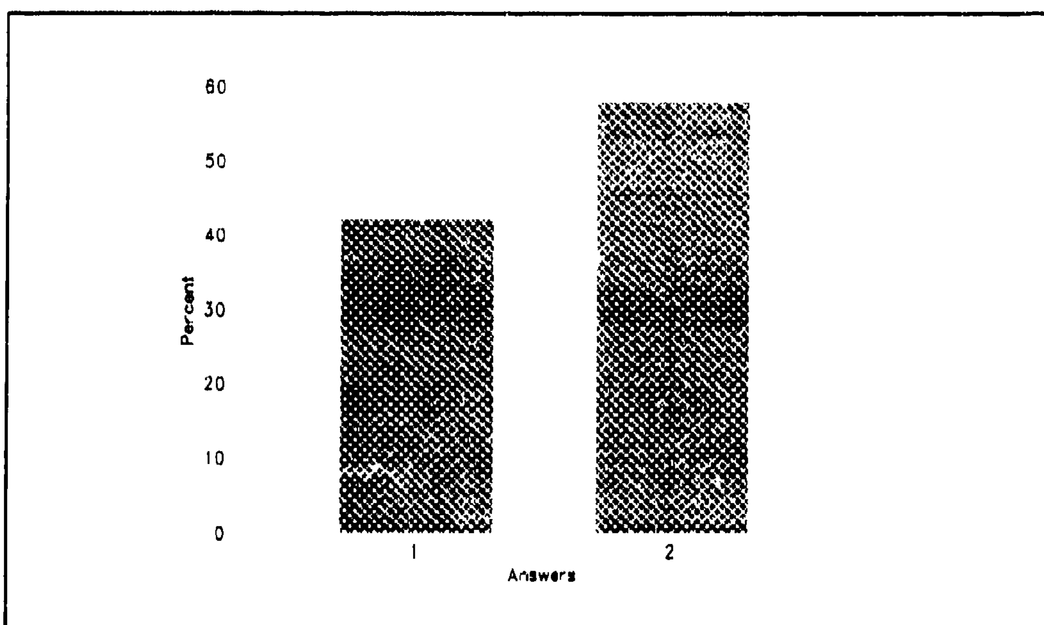

Figure 9. Question Nine Responses

10. In my opinion, the terms Integrated Logistics Support (ILS) and Acquisition Logistics (ACQ LOG) are:

1. Interchangeable
2. Equivalent in practical application
3. ILS is a subset of ACQ LOG
4. ACQ LOG is a subset of ILS
5. Other (specify)
6. Don't know
7. Don't use these terms in my job
8. NASA uses other terms that have similar meaning (specify)

Comment(s): "NASA does not view ILS in the same manner as DOD. To NASA ILS (logistics) is basically supply support (spares). Maintenance is an OPS element, GSE is a processing element (T&V)."

"Everyone within NASA does logistics, starting with the design engineer who defines the acquisition logistics."

"This center does not use the term Acquisition Logistics. However, some modified form of ILS is in effect, which mostly means logistics when we need it."

"ILS is divided between several organizations outside of logistics. In the logistics directorate the function being performed is logistics engineering. Acquisition logistics cuts across two different organizations, procurement and supportability analysis."

"Don't use the term acquisition logistics."

"(DELETED) Space Center definition, in general, is that acquisition logistics deals with identifying and acquiring spares."

"ILS should be cradle to grave."

"These are separate entities. ILS is Program Support Logistics. Am unfamiliar with 'Acquisition Logistics' as defined below."

"Where do you include operating warehouses, shops, transportation, facilities, and buying material? Your definitions fall short, particularly ILS."

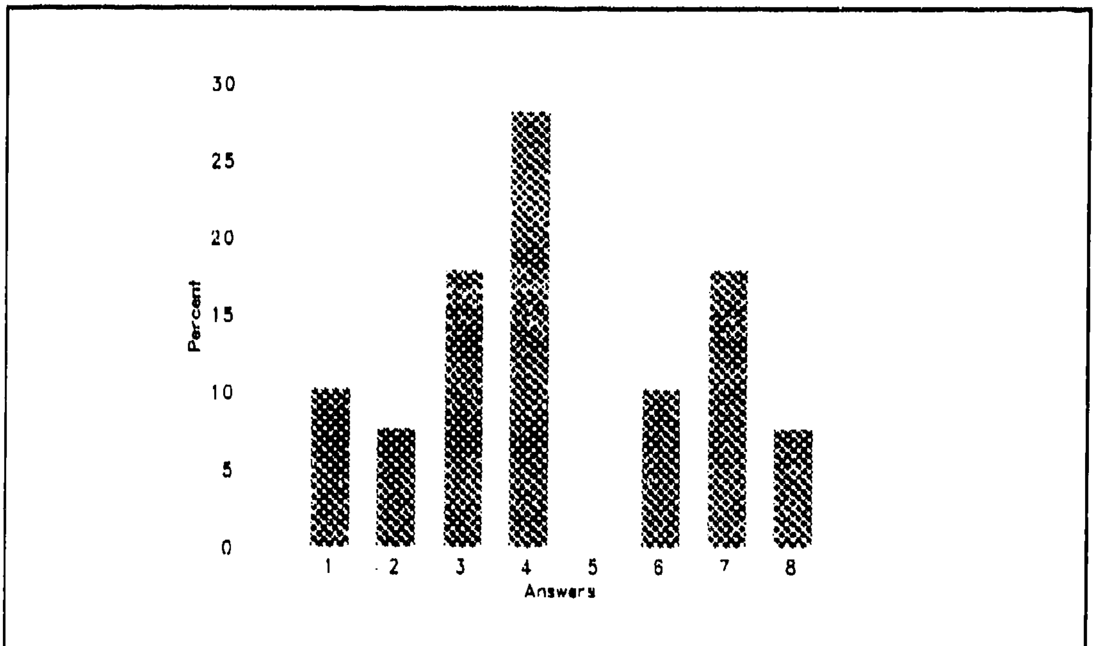

Figure 10. Question Ten Responses

11. This organization places great emphasis on integrated logistics support during systems development and acquisition.

Comment(s): "Organization = NASA."

"Past, NO. Currently growing."

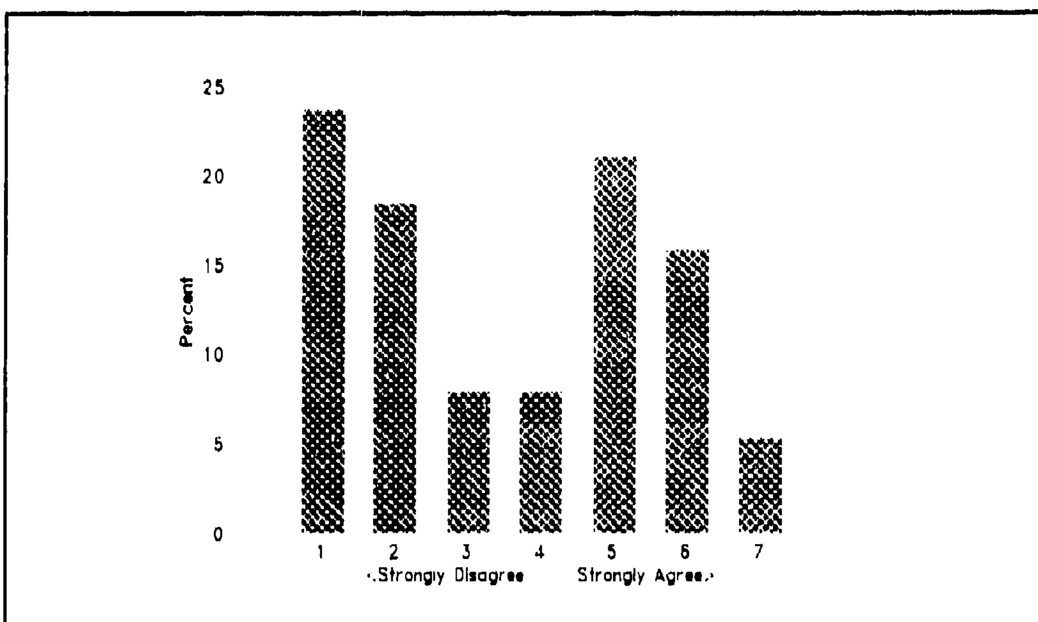

Figure 11. Question Eleven Responses

12. This organization selects only experienced, qualified individuals to work as logistics managers.

Comment(s): "I am taking for granted that a 'logistics manager'
refers to a non-supervisor like myself."

"Better define 'managers', i.e. personnel, supervisors, monitors?"

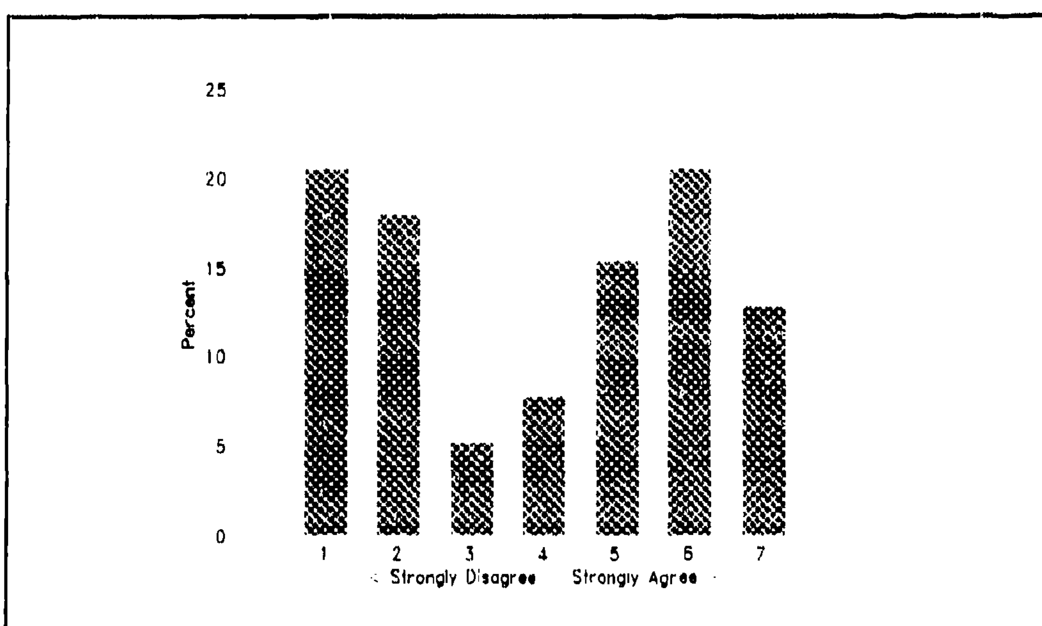

Figure 12. Question Twelve Responses

13. This center provides excellent guidance, particularly written guidance, for developing logistics support requirements.

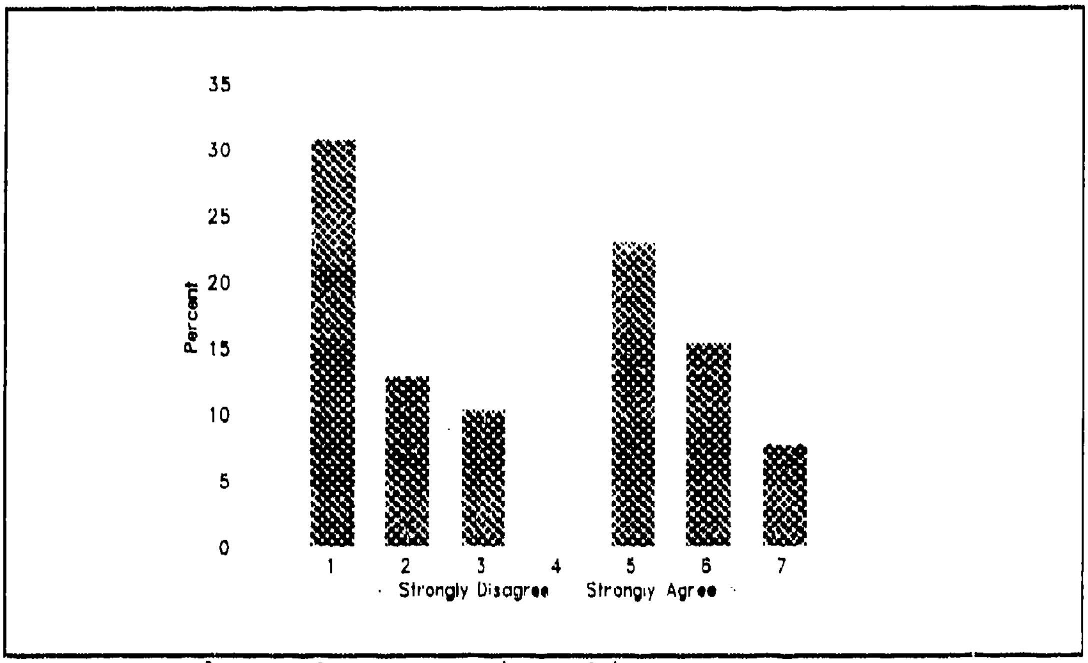

Figure 13. Question Thirteen Responses

14. My immediate supervisor understands my job.

Comment(s): "She attempts to understand and work with us."

"He's not NASA."

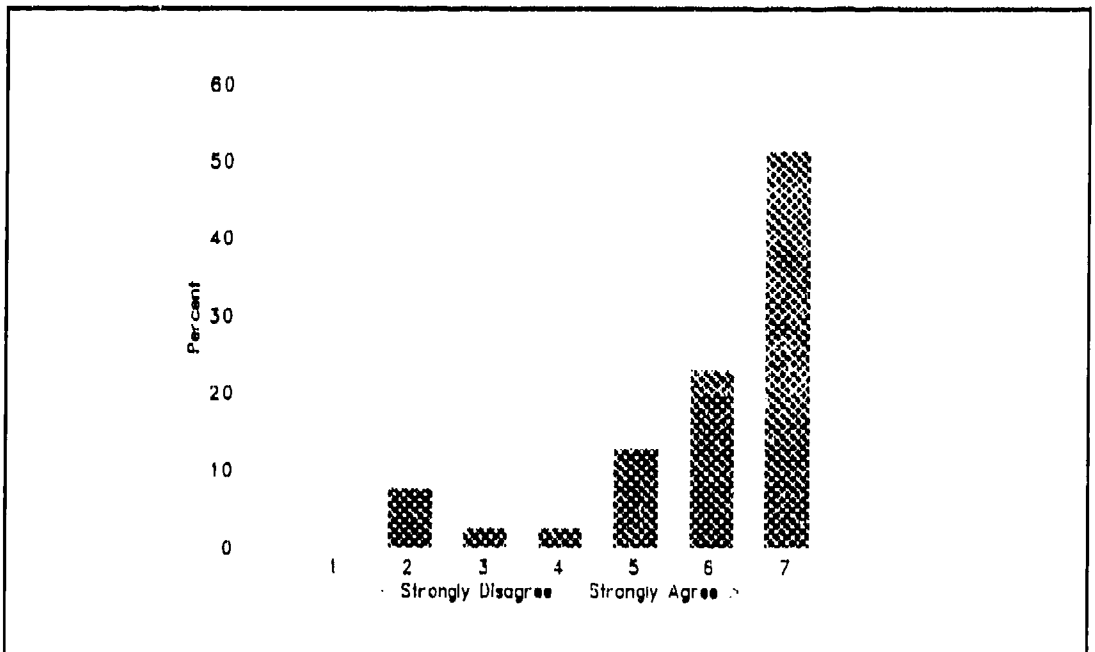

Figure 14. Question Fourteen Responses

15. No changes are necessary in this organization in the management approach to acquisition logistics.

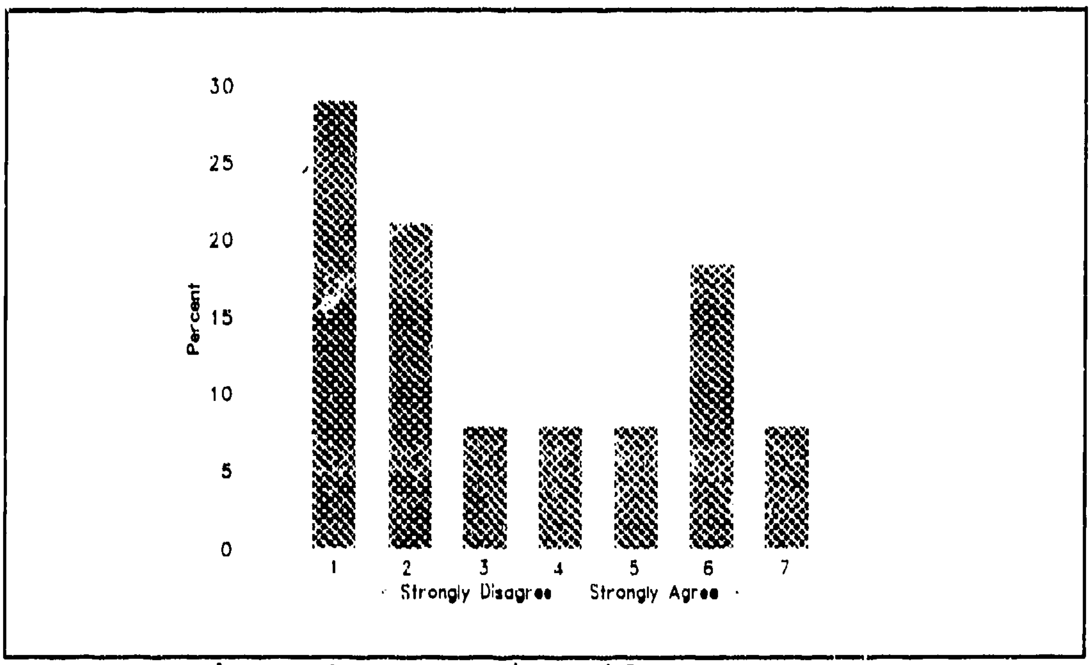

Figure 15. Question Fifteen Responses

16. I have the authority necessary to do my job.

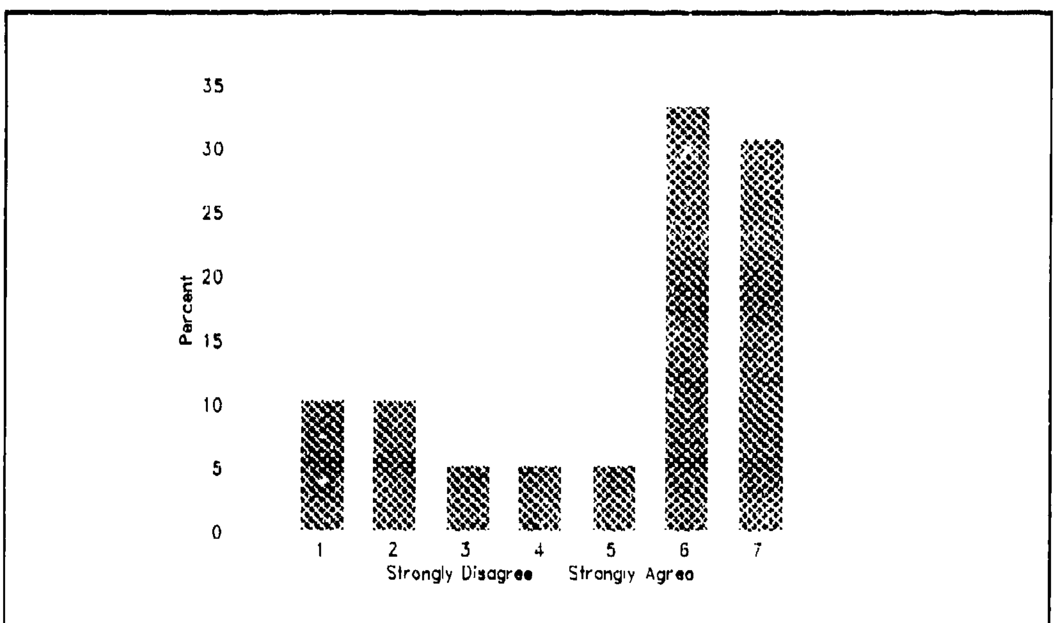

Figure 16. Question Sixteen Responses

17. Logistics planning is crucial to the success of current and future NASA programs.

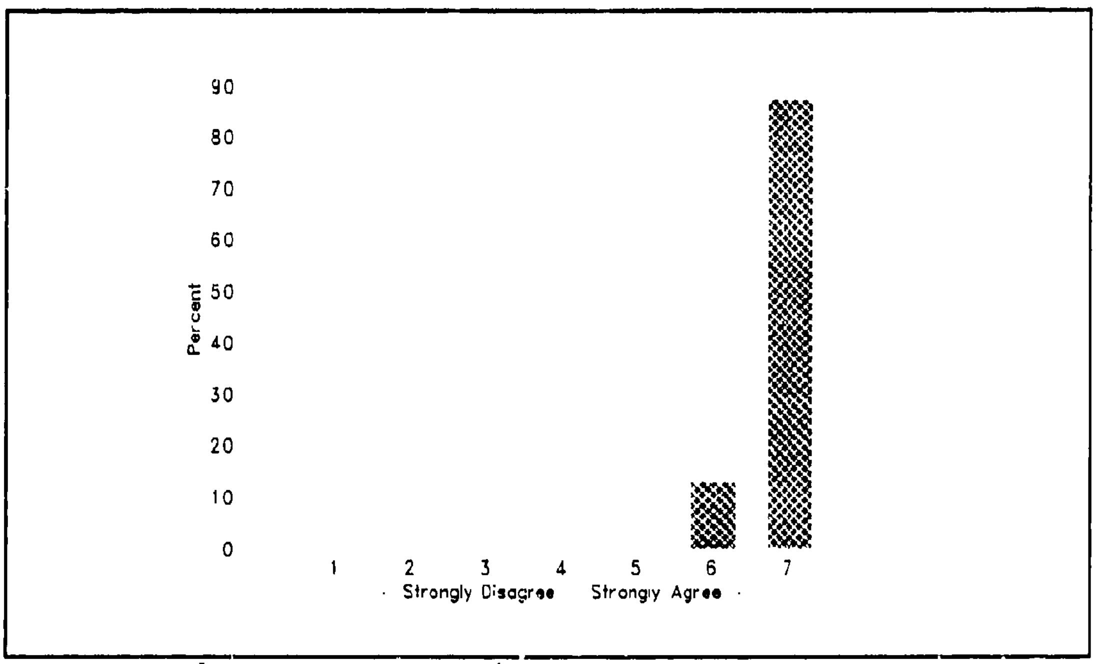

Figure 17. Question Seventeen Responses

18. The logistics posture of NASA has improved compared to when I joined the organization.

Comment(s): "This is a non-descriptive term!"

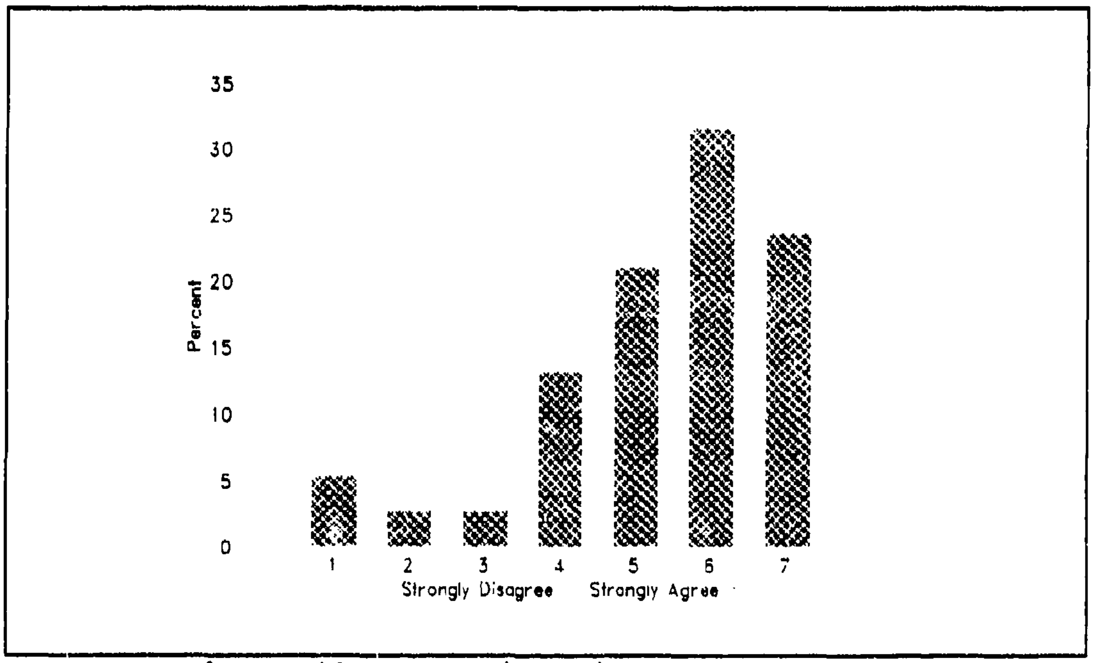

Figure 18. Question Eighteen Responses

19. NASA routinely offers training and/or professional development courses in logistics.

Comment(s): "If the budget is tight, requirements for training are
simply not prioritized."

"Many logistics courses are taken through GSA."

"The training is available, but we have not availed ourselves of it. The need has not been apparent."

"NASA training is available, not mandated or advertised."

"Support such training from outside sources with funds."

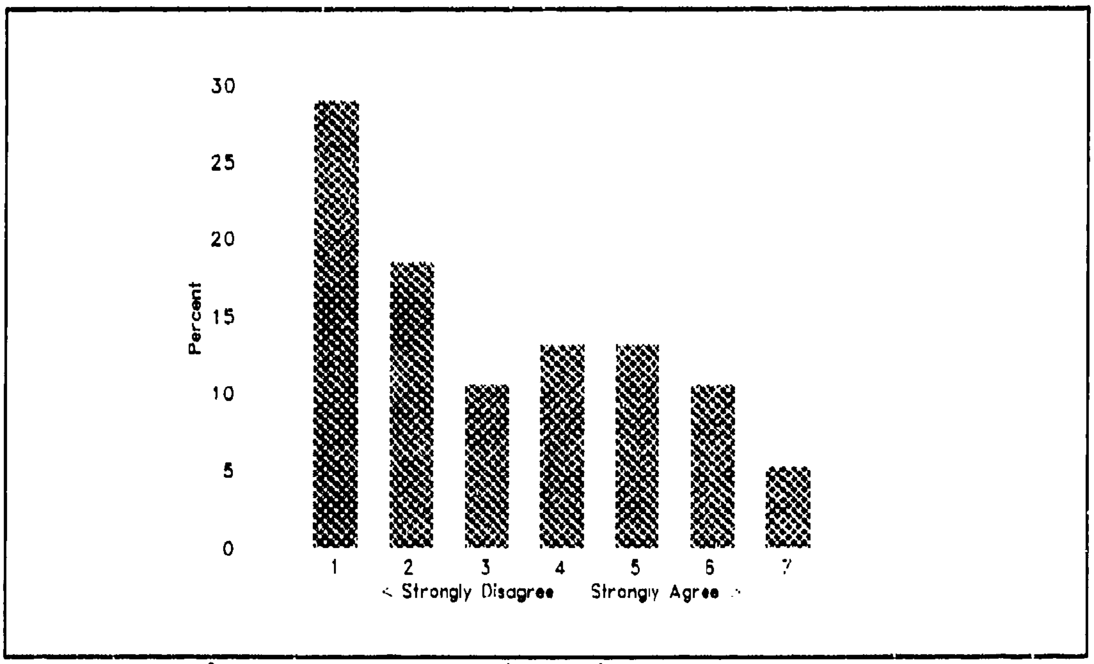

Figure 19. Question Nineteen Responses

20. I am directly involved in planning Integrated Logistics Support (ILS) for NASA.

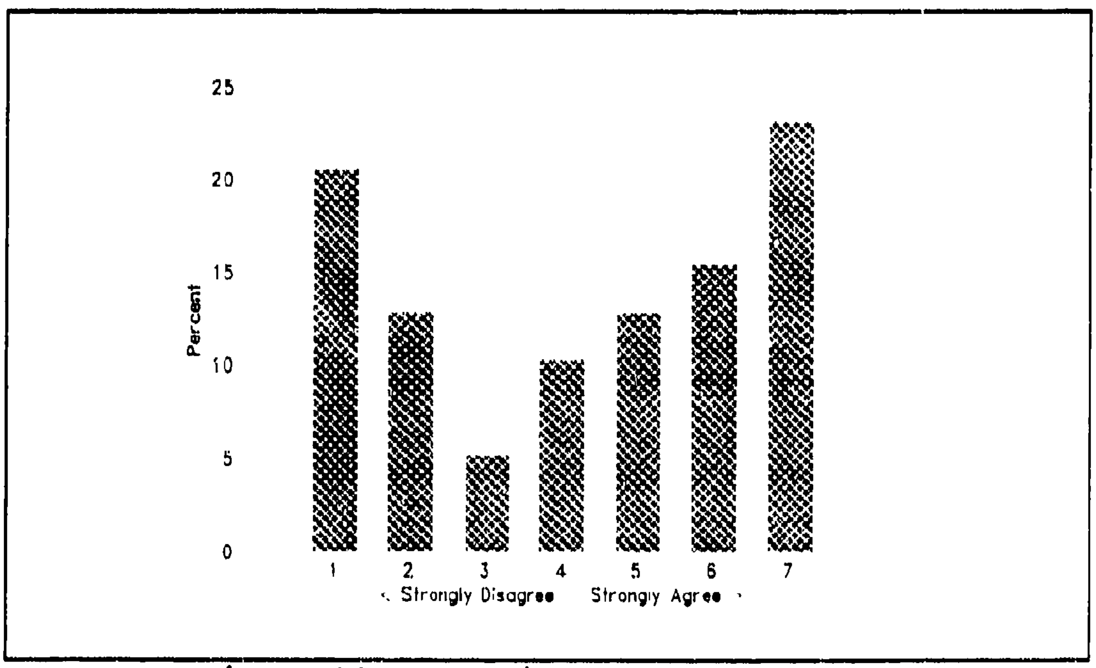

Figure 20. Question Twenty Responses

21. I am directly involved in executing ILS for NASA.

Comment(s): "Involved in a portion of the life-cycle."

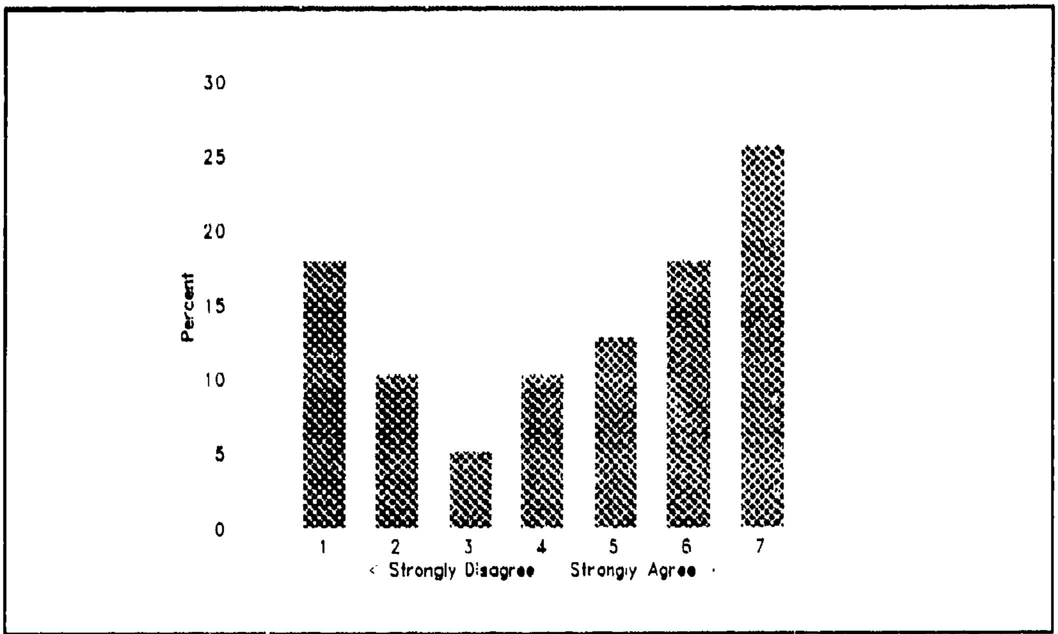

Figure 21. Question Twenty-One Responses

22. Existing NASA Management Instructions (NMIs) provide adequate guidance for developing program logistics support requirements.

Comment(s): "However, they (NMIs) are not adhered to."

"NMIs are NOT program requirement documents."

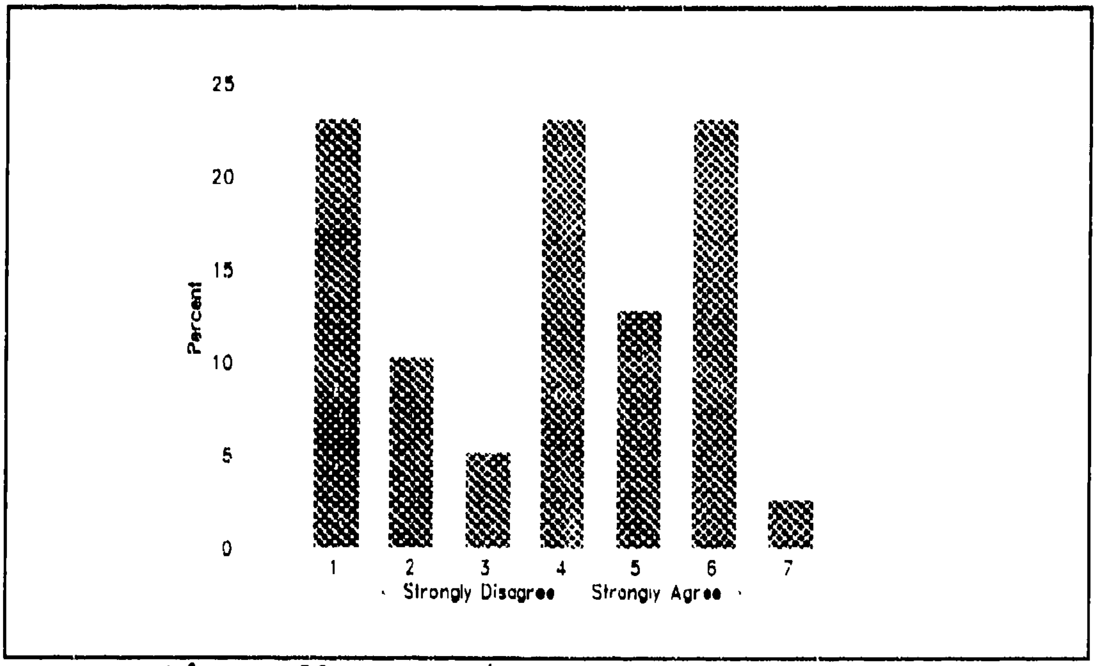

Figure 22. Question Twenty-Two Responses

23. The current NASA system for developing program logistics support requirements is effective.

Comment(s): "Unknown."

"The cart is still leading the horse, and NASA is still asking the contractor 'What do we want?'"

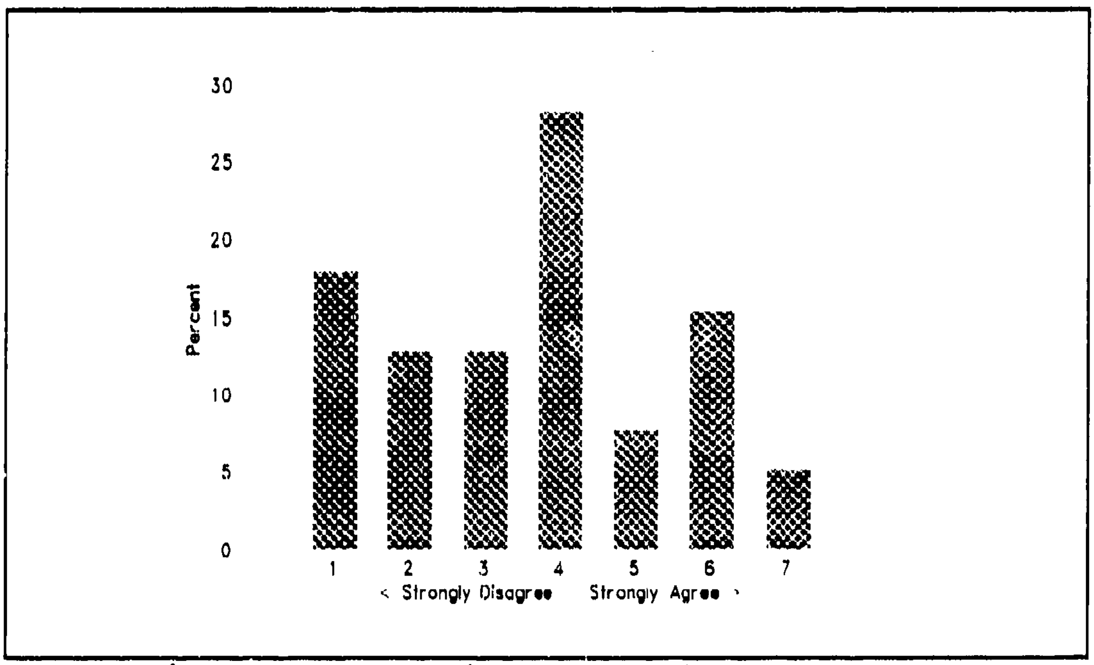

Figure 23. Question Twenty-Three Responses

24. Vision 21, the NASA strategic plan, will have a significant and positive impact on the way NASA plans logistics support for future systems.

Comment(s): "They rarely do. Great ideas, not enough $ or people."

"Unknown since I didn't read this."

"Show me."

"Don't know - have not read plan."

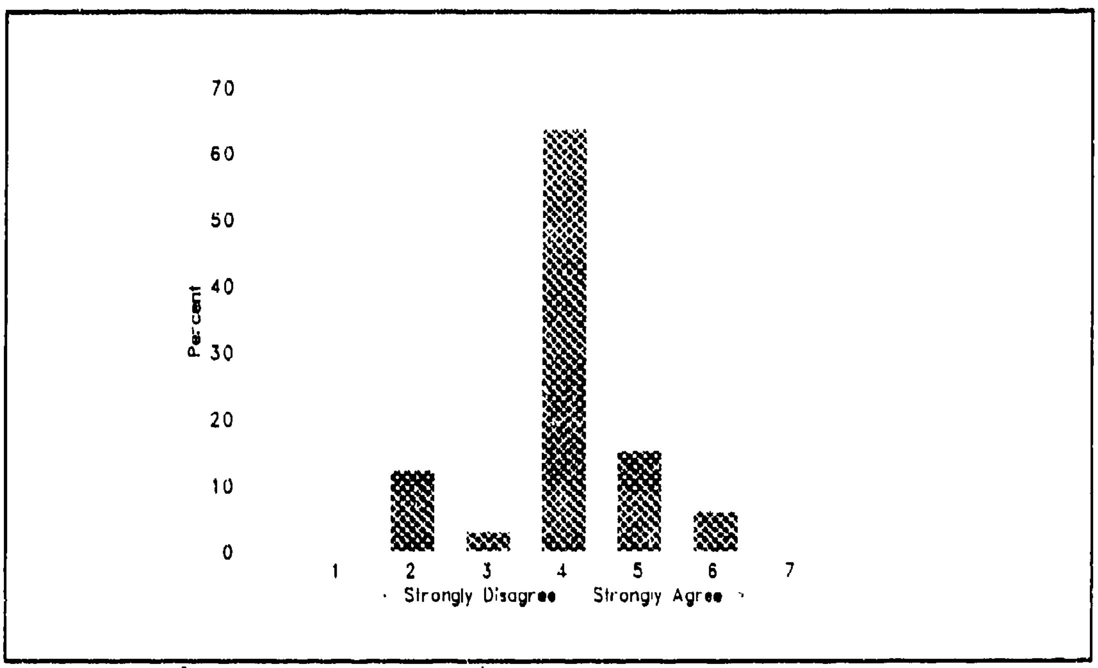

Figure 24. Question Twenty-Four Responses

25. The nine major NASA centers (Goddard, Lewis, Johnson, etc) routinely coordinate logistics support requirements with each other.

Comment(s): "Operate independently."

"Usually through HDQs NASA-wide programs. Sometimes directly with another center."

"Except for (DELETED) Program."

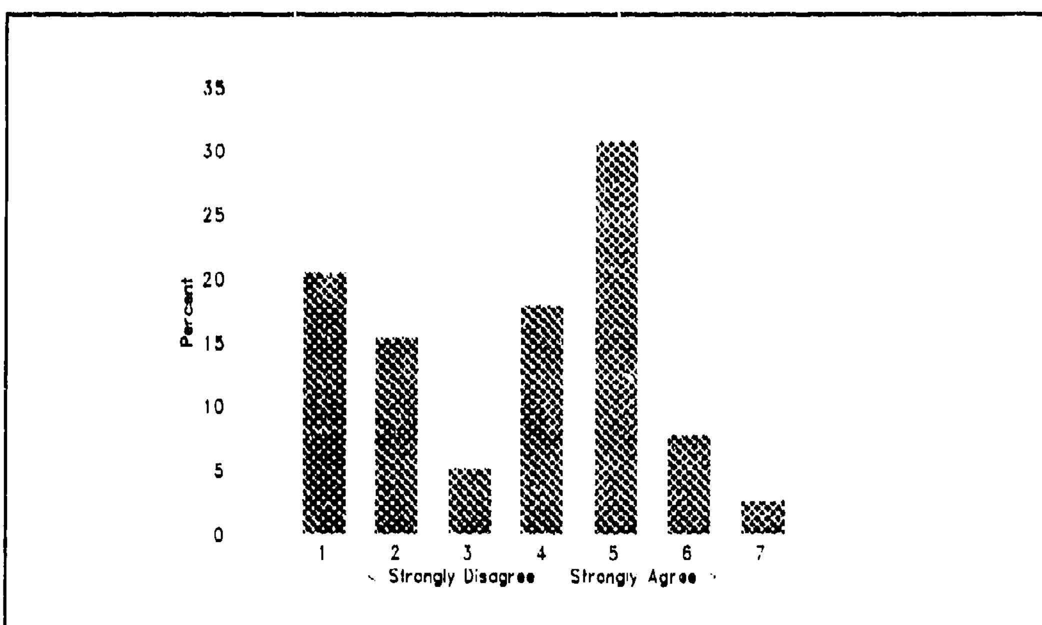

Figure 25. Question Twenty-Five Responses

26. The centers seem to use varied methods for developing program logistics support requirements.

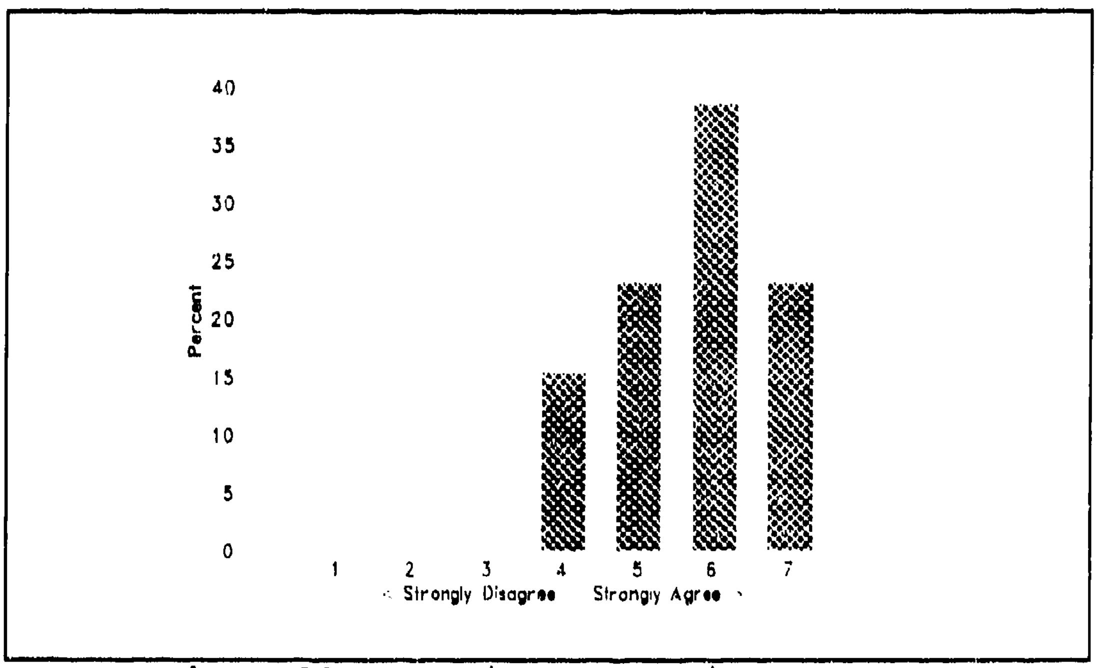

Figure 26. Question Twenty-Six Responses

27. The NASA baseline logistics support concept is designed for "one-time use" systems.

Comment(s): "27 and 28 are confusing, the answer would depend on
your own position."

"NASA initial logistics support is to support launch processing 'one-time' process. Each project was a total new effort."

"There is no such animal (NASA baseline logistics support concept)."

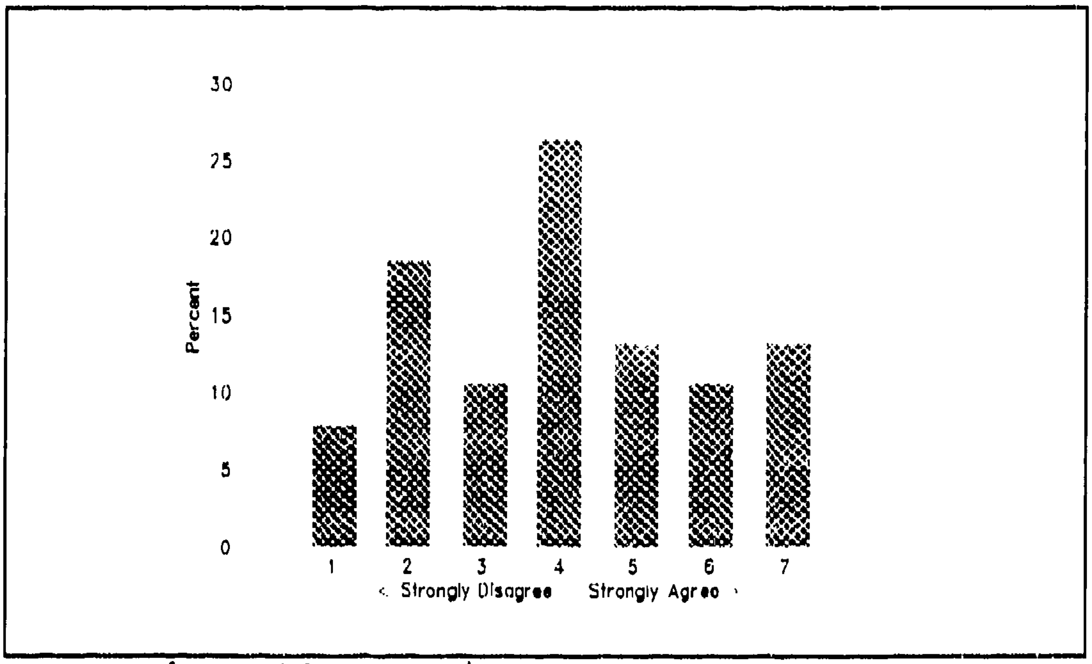

Figure 27. Question Twenty-Seven Responses

28. The NASA baseline logistics support concept is designed for "reusable" systems.

Comment(s): "NASA is just in the process in defining what is required to support a reusable system. There was no planned logistics program, this is all new to them. They rely on contractor expertise for logistics."

"Baseline depends on the program."

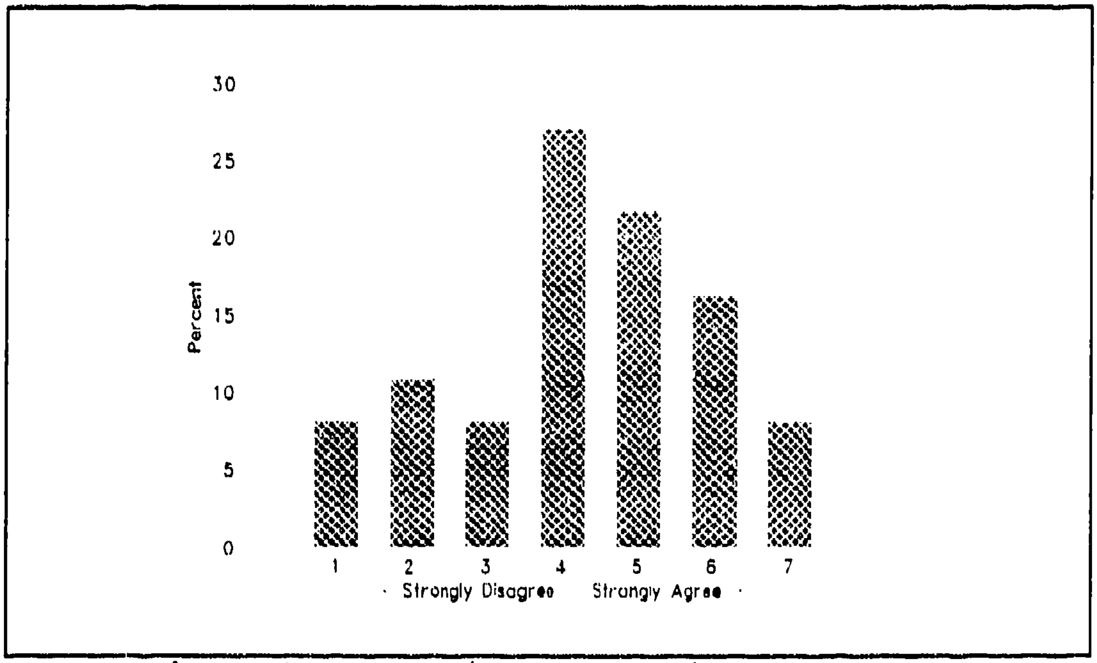

Figure 28. Question Twenty-Eight Responses

29. Significant differences exist between the logistics support concepts used for the STS/Shuttle and the SSF Programs.

Comment(s): "Don't know what SSF means."

"And are necessary because of their nature."

"The concepts are coming together. Space Transportation System logistics were cut and had to be worked after the fact. Space Station Freedom appears to be headed in the same direction."

"Don't know the terms."

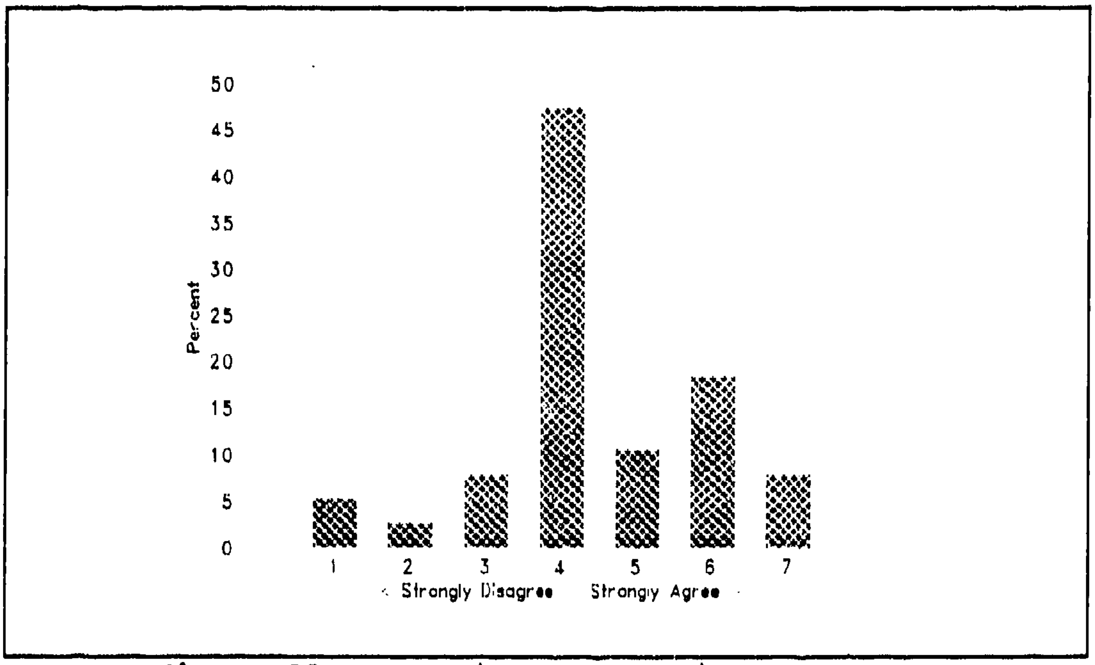

Figure 29. Question Twenty-Nine Responses

30. NASA has one person "in charge" of logistics.

Comments: "Logistics are performed by a whole organization of personnel, both civil servant and contractors at a variety of supervisory and non-supervisory levels."

"Depends on how you interpret 'in charge'."

"For all programs this will not work - for one program it might work!"

"The meaning of 'Logistics', 'ILS' etc are confused here. 'Logistics in the Center Operations Directorate are separate from Program Support Logistics. I feel these questions cannot give you a valid meaningful picture until the above is clearly defined in relationship to the question."

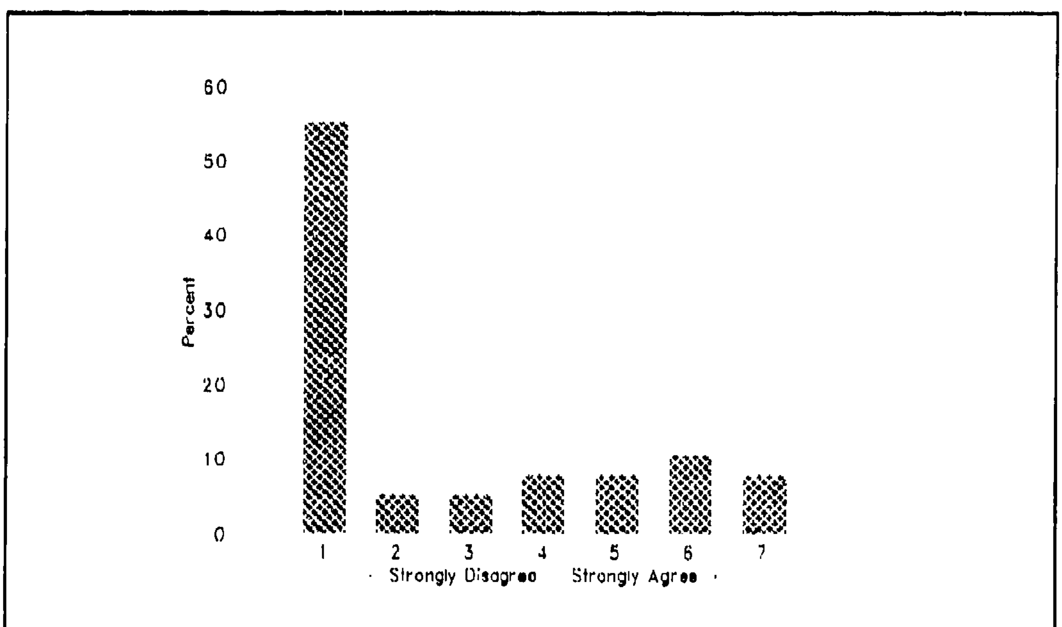

Figure 30. Question Thirty Responses

31. NASA would benefit from written organization-wide guidance concerning logistics.

Comment(s): "I feel this already exists."

"And related organizations."

"The centers all too often function as though they're autonomous."

"As stated above, this cannot provide an accurate picture."

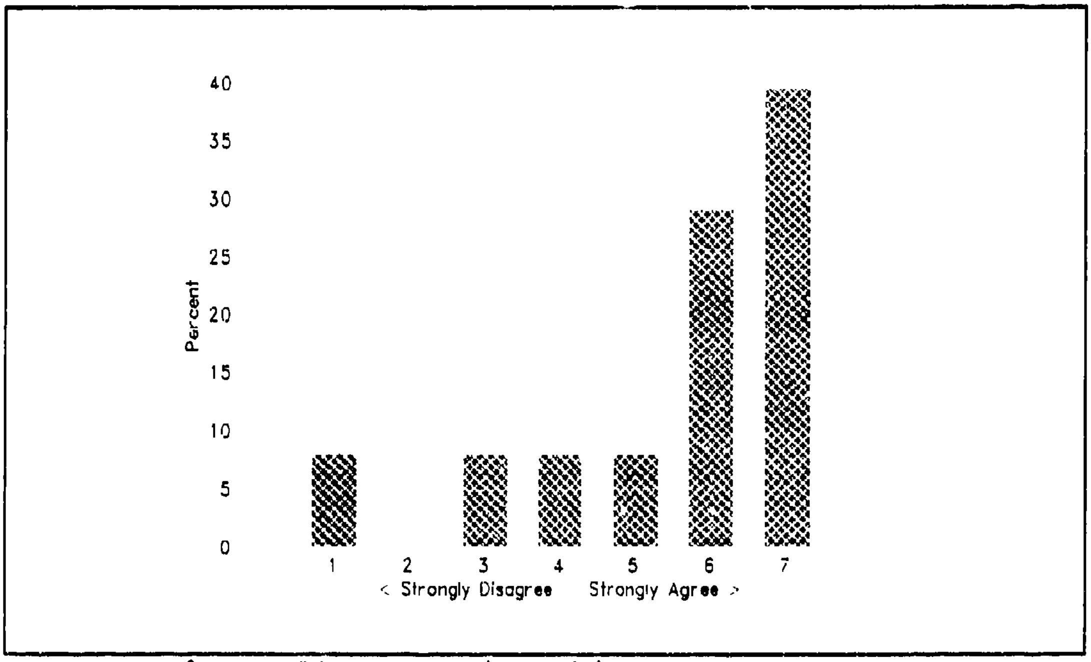

Figure 31. Question Thirty-One Responses

32. The NASA logistics system requires change to support long term programs.

Comment(s). "We need more money allocated, to properly meet the needs of our customers in a quicker fashion."

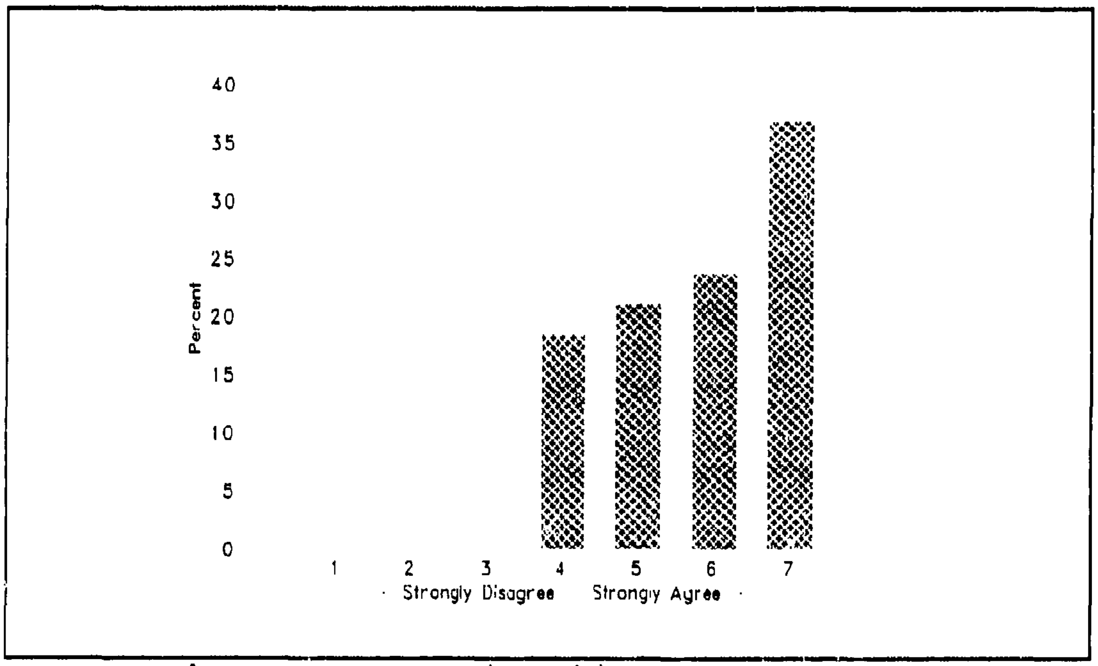

Figure 32. Question Thirty-Two Responses

33. NASA logistics managers are routinely involved in configuration changes in NASA systems.

Comment(s): "Program?"

"We are informed. We do advise."

"On our contract."

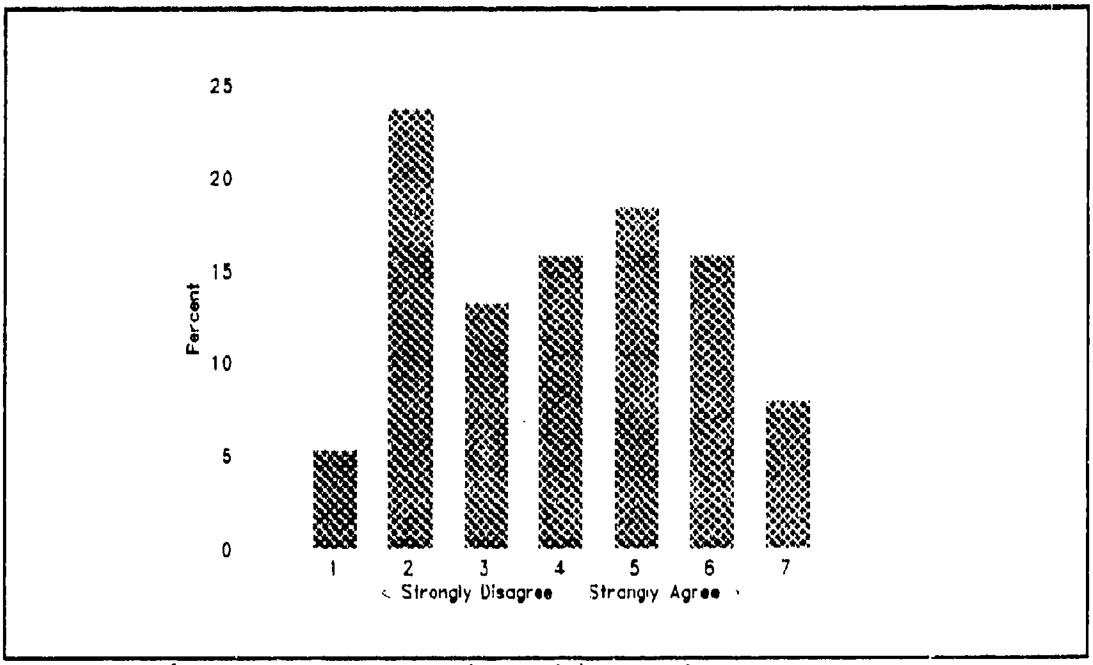

Figure 33. Question Thirty-Three Responses

34. NASA logistics managers maintain a consistent interface with their customers, relevant to systems logistics matters.

Comment(s): "NASA sometimes has a problem identifying who their
real customers are."

"NASA does not have logistics managers. This function is embedded in engineering as a general rule!"

"On our contract."

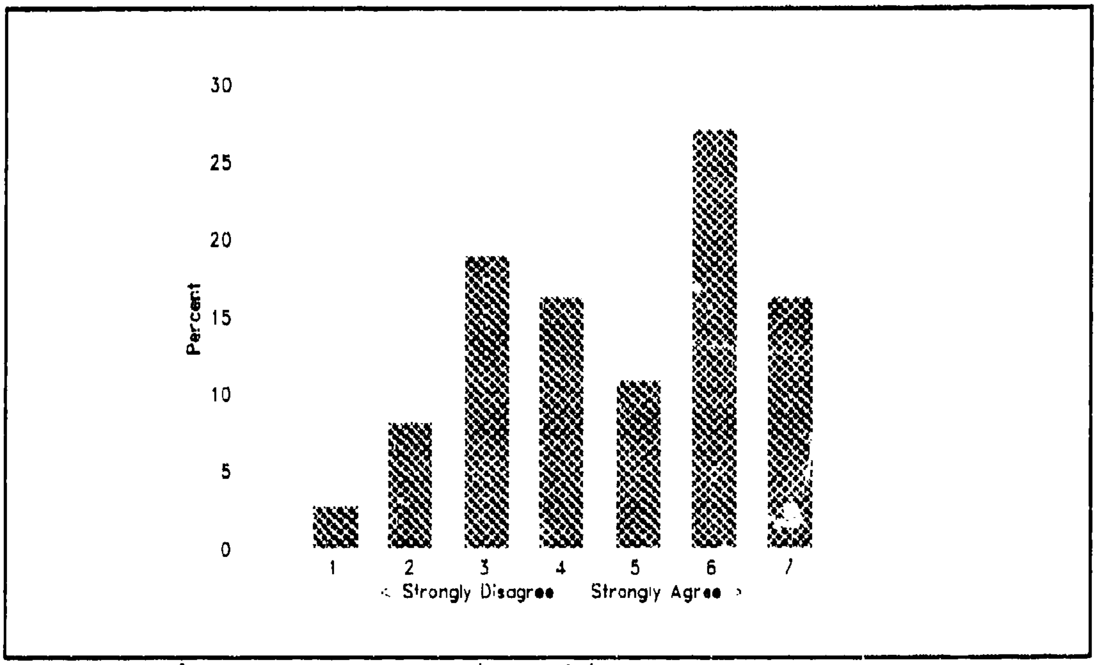

Figure 34. Question Thirty-Four Responses

Appendix C: Unstructured Interview Comments Applicable to IQ 2

Interviewee 5.

-- NASA is reluctant to make changes that smell DOD.

-- It is difficult for logistics to influence a program.

-- "Logistics is the most misunderstood word in the world. If you haven't done your logistics you haven't done your engineering."

-- Needs must be tailored to the budget, the mission, and the life of the program.

-- Our engineers say logistics is "gold plating" -- they cannot see designing for supportability.

-- Our engineers are being trained by the old engineers who are operating under the assumption that because they were successful with Apollo that they were doing everything right. They can still improve. Our new engineers need to understand logistics.

-- Endeavour was built from spares. Some special borrowing for Endeavour made the spares pipeline hiccough. The money for Endeavour replaced spares.

-- Each of the shuttles have been changed from their original configuration. The changes have not been in logistics areas. The changes have been operations based. Some have served to improve supportability issues, particularly in terms of reliability.

-- Maintenance and Support is an operations function. Configuration management is system design.

-- Logistics influence is a lobbying effort.

-- Logistics was usually a sideline used to bless activities. [since the people were not trained and logistics was not their primary function, they gave a logistics blessing with having any true logistics impact].

-- Logistics has no formal influence on design.

-- Everyone has heard the horror stories of Shuttle maintenance. We have had to cut through bulkheads to change out parts.

-- Logistics makes it a point of getting involved -- "If I don't catch as catch can, It don't get caught." Some things are left until they surface naturally, some things are never worried about.

-- Fenced dollars and centralized functions for the shuttle are the key to the development of shuttle logistics.

-- It would be good for NASA to gain the organic capability to do ILS as the budget decreases. We depend totally on contractor support.

-- NASA should be state of the art in everything it does. We have come a long way but we are not keeping up the state of the art logistics systems.

-- Management doors in NASA are closed more than they used to be. Now there are two extra layers. We were more effective when we were smaller.

-- Money does get earmarked for programs.

-- Engineers with additional duties of logistics don't necessarily have logistics as a priority.

Interviewee 8.

-- SSF being funded from existing funds. All other programs are giving to SSF. 30% reduction in STS operating budget.

-- Discussions of changing organizational structure in NASA stated to be career limiting. Changes are not needed.

-- KSC fixes what the other centers didn't do right. Some things show up not completed or tested. The shuttle came with two tractor trailers of paper.

-- The STS had an ILS plan based on 4100.35M (AF document). It was a level two requirements document. There were some impacts on design. There was a clause that designs were not closed until American Airlines, Who had the maintenance contract, signed off.
The maintenance contract was cut.

Interviewee 13.

-- The maintenance contract on the shuttle requires the contractor to go through a certification process. We must develop the capability or manage the repair/contract of every piece of all four shuttles. To do this we must go to the original vendor for whatever information exists. If

NASA had required the original vendors to have standardized tech data and drawings, the task would be much easier. We have problems because some of the OEMs (original equipment manufacturer) don't exist any more, some of the proprietary issues weren't settled, some of the data that does exist doesn't allow us to recreate what originally worked. As a result we sometimes have to reverse engineer.

-- We film our training because some of the repairs do not turn up frequently.

Interviewee 14.

-- We are keeping a data base of every part on every shuttle.

-- We work two shifts 60 hours a week.

-- Our technicians have at least an Associates degree. Many are engineers.

Appendix D: Unstructured Interview Comments Applicable to IQ 3

Interviewee 1.

-- SSF is being done like it is [4 work packages (WP) and no lead center] because of 51L. The operators need more of a hand -- The diversity of the tasks requires that they be farmed out to the centers with the expertise.

-- The Phillips report sent SSF back to the Drawing board. The study showed that the previous design required an unrealistic amount of EVA [extra vehicular activity = space walking] for construction.

-- Three to four years into the program and requirements are finally showing up.

-- The corporate culture of NASA is such that supportability is left until after R & D. The feeling is that there is no need for supportability if the program or system won't be funded.

-- Logistics personnel in NASA are often "other duties assigned"-- engineers with an additional duty called logistics -- training is not often provided.

-- 346's [designator for logistician] are only used on the institutional level.

-- Shuttle bay fit is not part of SSF Design.

-- LSA is not part of design. Design has little ILS.

-- LSA was not implemented correctly. The analysis was skipped and data bases were created.

-- SSF is being developed with no definition of tasking.

-- Because of budget constraints, each center was tasked with doing their own hardware -- each center designs, builds, and will support.

Interviewee 2.

-- Logistics [in NASA] means spares - something you get after the system is developed.

-- Money was given to implement ILS. After the ILS program was set the budget was cut and the ILS book was given to engineering.

-- I am blind to budget decisions but frustrated by the limitations imposed by it. [response to the question of who or what level was cutting the specific pieces of the program]

-- ILS may not be a cost effective idea in the space program because of the limited number of production items and the cost of spares.

Interviewees 3. [4 people].

-- NASA is not efficient but are effective. When the time comes to "throw a launch," the army is assembled and things get taken care of.

-- There is no uniform understanding of Logistics in NASA.

-- Logistics implementation is just lip service. The names are there but there is no real credible effort to make it work. Then as the effort fails the higher ups have justified not doing more of it. The direction is not "to do" but "to try" -- the result is that it fails.

-- New initiatives have logistics and support figured in from the concept phase.

-- Budget process may not support true acquisition logistics. Won't be able to get the program funded if the Acq cost is ILS.

Interviewee 4.

-- The change in NASA logistics from STS to SSF only be buzzwords. Designers are over cost, behind schedule, and overweight -- logistics is just another complication.

-- A proposal was made to purchase lightweight tools. It was cancelled by someone in the chain -- not the program. The proposal would have saved money in the launch phase and paid for the purchase. [the implication was that someone is not interested in thinking life cycle cost -- get the system fielded by minimizing front end costs]

-- There are still some engineers who don't know what ILS is.

-- There was a congressional requirement to add ILS.

-- Contractors know ILS because of their interface with the DOD. The contractors believe in it and use it but NASA doesn't know what to do with it. NASA has to contract to get someone to read and understand what their contracts require.

-- Logistics is often "other assigned duties."

-- ILS and LSA cut for all manned systems hardware.

-- Program manager makes budget cuts.

-- NASA part of HUD -- money is earmarked before it gets to the center.

-- Shuttle is ongoing R&D nothing is set.

-- Astronauts have been pushing for accessibility and maintainability.

-- Logistics should be in the systems engineering process.

-- NASA structure doesn't support the ILS process.

-- NASA's organic capacity in logistics is limited.

-- The ILS package for manned system hardware for SSF created by Lockheed.

-- A contractor reviews the paperwork submitted to NASA. ILS was mandated by congress. The contractors are familiar with it and are doing ILS but NASA doesn't know what to do with it.

-- Level II does international coordination.

-- LSA not required for Internationals.

-- Parochialism exists and really drives the costs up.

-- The critical design review for Maintenance Equipment that is supposed to be integrated onto benches is before that of the benches.

<u>Interviewee 6</u>. 3 people.

-- Commonality scrubbed by budget. Logistics is something that can be done later. "get the rubber on the ramp."

-- Maintenance scrubbed, paper tech data scrubbed. Depot level is not done so the item becomes sole source because no one else can fix the item.

-- MOD astronaut core/users will integrate T.O.'s taking data from each work package.

-- Everything is scheduled maintenance.

-- No maintenance data collection in LIS to track failures. Will have to be done by sifting through data.

-- MOD tracks hardware on orbit -- orbiting time, actuations, inventory, etc.

-- Spares money not available till 95.

-- Spares will be produced lead time prior to MTBF -- this means that some things will be broken before spares can be purchased.

-- Logistics means spares.

-- On orbit maintenance = MOD.

-- Training is an operations function and is being done but maintenance tasks are being learned real time instead of planned.
Time spent on MX tasks small compared to the other tasks.

-- In the DOD the user defines what is needed and the infrastructure supports the input of needs and design requirements.
NASA is trying to implement a logistics program without the infrastructure to support it -- therefore they must rely on contractors.

-- NASA's philosophy is to let the contractor make a proposal and for NASA to say yes or no. (as opposed to NASA deciding what they want.

-- The AF people were taken on to help but are buried in work and in their ability to carry out their charter.

-- AF people have answers to a question that NASA hasn't asked.

-- Cuts made early in the program translate to higher costs downstream.

-- When only one system is developed and produced it is more expensive for that one piece. It is likely that some of the contractors capabilities will disappear before the end of the life of the system.

-- Ship and shoot mentality is still prevalent.

-- NASA is moving into a new world but they don't have the infrastructure to support the demands.

-- The lack of control from level two to three is partly due to the fact that the money doesn't flow through level 2.

-- Not having money up front is somewhat akin to having a long mortgage. If you don't have the money upfront you end up paying more in the long run.

-- Yearly budget process is a constraint.

-- Some of the break out of the systems is intentional to hide the true total costs of the system to avoid sticker shock.

Interviewee 7. Two people.

-- To NASA Logistics and Maintenance are Cats and dogs. Logistics does not equal maintenance.

-- NASA works not by planning but uses a standing Army to fix things when something goes wrong. Rely on this technique rather than trying to avoid it. Maintenance to operations support is done real time with whatever it takes.

-- On orbit maintenance for SSF has enhanced the need for front end logistics.

-- Sustaining engineering = MX = operations.

-- There is no formal design review process for logistics. I have been able to effect design by watching what design was doing and lobbying for changes. In one instance I got an astronaut interested in an issue that I felt was really important -- his influence as an astronaut pushed my design change through.

-- Still one shot at a time.

-- Centers are autonomous because of the flow of money.

-- Different missions cloud HQ's ability to provide guidance.

-- In the beginning the lessons of the shuttle program were used but the budgets cuts got them.

-- There is some commonality. The interfaces for things are pretty common. The backs of things are not so common. Interfaces meaning with the operators.

-- JSC was the lead center for SSF before 51L. Then the lead center moved to Reston. We went from one center agreeing with the integrator to none.

-- Org structure and budget structure cited again as problems.

Interviewee 8.

-- SSF being funded from existing funds. All other programs are giving to SSF. 30% reduction in STS operating budget.

Interviewee 9. 3 people.

-- "The "L" word [logistics] should be deleted from the NASA vocabulary. It should be restated in engineering terms. Logistics in NASA means pens and paper. At a recent conference logistics was slated first on the agenda -- the MC then gave directions to pens and paper, the copier, and the restrooms."

-- A diagram of the organizational structure for the work package was drawn on a chalk board. The accompanying discussion detailed how the Project Manager is tied to both the Program Manager and the Center Director. The Center Director controls the budget flow.
The money comes from the regional congressional process. The discussion highlighted that it was not likely that the logical supervision, that of the Program Manager, would carry more weight than the Center Director who holds the purse strings.

-- NASA Centers are built as centers of particular types of excellence. Programs are divided up and given to centers based on these specialties, unless some political consideration interferes with the process. The center directors have a great deal of influence. This is critical because programs do not have one person or office overall responsible. NO lead center, no person in charge.

-- "Most people have multiple bosses but there is no guidance to tell how those conflicts should be resolved. Acquisition goes through the center not the program."

-- There is no common basis for understanding the ideas of logistics. Even if Logisticians get training, they cannot communicate to everyone else. The suggestion is that Logistics training is institutionalized.

--"Logistics (institutional) is considered an administrative function."

-- Budget and launch dates are fixed so the NASA officials are limited in the control that they have on the quality of the product. Designing and developing the "best" and "safest" system is not the priority.

-- All the centers are involved in rivalries.

-- Systems Integration is to be accomplished after the different work packages are developed. The Level II contractor is described as a "paper tiger."

-- ILS review conferences are not mandatory. One of the Loggies in another work package seldom attends and has voided all of the decisions of the conference because he didn't accept the decision and would not back the person he sent to represent him.

-- "Standard operating procedure is to work in spite of the system."

-- "NASA employees have either 30 years of service or 10 years of service. The external environment has changed but the higher levels do not understand. They still think that they have an unlimited budget, solid support, and one shot at a time operations."

-- The contractors headed off attempts to make mirror image parts of the system interchangeable by jacking up costs. The program would not back challenging the contractor.

-- One engineer suggests that NASA should take on the task of designing. The contractors are involved too early. There is no statement of need. If NASA designed and let the contractors build, NASA would have much more control over the process and there would be a much better system as a result.

-- Some of the alleged reparables are spec'd for a launch plus an abort. This means that once they have been launched there is no point in repairing them because they can't be launched again. This is one of the reasons the turn time for the shuttle is so great.

-- This center has the expertise and resources to produce their SSF work package. They do not do it because of the economic effect of involving contractors. However, NASA needs to be able to give more design and direction. "It is like the first string is being forced to sit on the sidelines and watch the subs play the game."

-- Each center/work package has its own prime contractor. There is no commonality of hardware or anything because no center wants to rely on another for inputs for their design. Remember, integration happens after the different work packages are built.

-- By the time logistics gets involved in the process it is too late to change anything. It is if logistics is only involved because someone has been told to do so.

-- Shuttle interface has not been considered as part of design requirements even though the shuttle is the only source of supply envisioned for the SSF program.

-- The four work packages are completely independent of each other. There is no common hardware. There are four databases, one for each work package. Part of integration will be to make an overlay so that the astronauts have only one. Presently, updating one data base will not update the others.

-- The LSA program is a DoD package tailored to fit NASA. NASA has no guidance of its own for program logistics. Part of the problem is that NASA does not want anything that is remotely like the DoD.

Interviewee 10. 3 people.

-- Our inventory management system is Air Force based. The entire center is on the system but there is no standard provisioning -- the system is partitioned with the sections being visible to each other but do not issue without approval of the owner. This system is lightyears ahead of the rest of NASA.

-- Procurement is another function but we do have interface.

-- NASA HQ is pushing us to adopt their inventory management system. Their system may work for the rest of NASA but ours is better for us.

-- We do LSA on new items.

-- Storage space is a problem -- we have warehouse space that we can't use because the lights are too high. We can't get high enough on the priority list to get the money to raise the lights.

-- The centralization of material and safety hazards data sheets is in work.

Interviewee 11.

-- There should be an agency wide logistics system.

-- Our inventory management system is based on a system designed at Maxwell AFB.

-- The payload function at KSC provides the requirements for shuttle interface to the SSF design engineers.

-- In payload the backshops are considered engineering functions.

Interviewee 12.

-- Sustaining engineering normally stays with the developing organization.

-- Cutbacks cause continual SSF restructuring. See attached briefing.

-- The astronauts must go to each WP for training -- there is no integrated training function.

-- Even with the lessons that we have learned the decisions to cut logistics are tough to make. The earlier logistics is factored in the better.

-- Level II is trying to act like a prime. They have passed information to the program manager -- some guidelines and planning requirements. Level II just looks over the shoulder because they have no muscle.

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The purpose of this study was to review past actions and assess current plans for establishing more integrated logistics management in NASA. The focus of this study was acquisition logistics, the beginning of the ILS process.

This study includes a historical review of acquisition logistics in NASA's major space programs as well as a review of numerous acquisition logistics models. Logistics managers from the Space Shuttle and Space Station Freedom programs were interviewed, surveyed, and observed to provide evidence of the degree to which these two programs are meeting or have met the objectives of the acquisition logistics model selected as most appropriate.

Findings indicated that the Space Station Freedom, like the Space Shuttle program, is losing support and funding for ILS programs. NASA managers are opting to sacrifice long range cost savings in exchange for lower system development costs.

Recommendations include increased emphasis on educating the management and engineering communities of NASA on the benefits of well supported and funded acquisition logistics programs.

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