AFIT/GCM/LSP/92S-7

PUBLIC SPACE LAUNCH ACQUISITION: A COMPARATIVE CASE STUDY

THESIS

Kenneth R. Leeson, Captain, USAF
Lee W. Rosen, Captain, USAF

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The opinions and conclusions in this paper are those of the authors and are not intended to represent the official position of the DoD, USAF, or any other government agency.

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THESIS

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Kenneth R. Leeson, B.S.

Captain, USAF

Lee W. Rosen, B.S.,M.S.

Captain, USAF

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Preface

The purpose of this study was to identify, compare, and contrast the space launch acquisition procedures currently employed by major Government agencies including: the U.S. Air Force, the National Aeronautics and Space Administration, and the Strategic Defense Initiative Organization. The research was performed using case-study contractual documentation and personal interviews to assess the acquisition procedures along several specified critical issues and elements. These issues and elements were determined using a Delphi survey of space launch experts. The results of the research documented some fundamental differences in procurement practices, and offered reasons for these differences.

We would like to thank our thesis team of Dr. Wells and Dr. Goetz for their support and encouragement throughout the research process. Finally, our families' understanding and compassion made this year substantially easier to bare; thanks Lisa and Dorothea.

Ken Leeson and Lee Rosen

Table of Contents

Page

Page

List of Figures

List of Tables

AFIT/GCM/LSP/92S-7

Abstract

This study analyzes three commonly practiced approaches to Government acquisition of space launch services. These approaches are employed by the U.S. Air Force, the National Aeronautics and Space Administration, and the Strategic Defense Initiative Organization. The literature review provides a comprehensive overview of the commercial space launch industry and details critical perspectives on commercial launch. Launch contracts which were representative of each organization's acquisition procedures were investigated and evaluated along several critical issues and elements of the space launch acquisition process. These issues included payload characteristics, government oversight, contractor incentives, insurance, liability and cost. The critical issues and elements were determined by using the Delphi method to survey 25 experts in the space launch field. Archival contractual data from the three government agencies were obtained and analyzed, culminating in the creation of an outline and summary matrix. The study found many inconsistencies among the different agencies' acquisition procedures. The thesis ends with a recommendation for a hybrid acquisition approach encompassing the strengths of the three cases. This approach entails the use of positive and negative Contractor incentives, Government self-insurance, and streamlined commercial-like acquisition procedures.

PUBLIC SPACE LAUNCH ACQUISITION:

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I. Introduction

Overview

This chapter explains the background of this study and why this study was completed. The chapter also states the specific problem which the researchers have identified, and it details the research questions which were employed to investigate the problem.

Background

Recent world events have prompted President Bush to begin programs that considerably downsize the U.S.'s military forces and emphasize efficiency within the Department of Defense. One of the major initiatives of this new policy involves a piece of pending legislation called the Space Transportation Purchase Act of 1991, which will mandate the procedures by which the Air Force and other federal agencies contract for space launch services (Dale, 1991).

Traditionally, the Air Force has purchased the launch vehicle and then implemented varying degrees of government supervision in the actual launch process (Congressional Budget Office, 1991:11). Similar procedures were also used by the National Aeronautics and Space Administration (NASA). However, the passage of the Space Transportation Purchase

Act of 1990 mandated that NASA and other federal agencies procure "space transportation services" (U.S. Congress, HR 98, 1989:10). In its condensed form, "transportation services" implies that the purchaser will write one contract for the launch of a spacecraft. This contract would begin with the procurement of the vehicle and end with the placement of the payload into its proper orbit. All aspects of the launch would fall under the responsibility of the contractor (U.S. Congress, HR 98, 1989 :9). One exception to this procurement procedure that is allowed by the Act occurs "when the Secretary of Defense certifies to the National Space Council that national security reasons require otherwise" (U.S. Congress, HR 98, 1989:10). This provision has allowed the Air Force the flexibility of supervising various aspects of the launch operation (Berkowitz, 1989:80-81). NASA, which does not fall under this national security exception, has also been purported to incorporate varying degrees of oversight into the process by inserting special clauses in the service contract (Berkowitz, 1989:80-81). The 1991 version of the Space Transportation Purchase Act, if passed, will eliminate the ability of government agencies such as the Department of Defense and NASA to incorporate oversight into the launch process (Dale, 1991). This change would significantly impact the Air Force's space launch procedures, and must be analyzed in order to identify potential problem areas.

Research Focus

The focus of the research was to identify the differences among three commonly implemented approaches to government space launch. These three mechanisms included the Air Force approach to launch, which utilizes limited commercial procedures and significant government oversight; the NASA launch service approach with contractually integrated government oversight; and the establishment of a launch service contract that involves exclusive contractor supervision and liability. The Strategic Defense Initiative Organization (SDIO) has contracted for launch services in this manner.

Problem Statement

The purpose of this research is to identify, compare, and contrast the processes that are contained in the Air Force, NASA, and full service (SDIO) approaches to Expendable Launch Vehicle (ELV) space launch acquisition.

Research Question

What are the significant differences between the Air Force, NASA, and SDIO approaches to space launch acquisition?

Objectives

1. Identify critical issues and elements of the launch process that are relevant to each approach.

2. Collect data (in the areas identified as critical issues and elements) on the approaches, and categorize the data into these critical sub-tasks.

3. Analyze, compare and contrast the processes involved in implementing the different approaches.

4. When possible, offer explanations for the differences among the approaches.

Scope

The researchers reviewed the evolution of the United States commercial space launch industry. They did not consider foreign space launch. Specifically, three types of government launches were examined: 1) An Air Force space launch that involved limited commercial practices and significant government oversight. 2) A NASA launch that relied on contractual clauses in the launch service contract to impose moderate oversight (Berkowitz, 1989:81). 3) A launch that was conducted by the Strategic Defense Initiative Organization that utilized commercial launch service practices (Dickman, 1991).

By restricting this study to the three government agencies, the researchers were able to examine the contracting process in detail. However, this restriction may limit the applicability of this study to other government agencies' launch procurement practices. Also, the study may not be generalizable to the commercial launch sector.

Definitions

Expendable Launch Vehicle. An expendable launch vehicle (ELV) is a single use, ground launched vehicle capable of lifting its payload into space (U.S. Congress, Commercial Space Launch Act of 1984, 1984:3056).

Launch. A launch is the act of attempting to place or actually placing "a launch vehicle and its payload, if any, in any sub-orbital trajectory, in Earth orbit in outer space, or otherwise in cuter space" (Department of Transportation, 1989:18).

Launch Services. Launch services are "those activities involved in the preparation of a launch vehicle and its payload for launch and the conduct of a launch" (Department of Transportation, 1989:18).

Payload. A payload is "an object which a person undertakes to launch into space or place in Earth orbit by means of a launch vehicle, including sub-components of the launch vehicle specifically designed or adapted for that object" (Department of Transportation, 1989:18).

Government Launch. A government launch occurs when "the government has control of the launch operation and assumes full responsibility for the launch" (U.S. Congress, HR 98, 1989:84). NOTE: A government launch may incorporate a variety of commercial practices.

Commercial Launch. A commercial launch occurs when a contractor has control of the launch operation and assumes full responsibility for the launch. This type of launch must be licensed by the Department of Transportation (U.S. Congress, HR 98, 1989:84). NOTE: A commercial launch may be utilized by a federal agency.

Thesis Overview

The remainder of the thesis contains a comprehensive literature review (Chapter 2), a in-depth description of the methodology used in the research (Chapter 3), a detailed outline of the findings (Chapter 4), recommendations and conclusions concerning the differences among the three government approaches, appendices, and a bibliography.

II. Literature Review

Overview

The literature review was accomplished in several major sections including: the evolution of the commercial space launch industry; current perspectives on the space launch industry; the companies and products involved in the industry (primarily focusing on the Medium Launch Vehicle (MLV) class of rockets, the Atlas and the Delta); and speculation concerning the future of the commercial space launch industry.

Evolution of the Commercial Space Launch Industry

Introduction. While it is difficult to determine the exact point in time when the U.S. commercial space launch industry began, this chronology begins on January 31, 1958 when the Explorer 1 satellite was lifted into orbit on a Jupiter-C rocket (McDougall, 1985:168). This 10.5 pound satellite seems trivial when compared to the 65,000 pound capacity of the space shuttle, but this difference highlights the technological achievements that occurred over just two decades (Damon, 1989:114). The commercialization of space, as an ideal, has been in existence from the onset of space transportation. The National Aeronautics and Space Act of 1958 directed the National Aeronautics and Space Administration (NASA) to "seek and encourage to the maximum extent possible the fullest commercial use of space" (Congressional Budget Office, 1991:2). However, throughout the developmental years the goal of commercialization was overlooked. In fact, the United States Government would serve as the sole provider of space launch services to the non-Communist world up until the early 1980's (Congressional Budget Office, 1991:10). The reasons for the dependence on the government are rooted in the very nature of launch development.

Ballistic Missiles. Throughout those two decades, the ELV industry grew as an outcropping of the DoD's Intermediate-Range Ballistic Missile (IRBM) and Intercontinental Ballistic Missile (ICBM) weapon systems development. Virtually all space payloads were orbited on versions of existing IRBMs and ICBMs (Office of Technology Assessment, 1986:41). Those vehicles that carried commercial payloads could be produced only under contract with DoD and NASA.

Commercial entities (ie. companies that wanted a communications satellite placed into orbit) were required to contract with NASA. In turn, NASA would purchase a commercially produced version of an IRBM or ICBM through traditional government procurement practices, and the launch of the payload would be accomplished by NASA who supervised private sector contractors (Department of Commerce, 1988:5).

Space Shuttle. This policy was implemented throughout the 1970s and early 1980s until the declaration of the Space Shuttle's operational capability prompted the U.S. government to declare the Shuttle as the nation's only space launch vehicle (Department of Commerce, 1988:5). This decision effectively eliminated the ELV industry. With the advent of the Space Shuttle in the early 80's, government views on space transportation began to shift. In August of 1981, the president ordered the National Security Council to oversee a review of the space launch process. Subsequently, in July of 1982, the president issued a national security decision directive that listed the expansion of private sector investment into space activities as a national goal (Tokmenko, 1989:45). Counter to this objective, however, NSC-42-1982 was enacted and stated that the STS (Space Shuttle) would become the nations primary system for placing government payloads into orbit (Tokmenko, 1989:45). Shortly thereafter, the Department of Defense, in order to help the shuttle program become cost effective, transitioned all of its launch requirements to the STS (Koutz, 1988:6). Essentially, a government launch system would be utilized for all of the government's space launch requirements.

Commercial Space Launch Act of 1984 (CSLA of 1984). The Commercial Space Launch Act of 1984 was the answer that the ELV industry had hoped for as it represented the first in a series of legislative initiatives to commercialize the space launch industry. The act attempted to promote commercial space launch by, "(1) streamlining the regulatory approval process governing space activities, and (2) admonishing all branches of the government to support the industry in whatever ways possible (U.S. Congress, Commercial Space Launch Act of 1984, 1984:3056)." The major provisions of the Commercial Space Launch Act of 1984 are summarized in Table One.

Table 1

Major Provisions of the Commercial Space Launch Act of 1984

(Department of Commerce, 1988:7)

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1. Required stable, minimal, and appropriate regulatory guidelines that are fairly and expeditiously applied.

2. Established the Department of Transportation as the lead regulatory agency responsible for:

    - licensing
    - making government launch facilities available for commercial use
    - establishing liability insurance requirements
    - acting as an investigation or inspection authority

While the Commercial Space Launch Act of 1984 represented the first attempt by the government to encourage the commercial space launch industry, the government continued to subsidize the space shuttle as the leading competitor to the industry. To ease this burden on the commercial space launch industry, the President directed NASA to establish space shuttle prices which reflected the full cost recovery for commercial flights. The price charged for a shuttle launch was generally considered to be below full cost recovery (Department of Commerce, 1988:6). This action stifled the commercial space launch industry.

However, experts were predicting that the shuttle's services would cost as little as one fifth of those offered by ELV's. These estimates were driven by a flight rate that was expected to reach 40-60 flights per year (Congressional Budget Office, 1991:10). When the performance of the shuttle fell far below expectations, competitive forces in the industry would be rejuvenated (Congressional Budget Office, 1991:10).

It took a disaster to resurrect the commercial space launch industry. On January 28, 1986, the Space Shuttle Challenger exploded over Florida leaving the U.S.'s space launch capability in a debilitated state. A review of the nation's capabilities and payload requirements revealed the need for a mixed fleet of shuttles and ELVs. These requirements were codified by National Security Decision Directive 254 which stated the following:

- Critical mission needs will be supported by both the shuttle and ELV's to provide added launch assurance when necessary.

- NASA will phase out launching commercial and foreign payloads not requiring a manned presence or shuttle unique capabilities.

- NASA will not maintain an ELV adjunct to the shuttle.

- NASA is authorized to contract for necessary ELV launch services if any additional NASA capacity is required (Tokmenko, 1989:45).

This legislation had the effect of opening up a tremendous market for ELV launch service in the United States. Immediately following implementation of this directive then

Secretary of the Department of Transportation, Elizabeth Dole stated:

> ...the greatest barrier to the successful commercialization of a private sector space transportation industry was not excessive regulation, but a highly subsidized shuttle system (Tokmenko, 1989:45).

Amendments to the Commercial Space Launch Act. In the wake of the report on the Challenger accident, the President made a comprehensive revision to National Space Policy in 1988. Elements of this policy included:

> -To require NASA and DoD, in consultation with the Department of Transportation, to make national launch property, facilities, and services available for commercial use, reimbursable at direct cost.
>
> - To reinforce the existing policy prohibitions concerning commercial use of the Shuttle.
>
> - To prohibit NASA from maintaining an ELV adjunct to the Shuttle.
>
> - To require the U.S. government to purchase commercial space transportation services to meet its requirements to the fullest extent feasible.
>
> - To prohibit the U.S. Government from competing with or deterring U.S. commercial space transportation service providers except for national security.
>
> - To require the Government to undertake research and development aimed at reducing the cost of space transportation and related services, to enter cooperative agreements with industry to encourage private sector research and development, and to provide for timely transfer of Government developed space technology to the private sector, in a manner which protects the commercial value of the technology (Department of Commerce, 1988:6-7).

Congress, agreeing with the President's directive, adopted the provisions (along with guidance as to how this act would be enforced) as amendments to the Commercial Space Launch Act of 1984 (Hale, 1990:15).

On November 16th of 1989, President Bush continued the legislative push towards the commercialization of space by releasing a new national space policy. Guidance concerning the procurement of space launch services was developing at a rapid pace. The new space policy reiterated the evolving intentions of the national leadership:

> Government Space Sectors shall purchase commercially available space goods and services to the fullest extent feasible and shall not conduct activities with potential commercial applications that preclude or deter Commercial Sector space activities except for national security or public safety reasons (Office of the White House Press Secretary, 1989:4).

Though this policy statement emphasizes the importance of commercializing the space launch process, it was still lacking specificity and direction. Upon passage of the Space Transportation Act of 1990, specific guidance was handed down to government organizations for implementation. In relation to the procurement of launch services, the law stated:

> In General - Except as otherwise provided in this section...the Federal Government shall purchase space transportation services from commercial providers whenever such services are required in the course of its activities (U.S.Congress, HR 98, 1989:10).

Exceptions to this guidance were also specified:

> (1) the Secretary of Defense certifies to the National Space Council that national security reasons require otherwise;
>
> (2) the Administrator of the National Aeronautics and Space Administration certifies to the National Space Council that the unique capabilities of the space shuttle are required; or
>
> (3) the Secretary finds that the space transportation services required are unavailable at a reasonable price

> from commercial providers (U.S. Congress, HR 98, 1989:10).

The stipulations in this law set the ground work for a mandatory requirement for all government agencies to purchase full service commercial launch contracts. As stated in Chapter 1, the ability of the above legislation to fulfill this requirement is currently debateable. The situation has dissolved into a battle of semantics. Laws are pending that may resolve many issues.

Additional Legislation. Recently, a flurry of legislation has been proposed which drastically changes the procedures for the commercial launch of U.S. government payloads. Traditionally, all liability and insurance issues for such launches were the responsibility of the government. This new legislation, if passed, would relieve the government of much of its responsibility, and pass that responsibility to the contractor.

HR 672, dated January 28, 1991, is an example of legislation that deals with these issues. It proposed that NASA...

> shall not enter into any contract which waives liability that would otherwise attach to the contractor for defects in material or workmanship of articles provided under the contract or for failure to conform with requirements of the contract (U.S. Congress, HR 672, 1991:1-2).

This piece of legislation was recently incorporated into HR 2162 (Furman, 1992).

HR 2162 includes provisions which spell out when the contractor would not be forced to assume certain liabilities. These provisions allow the government to assume liability if risks to the contractor are so high that no contractor would submit a bid; or, the cost to NASA is significantly less under contracts containing waivers of contractor liability (U.S. Congress, HR 2162, 1991:4). HR 2162 was tacked onto another piece of legislation, HR 4364, which was passed through the House of Representatives and at the time of this report was in Senate sub-committee (Furman, 1992). An addition to HR 4364 is a sub-section referred to as Title 4. This provision requires a research study of "high-risk" contracting. A pilot program which the legislation requires seeks to share risk between the government and the contractor by using innovative contractual techniques such as negative award fee contracts and positive fee incentives (Furman, 1992).

The Omnibus Space Commercialization Act of 1991 (U.S. Congress HR 3153) was considered by many to be the Act that would revitalize the commercial space launch industry. It contains provisions that require the federal government to "purchase launch services from commercial providers whenever such services are required in the course of its activities" (U.S. Congress, HR 3153, 1991:9). Exceptions to this provision are made for payloads that require the unique capabilities of the space shuttle; commercial launch services cannot meet specific mission requirements; an unacceptable risk of loss of a unique scientific opportunity exists; and where the payload serves national security or foreign policy purposes (U.S. Congress, HR 3153, 1991:9-10). This piece of legislation was replaced by HR 3848.

Another recent piece of legislation known as the Commercial Space Competitiveness Act of 1991 (U.S. Congress, HR 3848, 1991) goes one step farther than HR 3153. This bill requires the federal agency which invokes an exception to HR 3153, to justify its action in writing by describing in detail why commercial launch services cannot meet the mission requirements in a reasonable and cost effective manner. This bill proposes a "launch service voucher" system in which scientists requiring space launch receive vouchers from NASA to purchase commercial launches. This bill was passed by the full House, and has been introduced in Senate sub-committee (Furman, 1992).

The current legislation seems to be moving in the direction of requiring all federal government agencies to purchase full commercial space launch services (Furman, 1992). This move to bolster the commercial space launch industry mandates that government agencies relinquish some of the oversight and control they once had over the ELV space launch process. Until the many of the exception provisions are either more strictly enforced, or eliminated, federal agencies will continue to pursue launch procurement strategies that best meet their individual requirements.

Perspectives on Commercial Space Launch

Introduction. Since its inception, space launch has been the domain of the government. From the early ballistic missile successes to the Space Shuttle's operational status, the government has controlled the commercial space industry. During the last decade the government has forced itself to share its space launch dominance with commercial entities, as sole reliance upon the Space Shuttle proved to be disastrous.

Commercial Space Launch Defined. The influence of political turf battles among different government agencies, commercial entities, and "experts in the field" makes it difficult to find a consensus as to the definition of a "commercial launch". One member of academia has forwarded this simple definition: "Under a commercial contract, the launch company agrees to put a satellite into a given orbit at a given time and a given price" (Berkowitz, 1989:80). Along similar lines, the Department of Defense has defined launch services as "those activities involved in the preparation of a launch vehicle and its payload for launch and the conduct of launch" (Department of Defense, 1986:1). These activities include, but are not limited to, launch vehicle production, payload integration, launch operations and placement of payload into orbit (Congressional Budget Office, 1991:16).

These definitions imply that the procurement of commercial space launch services requires a contract with a commercial firm covering the entire spectrum of the launch process from inception to acceptance. The actual launch process for government payloads is seldom turned over to the contractor in its entirety; the government waives insurance requirements and retains ultimate authority and liability during the launch. The Department of Transportation has recognized that in many cases, the Department of Defense and NASA often act as launch operators for missions involving their respective payloads. DoT has labeled these "government launches" (U.S. Congress, HR 98, 1989:40). The "commercial" designation is reserved for launches that are supervised in their entirety by contractor personnel (U.S. Congress, HR 98, 1989:40).

NASA officials have suggested that launch types fall into three categories: military, civil (NASA), and commercial (U.S. Congress, HR 98, 1989:73). This distinction in launch procedures is also described in an article by Bruce Berkowitz, adjunct professor in the Department of Engineering and Public Policy at Carnegie Mellon University.

Dr. Berkowitz insists that the Air Force has all but rejected the concept of commercial space launch. He reports that in most cases, the Air Force claims that its payloads are critical to national security. This allows for a waiver from purchasing purely commercial space launch services and ensures that military personnel will be supervising large portions of the launch process (Berkowitz, 1989:80). Berkowitz is also critical of launch procedures involving NASA payloads. NASA is required by law to purchase bona fide commercial launch services, however, the NASA contracts *include clauses that allow for significant government* oversight throughout the launch process (Berkowitz, 1989:80-81).

Fully Commercial Government Launch. It should be noted that there have been government launches that have utilized commercial practices in full. A NASA official recently cited the launch of a Navy UHF Satellite as an example. The launch involved a military payload, a commercial vehicle and contractor oversight and responsibility for all phases of the activity (U.S. Congress, HR 98, 1989:85-86). In May of 1988, NASA contracted for the launch of Geostationary Operational Environmental Satellite (GOES) in a similar fashion. NASA awarded the comprehensive contract on a competitive firm fixed price basis that stipulated that the contractor maintain responsibility for full systems integration. Contract acceptance occurred at the proper orbit rather than the traditional locations; launch site or contractor plant (Tokmenko, 1989:4). The GOES launch services contract was also the first of its kind to require "reflight or refund" provisions to protect the government against launch failure (Tokmenko, 1989:7). Finally, the GOES procurement required the contractor to construct the launch system according to government specification (Tokmenko, 1989:4).

What is unique about GOES and the Navy UHF satellite that allows full commercial contracting practices to be utilized? Congressman Ron Packard of California has been researching this question. He has claimed that, up until this point, services received under bona fide commercial space launch contracts have satisfied government needs. In addition, he states that there are no significant differences between the payloads that are launched commercially and payloads launched by the government (U.S. Congress, HR 98, 1989:17). In researching this topic, Representative Packard has uncovered other questions that require attention including: 1) Who is responsible for deciding whether or not a payload will be launched commercially? and 2) What factors drive this decision?

Commercial Launch Decisions. Dr. George Schneiter, Deputy Director, Defense Research and Engineering, stated in his testimony before Congress, that the nature of the payload has nothing to do with whether or not the launch is commercial (licensed by DoT), or government (U.S. Congress, HR 98, 1989:88). In essence, at the time of the testimony, there were no set criteria for determining whether or not a launch would fly commercial or government. There were, however, some instances when a launch required technical capabilities that were only available through government involvement. An example would be payloads that required the heavy lift capabilities of the Titan IV launch vehicle. These services were not being offered commercially at the time they were needed (U.S. Congress, HR 98, 1989:88-90).

The actual responsibility for determining whether or not to launch in a commercial fashion was left to the agencies that owned the payload and were contracting for the service (U.S. Congress, HR 98, 1989:54). The decision would rest on the user's determination of risk and its associated tradeoffs. The definition and subsequent measurement of "risk" appears to be the key component of the controversy. Due to the fact that the satellite owner maintained top authority on launch decisions, the owner's perceptions of the risks involved were paramount.

Contractor-Related Factors. The monetary value of a payload is not the only factor that ties into the risk equation. The process of purely commercialized contracting implies that a less experienced contractor could successfully win the award to service the launch of a spacecraft that is extremely vital to national security. Could the U.S. trust a fledgling ELV operator and his untested launch vehicle in this situation (Tokmenko, 1989:7-9)? This idea of measuring the value of a payload by its effect on national security is the basis behind government decisions to waive the requirement to purchase bona fide commercial launch services.

Safety and Liability Factors. Safety and liability issues are also significant factors in the arena of risk evaluation. DoT officials have stated the following: "There is certainly room for improving the process by which the government does business with private launch firms, but safety must always come first" (U.S. Congress, HR 98, 1989:45). The importance of safety, coupled with the high costs of launch property and detrimental effects that launch failure can have on national security, complicate the liability issue. Department of Defense directives specifically state:

> For activities other than those carried out under a DoT launch license, the user shall assume the responsibility for all damage to property of the Government and its contractors and subcontractors arising out of this agreement, regardless of fault (Department of the Air Force, 1989:4).

Essentially, when the government procures launch services and maintains the role as supervisor for the launch, it assumes full liability for the launch (U.S. Congress, HR 98, 1989:193). If a launch is commercial in nature, a license is required by the Department of Transportation and the contractor is subsequently mandated to purchase launch insurance to cover necessary liabilities (U.S. Congress, HR 98, 1989:81-82). It should be noted that the insurance requirement is not a trivial issue. From 1977-1985, the insurance ratio for space launch was 200%. This means that for $450 million dollars in premiums collected over that time span, $900 million dollars in claims were paid out. Actual premiums have been running as high as 20-28% of the value of the satellite (U.S. Senate, 1988:5). These statistics indicate two things. First, with reliability for ELV launches hovering between 85% to 97%, losses are relatively frequent occurrences (Allison, 1990:142-144). Secondly, when launches do not work as planned, the results are catastrophic.

The Air Force has taken a cautious stance towards full service contracts. In recent testimony before Congress, Brigadier General (then Colonel) Robert Dickman, U.S. Air Force Assistant Secretary of Acquisition, Deputy Director of Space Programs stated that "since the start of commercial launch activity, a somewhat lower reliability has been demonstrated as compared to Air Force launches, and at least some of the failures are due to less oversight" (U.S. House of Representatives, 1991:7). Brigadier General Dickman made it clear that payloads that are more sophisticated, expensive and critical, demand more government oversight (U.S. House of Representatives, 1991:7). NASA officials point out that their payloads are typically valued at between $200 and $300 million as compared to commercial industry payloads ($40 to $50 million). In this respect, they feel that additional oversight is money well spent (U.S. Congress, HR 98, 1989:75). To the contrary, Congressman Packard points out that $40 million dollars to a private company is monolithic compared to $200 million federal dollars (U.S. Congress, HR 98, 1989:75).

Cost Factors. Risk is certainly a significant factor when considering the procurement methods for space launch. But in today's tightening fiscal environment, cost considerations are equally influential. A Congressional Budget Office Study states:

> The policy of commercializing launch services has sought to lower the cost of government launches by substituting commercial terms and procedures for the government's traditional way of purchasing vehicles and

directly supervising launches (Congressional Budget Office, 1991:xv).

Dr. Berkowitz has claimed that commercialized launches can be up to 30% cheaper than launches carried out by the government (Berkowitz, 1989:77). Even though Berkowitz did not substantiate the reasons for the savings figures, others have forwarded general concepts in support of this premise. Brigadier General Dickman refutes this cost savings by pointing out that the cost of insurance does not need to be included in the cost of a government launch because the government assumes all liabilities in the event of failure (Dickman, 1991). This savings, as illustrated previously, can be substantial.

One underlying argument focuses on basic economic principle of "economies of scale." The belief is that the United States Government, which is the space industry's largest customer, should buy its services "off the shelve" in as many instances as possible (U.S. Congress, HR 98, 1989:22). By equating the requirements of the commercial and government markets, launch service providers are able to standardize their launch procedures and vehicles, and spread the benefits to users in the form of lower costs (Congressional Budget Office, 1991:20).

Much of the cost related controversy centers on whether or not the actual launch vehicle should be produced according to government specification. It has long been noted that the rigid standards imposed by military design specifications (Milspecs) can be expensive. One author has suggested that products built according to military specifications cost 25% more than similar commercial items (Berkowitz, 1989:79). The matter is accentuated when one considers that a product purchased under Milspec or NASA specification (NSPEC) must be monitored by government personnel. This "non-touch" type of labor, according to Berkowitz, accounts for up to half of the cost of a typical launch (Berkowitz, 1989:79). Lastly, the entire industry suffers, because launch vehicle manufacturers cannot afford to run separate production lines for commercial and government customers. According to Berkowitz, all launch vehicles must therefore be built to the government specifications and costs are inflated (Berkowitz, 1989:80).

Air Force officials have refuted these charges by stating that there are no substantial cost advantages to be gained from launching a payload commercially (U.S. House of Representatives, 1991:7). In regards to military specifications, Brigadier General Dickman pointed out that the only specifications required by the DoD are quality specifications, not technical specifications (Dickman, 1991). He added that commercial Delta ELVs and USAF Delta ELVs are produced on the same production line with the only difference being quality assurance related (Dickman, 1991). Finally, Brigadier General Dickman stated that the Air Forces quality oversight program was so effective that commercial launch customers have solicited the Air Force's help in overseeing quality issues (Dickman, 1991).

Finally, the costs of full reliance on contractor operated space launch are not necessarily measured in fiscal terms. It is important to consider the cost of loosing an in-house (Air Force) capability to perform launch operations (Congressional Budget Office, 1991:40). This type of opportunity cost is difficult to measure, but could be significant given the appropriate circumstances (ie. wartime).

Licensing. As noted earlier, the Commercial Space Launch Act established the Department of Transportation (DoT) as the lead regulatory agency responsible for commercial space launch licensing requirements (U.S. Congress, Commercial Space Launch Act of 1984, 1984: 3056). The Office of Commercial Space Transportation (OCST) is DoT's primary administrator of the policies laid out by the Commercial Space Launch Act. According to a DoT pamphlet, OCST is:

> responsible for administering its regulatory authority to protect public health and safety, safety of property, national security and foreign policy interests of the U.S., and to ensure compliance with U.S. international obligations (Department of Transportation Pamphlet, undated:2).

The licensing arm of DoT is the Licensing and Safety Division. Included in its activities are:

- Reviewing license applications and issuing licenses.
- Monitoring licensee activities.
- Setting insurance requirements.
- Developing public safety requirements and standards.

- Assessing environmental impacts of commercial space transportation activities (Department of Transportation Pamphlet, undated:3).

The primary purpose of licensing, as demonstrated in the activities list, is safety.

According to Mr. Bowles, Chief of the Licensing and Safety Division, DoT has done everything in its power to make the licensing process as simple as possible for all applicant (Bowles, 1992). First, launch providers only need to apply for a license once. The launch operators license remains valid for an extended period (ie. two years). This blanket launch operators license covers contractors for all launches that are considered standard. Any launches that would be considered non-standard (ie. odd trajectories, new launch systems) must be licensed separately on a specific launch license (Department of Transportation, 1989:1).

In the standard launch operators license, applicants provide a summary document stating who they are, which launch site they will be using, the type of rocket they plan to use, and the number of launches they anticipate (Wooster, 1991:56). Launch operators must pay a fixed $2500 license application fee, and licensees must pay an annual $2500 license renewal fee (Federal Register, 1991:56111). The launch fee for an orbital launch is based upon the launch vehicles maximum payload lift capability, multiplied by a factor of $2.50 per pound (Federal Register, 1991:56111). For example, a Delta 7920/7925 with a maximum payload lift capability of 10,830 pounds be subject to a per launch fee of $27,075.

Launch fees are not the only fees associated with the licensing process. Insurance policies for launch and for launch site liability and property must also be obtained in order for license approval. In McDonnell-Douglas' Cape Canaveral Air Force Station launch license, the company was required to carry $164,000,000 in launch liability insurance, $80,000,000 in property insurance, $30,000,000 in launch site liability insurance, and $60,000,000 in launch site property insurance (Office of Commercial Space Transportation, 1991:3-4).

Companies and Products

Introduction. The firms that make up the U.S. commercial space launch industry can essentially be divided into two distinct segments. These segments include large, well established government contractors, and small entrepreneurial firms. The commercial space launch industry differs from many other transportation industries in that space-related firms sell their services to other commercial entities, rather than their hardware as was the case in the traditional government procurement process (Department of Commerce, 1988:7). In other words, the firms provide a "package" which includes launch support, payload integration, launch services (the actual launch of the vehicle from sub-contacted government facilities in most cases), and the launch hardware (the ELV and its components necessary for launch) (Terhune and Green, 1989:1-4). On the contrary, when firms in the commercial space launch industry sell their products to the U.S. government (the industry's largest customer), traditionally the government has bought its launch vehicles through the Air Force or NASA, and used government personnel to prepare and launch the payload into space (Berkowitz, 1990:79). In either case, commercial space launch firms supply the vehicles, and sometimes the launch services.

The large firms in the industry are comprised of a group commonly referred to as the "Big 3" which include General Dynamics, McDonnell Douglas and Martin Marietta (Stone and Emond, 1988:8-9). These firms produce three expendable launch vehicles: the Atlas, the Titan and the Delta. These three launch vehicles are pictured in Figure 1 (Department of Transportation, 1989:6).

General Dynamics: Atlas. General Dynamics markets the Atlas rocket and Centaur upperstage vehicle which is capable of delivering a 13,500 lb. payload to low earth orbit (LEO, a 100 nautical mile circular orbit) at a cost of \$46-\$55 million (Office of Technology Assessment, 1986:20). The Atlas was developed for use as an Intercontinental Ballistic Missile (ICBM) during the early 1950s, and was used as the primary launch vehicles in the 60s during the Mercury and Gemini manned launch programs (McDougall, 1985:127,166). The Atlas reliability rate as of 1989 was 85 percent, with only two failures in the past ten years (Allison, 1990:142).

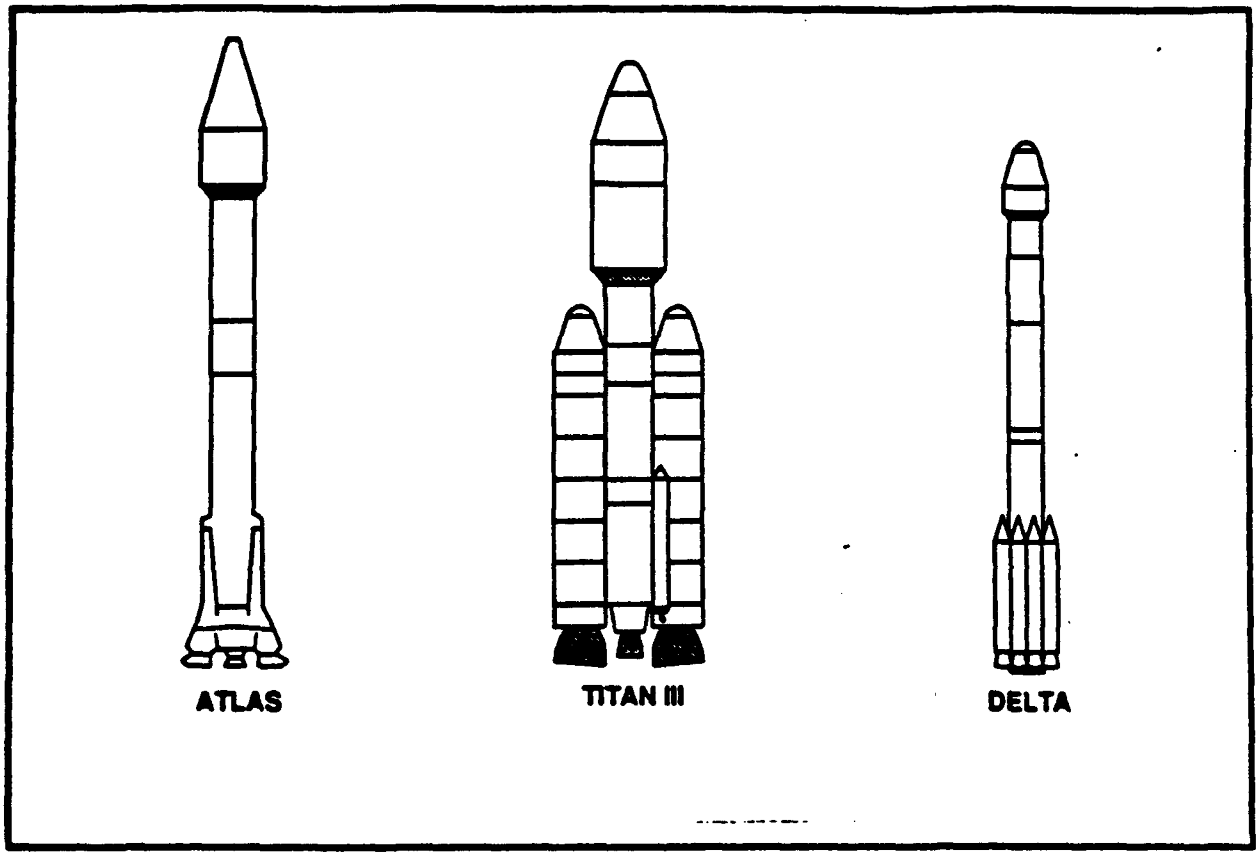

Figure 1. Currently Operational U.S. Commercial Launch Vehicles (Department of Transportation, 1989:6)

The Atlas, like most launch vehicles, is capable of being launched in several different configurations depending on the desired payload and orbit. All Atlas ELVs include similar major components of the core vehicle. These sections include the tank section (a thin-walled stainless steel structure which maintains its rigidity by pressurization and is separated into two tanks by a bulkhead); equipment pods (externally mounted on the tank section, the pods house various missile support equipment); and a booster section (which includes the two engines that are jettisoned after the initial stages of flight) (Department of Transportation, 1989:6). Atlas launch vehicles can be operated from both government launch facilities; the Eastern Space and Missile Center (ESMC) at Patrick AFB, Florida, and the Western Space and Missile Center (WSMC) at Vandenburg AFB, California. Figure 2 depicts the typical processing flow for the Commercial Atlas II Launch Vehicle (Department of Transportation, 1989:12).

McDonnell-Douglas: Delta. In January 1987, McDonnell Douglas entered the commercial space launch industry after the U.S. Air Force announced a requirement for a new "Medium Launch Vehicle (MLV)" (Stone and Emond, 1988:9). Capable of delivering 7,600 lbs. to LEO at a comparable price to the Atlas ($45 to &50 million), the Delta was a desirable vehicle because of its comparatively high launch rate capability (Office of Technology Assessment, 1986:20). At

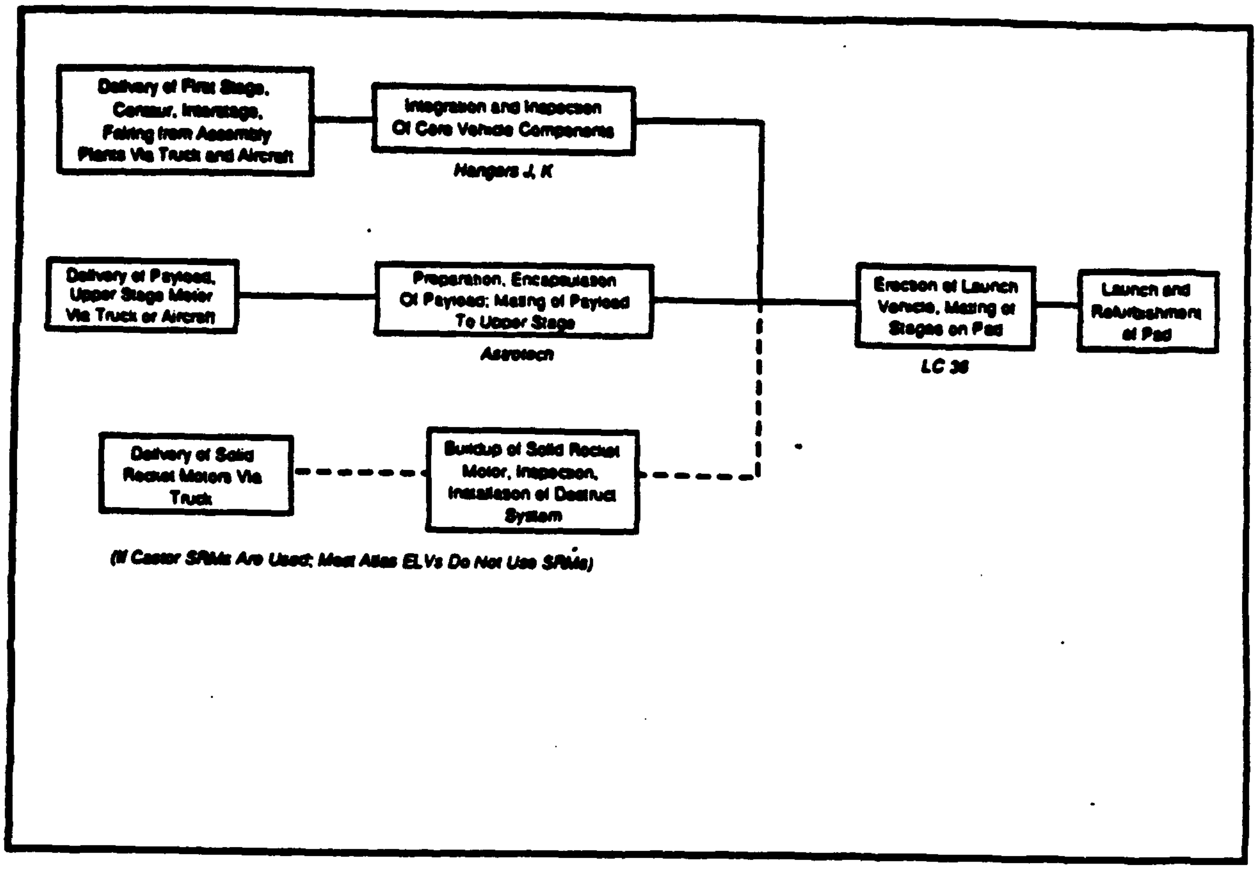

Figure 2. Processing Flow for Commercial Atlas II Launch Vehicle (Department of Transportation, 1989:7)

an estimated 18 launches per year, the Delta doubled the number of launches of the space shuttle, and tripled the yearly launch rate of any of the Big 3's vehicles (Office of Technology Assessment, 1986:20).

The Delta launch vehicle can be configured as either a two or three stage system, augmented with nine solid fuel strap-on motors (Department of Transportation, 1989:12). Launched from either the ESMC or the WSMC (Delta I only), Delta has maintained a 97.2 Figure 3 depicts the typical processing flow for the Commercial Delta Launch Vehicle (Department of Transportation, 1989:12).

Martin Marietta: Titan. The final member of the industry's Big 3 is the Martin Marietta Corporation with their Titan launch system. Another retired ICBM, the Titan IV provided the industry with its heavy lift capability. It can boost 39,000 lbs. to LEO at a cost of $100 million to $125 million (Office of Technology Assessment, 1986:20). The Air Force has ordered 41 Titan IVs with an option for eight more, and projections for a total of 61 to the year 2000 to serve the Air Force's heavy lift needs (Hanley, 1991:36). In its past 25 launches, the Titan has maintained an 85 percent reliability rate (Allison, 1990:148).

Entrepreneurial Firms. The commercial space launch industry has several barriers to entry including extremely high start-up costs, the long term return on investors capital, and well established firms that have earned the trust of their clientele (Struthers, 1989:75). One industry

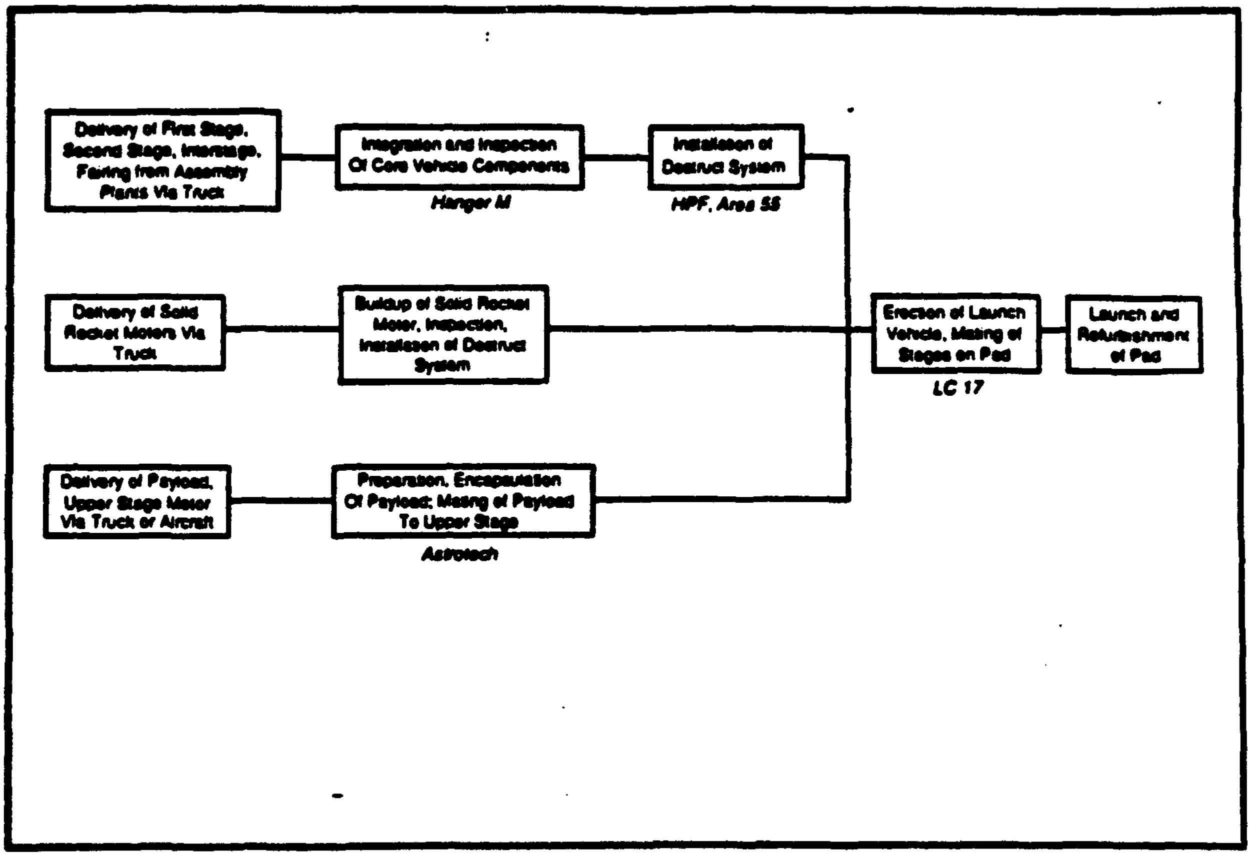

Figure 3. Processing Flow for Commercial Delta Launch Vehicle (Department of Transportation, 1989:12)

analyst feels the Big 3 will not be able to continue their dominance of the space launch industry when their launch prices hover from $3000-$6000 per pound; "Their launchers were originally designed and manufactured to meet military missile specifications, customers could be buying a Cadillac for a ride to space when a pickup truck would do" (Klotz, 1989:40). There are several small companies that are venturing into this industry. The names LTV (Scout Rocket), Orbital Science Corporation (Pegasus), AmRoc (Industrial Launch Vehicle (ILV-1)), E'Prime (EPAC Series), and Space Services Incorporated (SSI) (Conestoga) are firms marketing primarily smaller, more versatile launch vehicles that may reduce the cost per pound for space access (Department of Commerce, 1988:14). The first entrepreneurial firm to actually launch a payload into orbit was former astronaut Deke Slayton's SSI (Boehler, 1989:39). The Conestoga Starfire Rocket successfully carried an experiment package into LEO for the University of Alabama at Huntsville (Boehler, 1989:39).

Infrastructure. The infrastructure of the commercial space launch industry consists of more than just ELVs and the firms that produce them. A growing issue of concern is finding launch facilities to support all of these emerging firms and their rockets. The only two options presently available are Cape Canaveral, Florida (ESMC), and Vandenburg AFB, California (WSMC) (Klotz, 1989:40). The U.S. charges $4 million per launch at these facilities (Klotz, 1989:40).

The cost factor, coupled with the backlog of scheduled launches at these facilities has prompted the industry to look elsewhere for launch locations. Plans to develop land near Cape Canaveral in Florida, Wallops Island in Virginia, and Palima Point in Hawaii are being considered (Klotz, 1989:41). Chris Shove, Former Director of Florida's Office of Space Programs, believes that,

> This is the beginning of the evolution of a whole new transportation system. I feel like the guy who was the beginner of the FAA, when air transportation reached a point of vitality that it had to be dealt with. (Klotz, 1989:42)

As the number of firms entering the commercial space launch industry continues to grow, facilities to accommodate them must be made available.

The Future of the Commercial Space Launch Industry

Introduction. The number of companies, products, and launch facilities mentioned in the previous section can only continue to grow if the demand for space launch grows accordingly. Today, the principal markets for U.S. launch vehicles are:

- the U.S. government
- telecommunications satellites
- Earth observation satellites and
- Scientific satellites and spacecraft (Conchie and Parkinson, 1986:3).

Looking beyond the end of the century, the only two prospective markets that may become viable are space station servicing (a sub-section of the U.S. government market), and microgravity processing and research (Conchie and Parkinson, 1986:3).

Demand. The Office of Technology Assessment's (OTA) report on Launch Options for the Future relates the demand for launch services to the goals expressed by national space policy. The demand will fluctuate based on the following goals:

(1) The limitations placed on the future growth of NASA and the DoD.

(2) The desire to deploy the Space Station by the mid-90s while maintaining a commitment to NASA science programs.

(3) Projects to send humans to Mars or establish a base on the moon.

(4) Continue the trend of launching heavier communications, navigation, and reconnaissance satellites.

(5) The future role of the military in space including the Strategic Defense Initiative program (Office of Technology Assessment, 1986:74-77).

According to the OTA's report, the goals dictated by the U.S. government historically affect the focus of industry since the government is by far industry's biggest customer (Office of Technology Assessment, 1986:14). In terms of actual numbers of launches, the report speculates based on three levels of industry growth:

- Low Growth-3 percent average annual growth in launch rate (41 launches per year by 2010).

- Growth-5 percent average annual growth in launch rate (55 launches per year by 2010).

- Expanded-7 percent average annual growth in launch rate (91 launches per year by 2010). (Office of Technology Assessment, 1986:3)

The summary of the literature seems to indicate a potential for growth in the commercial space launch industry. Also, several cases of research and development of advanced launched systems by the private sector have been examined. However, one of the 1988 Amendments to the Commercial Space Launch Act requires the U.S. government to undertake research in the area of space launch technology (Department of Commerce, 1988:7). The government's response has primarily taken the form of two systems; the National Aero-Space Plane (NASP), and the Air Force's National Launch System (NLS).

National Aerospace Plane. The NASP was introduced in 1985 by President Reagan as the aerospace plane of the future. It would operate at hypersonic speeds (6,400 to 12,800 km/hr) in the upper atmosphere, and be capable of flying from the U.S. to the Orient in less than two hours (Williams, 1986:2). Because the technology needed to develop such a vehicle is highly advanced, NASP would not be available before the early part of the next century; even at increased funding levels (Office of Technology Assessment, 1986:45).

National Launch System. The Air Force's proposed unmanned cargo vehicle is the NLS. Its proposed large lift capacity (100,000-200,000 lbs. to LEO) and high launch rates (20 to 30 flights per year after 1998) make it an attractive system (Office of Technology Assessment, 1986:46). However, the costs associated with developing a new launch system "from scratch" are high, and funding for the NLS program has been well below requested levels (Office of Technology Assessment, 1986:47).

Launch Industry Conclusions

The commercial space launch industry developed out of an unusual set of circumstances. After America's moon landing triumph, the industry was gearing up to meet the launch demands of a new space-faring nation. The President's decision to build the space shuttle effectively banned new firms, other than those under contract by the U.S. government, from entering the industry. Coincidentally, it was also the space shuttle tragedy that forced the industry to expand. The Challenger incident made America realize that continual space access was not guaranteed.

The legislation contained in the Commercial Space Launch Act of 1984 and its amendments in 1988, paved the way for continual space access by mandating more affordable, less risky means for placing payloads in orbit. Established government contractors (the Big 3), and smaller entrepreneurial firms have created a myriad of options for space launch vehicles and services. The industry has the capability to meet the nation's demands for space launch.

Will there be a demand for industry to meet? The future of space launch is certainly questionable as the changing world order has placed the establishment of the nation's long term space goals on hold. The research and development of new space launch systems has also been placed low on the nation's list of priorities. However, the industry has been in a similar position in the past. The lessons learned from the Challenger accident taught the leaders of the nation that assured access to space is a critical commodity. A viable U.S. commercial space launch industry is one which is able to provide the nation with this capability.

The literature summarized in this section relates in detail the background, current positions, and future perspectives of the controversial area of space launch. Of particular interest was the area of launch procurement and contracting procedures. This comprehensive search has enabled the researchers to pinpoint the areas of coverage, and potential sources of data for the case studies. This research is the subject of subsequent chapters.

III. Methodology

Overview

This chapter explains the methodology chosen to complete this study. Included are the methods used to gather the necessary data that was needed to answer the research question, and to complete the objectives of the study discussed in Chapter 1. Different research techniques were summarized, and justified as to their application to this report.

Sample of Launches to be Evaluated

Three distinctly different ELV launch processes (cases) were examined and then compared. Data for these cross-sectional studies were derived from the following three launch occurrences: 1) An Air Force launch that involved limited commercial procurement practices and significant government oversight during much of the launch servicing. 2) A NASA launch that relied on contractual clauses in the launch service contract to impose moderate oversight (Berkowitz, 1989:81). 3) A launch that was recently conducted for the Strategic Defense Initiative Organization (SDIO) that emphasized commercial procurement practices (ie. minimum government oversight) (Dickman, 1991).

This predetermined sample represented the current spectrum of procurement practices for public ELV services (Rappaport, 1991). The cases were not meant to be mutually exclusive, but were instead intended to reveal significant variances in general areas of public space launch. This sample met the criterion to establish content validity which is defined as providing adequate coverage of the topic under study (Emory and Cooper, 1991:180). The sample was selected with the intent of controlling for launch vehicle type and payload. In all three cases, the launch vehicle was the McDonnell-Douglas Delta II rocket, and the payloads were of comparable weight and technical sophistication. These control measures helped to enhance comparisons between the three types of launches. This was accomplished by eliminating extraneous variables such the effect of vehicle type on launch procedures and the effect of payload complexity on oversight requirements. These controls were also included with the purpose of maintaining internal and external validity. The variables in the study represented what they purported to represent. They were generalizable across the population of all of the commercial space launches conducted using one of the three established processes for contracting (Emory and Cooper, 1991:180).

Identifying Critical Sub-Tasks

The first objective was to identify critical sub-tasks of the general launch process. These were then examined in all three cases. The researchers' purpose was to identify the areas of the launch process that experts in the field believed to be critical for the analysis. One researcher conducted a preliminary interview with the Senior Transportation Specialist of the Office of Commercial Space

Transportation in the U.S. Department of Transportation, Mr. Carl Rappaport. During the interview, the researcher discovered that areas such as launch costs, schedules and delays, industry incentives, reliability, and liability/termination issues were identified as critical sub-tasks that were worthy of consideration. Additional launch support events such as: Air Force Satellite Control Network (AFSCN) preparation, launch site preparation, delivery of spacecraft to launch site, mating of spacecraft to booster, countdown, boost, transfer orbit, and on-orbit test and check out, were also considered (Martin, 1989:3).

Delphi. In order to validate and determine the final list of critical sub-tasks on which the three launch processes were compared, the researchers chose to employ the Delphi technique. This technique, originally developed by the Rand Corporation, is used to systematically gather the judgements of experts on a particular subject (Griffin and Moorhead, 1986:497). The space launch industry's diverse application throughout the public sector (Air Force, NASA, SDIO, Navy, Department of Transportation etc.), private sector (all of the commercial companies previously mentioned) and academia, make the industry an excellent candidate for using the Delphi to gather a consensus of opinion on the critical sub-tasks. Since all of the experts in this field rarely meet face to face, and are physically dispersed, the space launch industry meets the criterion for use of the Delphi technique (Griffin and Moorhead, 1986:497).

The experts who participated in this study were identified by the researchers through the literature search, and through personal interviews. The literature search provided several names of individuals who wrote articles, or were identified in articles as experts in the field. During personal interviews with Brigadier General Dickman and Mr. Rappaport, the researcher asked the interviewees to identify those individuals who they would consider experts in the field. The recruiting of participants was accomplished through the use of an introductory letter. This letter introduced the researchers and subject area, and identified the National Contract Management Association and Brigadier General Dickman as the research sponsors (See Appendix B). The researchers then developed a broad questionnaire and sent it to the experts (See Appendix C). Once the first set of responses were received, the results were summarized and reported back to the experts in the form of a second survey (See Appendix D). This survey asked respondents to choose, on a five point Likert scale from Strongly Disagree (1) to Strongly Agree (5) if the critical issue/element should be included in the study. From these two iterations of the Delphi survey, the researchers reached a consensus of the critical sub-tasks of the launch process.

The objectives of the original Rand Corporation study, labeled "Project Delphi," were clear and simple - "obtain the most reliable consensus of opinion of a group of experts...by a series of intense questionnaires interspersed with controlled feedback." These justifications have changed little since the 1950's. The Delphi is used "when accurate information is unavailable or expensive to obtain, or evaluation models require subjective inputs to the point where they become the dominating parameter" (Linstone, 1975:10).

As pointed out in the literature review, space launch acquisition is fraught with politics and special interest. Opinion and subjectivity dominate virtually every aspect of government launch policy. A Delphi technique was chosen for the difficult task of sorting through the subjectivity in order to reveal those issues that most deserve attention. By consolidating the views of "the experts," researchers may use the Delphi as tool for narrowing and strengthening the primary research objectives.

As one author states, "When viewed as communication processes, there are few areas of human endeavor which are not candidates for application of Delphi" (Linstone, 1975:4). This same author lists several areas of application that suit the use of the Delphi Method. The following are examples of items on that list that were incorporated into this research:

- Gathering current and historical data not accurately known or available

- Delineating the pros and cons associated with potential policy options

- Putting together the structure of a model

- Exposing priorities of personal values, social goals (Linstone, 1975:4)

The Delphi techniques employed in this research were "modified" only in the sense that the survey instruments are tailored to the specific needs of the researchers. In principle, the Delphi that was constructed for this report follows the general framework of "conventional" Delphi methods. This framework is identified in the following quote:

> In this situation a small monitor team designs a questionnaire which is sent to a larger respondent group. After the questionnaire is returned to the monitor team, it summarizes the results and, based upon the results, develops a new questionnaire for the respondent group. The respondent group is usually given at least one opportunity to reevaluate its original answers based upon examination of the group response. (Linstone, 1975:5)

The initial questionnaire in the modified Delphi contained a single open-ended question asking the respondents to identify and define what they considered to be the critical elements and issues of the space launch acquisition process (See Appendix C). The intent of the researchers was to encourage the respondents to provide open, detailed opinions on the relevant subject. One expert on survey techniques points out that, "Open ended questions permit the respondent a great deal of latitude in verbalizing responses...are used by researchers in situations where the constraints of the closed-ended question outweigh the inconveniences of the open-ended question for both the researcher and the respondent" (Rea and Parker, 1992:44). Inconvenience in this context refers to increased effort on the respondent's part to complete the survey and increased difficulty on the part of the researcher in interpreting the results.

The second and final follow-up survey (See Appendix D) compiled and organized the results from the open-ended question in a short survey utilizing Likert scales. This implementation of closed-ended questions enabled the researchers to facilitate comparisons among respondents by standardizing alternative answers (Rea and Parker, 1992:39). The issues could then be rank ordered in terms of criticality.

Rea and Parker in Designing and Conducting Survey Research, state that, "The researchers should be relatively certain that the selected population possesses the knowledge and information required to fulfill the requirements of the research process" (Rea and Parker, 1992:39). As mentioned previously, the Delphi eventuates this requirement by focusing on "expert" opinion.

For this survey, 25 experts were selected in three primary ways. More than half of the respondents were referred to the researchers by a senior official in the Pentagon who is responsible for Air Force space launch acquisition. A smaller portion of the respondents were selected based on space launch acquisition literature they had written. Finally, some of the respondents were located through informal channels such as preliminary research phone calls and referrals by other respondents.

One expert on Delphi techniques has identified three categories of panelist that are desired when conducting this type of research. These include: Stakeholder - those respondents who will be affected by the research, Experts - relevant experts in the chosen subject area, Facilitator - respondents who can supply a more global view of the problem (Linstone, 1975:68). The demographics of the sample roughly satisfy this requirement. Of the 25 panelists, seven are Air Force Officers. Most of the military respondents could be considered stakeholders, and were employed by the Air Staff, Strategic Defense Initiative Organization, Space Systems Division, and Space Command. Ten of the panelists were non-military government employees from organizations such as NASA, the Department of Transportation, the Congressional Budget Office, and the Office of Management and Budget. The NASA personnel were primarily stakeholders, however, the others consisted of both experts and facilitators. The remaining eight respondents came from academia and industry. Industry personnel fit the stakeholder description, whereas academia was comprised of facilitators and experts.

Linstone, a expert on the Delphi method, has been quoted as saying: "Often the most fruitful parts of a Delphi process is assembling a panel, not simply for effort, but because it enhances your contacts" (Linstone, 1975:68).

The validity of this statement would surface throughout the many phases of interaction that the researchers had with the selected experts.

A mail-out format was selected as the medium for questioning respondents in both the open and closed-ended surveys. The researchers' reasons for opting to conduct written surveys are synonymous with the advantages listed in Rea and Parker. These include:

- Cost savings over personal interviews
- Convenient for the respondent
- Provides ample time for completion
- Maintains anonymity
- Reduced Interviewer bias (Rea and Parker, 1992:8)

Rea and Parker also recommend written follow-up notices at two and at four weeks after initial mail-out. They stress the importance of making your appreciation well known and frown on the use of target completion dates in these notices (Rea and Parker, 1992:85). The researchers in this study elected to send out a written follow-up ten days after the initial mail-out of the open-ended and closed-ended surveys (See Appendix E). Three weeks after the first follow-up, an attempt was made to contact every panelist who had not responded by telephone. These people were offered insight as to the requirements of the survey, and another copy of the survey if necessary. A second and final telephonic follow-up was conducted another three weeks later and addressed the same issues.

Some of the techniques recommended for increasing the response rate were implemented. Cover letters were all individually signed and every survey package included a self addressed stamped envelope. The instructions to the respondents were clearly written and distinctly separate from the survey itself (Rea and Parker, 1992:84). Both iterations of the Delphi employed these general techniques.

Case Study

A case study approach was selected as the research method of preference. According to Emory in Business Research Methods, "Case studies place more emphasis on a full contextual analysis of a limited number of events or conditions and their interrelations" (Emory and Cooper, 1991:142-143). This approach allows for an in-depth study of the complexities of space launch service contracting.

Case studies are particularly well adapted for research, if available data are historical or retrospective in nature, and a scarcity of data on the subject is a factor (Elmes and others, 1985:21). The dynamic subject of commercial space launch acquisition and contracting had a great deal of historical data. Data regarding the newer forms of full launch service contracts was scarce, however the information that was available was sufficient.

According to Stanford University's Dr. Kathleen M. Eisenhardt, a case study:

> ...is a research strategy which focuses on understanding the dynamic present within single settings...Moreover, case studies can employ an

embedded design, that is, multiple levels of analysis within a single study (Eisenhardt, 1989:534).

The cases examined in this research focus on the current Delta ELV launch acquisition procedures employed by the Air Force, NASA and SDIO. The critical issues and elements identified by the Delphi survey, serve as the multiple levels of analysis within the single study.

Many experts in qualitative research methods contend that the case study is an excellent "first look" at a problem (Starr, 1990:4). In this respect, case studies are useful in generating hypothesis concerning topics that are not well researched. The Government's policies/procedures for acquiring commercial space launches are a fruitful area for research. The case study methodology was deemed most appropriate because of its flexibility and responsiveness to new material.

Case Study Procedures. The methodical, analytical nature of case study research provided a well organized, concise comparison of government space launch acquisition policies and procedures. In her research, Dr. Eisenhardt identified eight steps of a process for building a theory using case study research.

> 1) Getting started, 2) Selecting cases, 3) Crafting instruments and protocol, 4) Entering the field, 5) Analyzing data, 6) Shaping hypothesis, 7) Enfolding literature, and 8) Reaching closure (Eisenhardt, 1989:533).

The researchers in this study employed a similarly rigorous procedure. The "getting started" phase involved an extensive literature search, and the establishment of contacts with several experts throughout the space launch industry, Government, and academia. These experts guided the researchers toward the particular cases to be studied. The researchers felt that the selected cases provided an excellent cross section of government space launch acquisition practices being utilized at the time of the study.

The evaluation of the selected cases required the development (crafting) of instruments and protocol. A Delphi survey was employed to determine the critical issues and elements on which each case was evaluated. This internal consistency across cases allowed the researchers to more easily make comparisons. The protocol set up to organize the case study data was a detailed comparison outline which was condensed into a summary cross-case matrix (See Appendix A). The vertical axis of the summary matrix includes the three government agencies that were analyzed, and the horizontal axis details the critical issues and elements of the space launch acquisition process as determined using the Delphi survey.

The researchers established contacts at each of the three government agencies to act as the focal points for data collection. Once the written contract data was completely collected, the researchers undertook the analysis of the contents as a focal point for the operationalization of each critical issue and element. After deciding on measurement standards for each issue, the researchers once again combed the available data, and attempted to complete the comparison outline to the fullest extent possible. Due to the dissimilarity of the data collected, certain outline blocks were initially left empty or partially filled. A search for additional data employed extensive telephone interviews with the data focal points. Objective questions were asked by the researchers in an effort to complete the outline.

The remaining steps of shaping hypotheses, enfolding literature and reaching closure were accomplished following the completion of the outline and matrix. Rather than hypotheses, the researchers made comparisons among the different agency approaches. These comparisons were intended to provide the most current description of the most critical elements of the space launch acquisition process and to aid the reader in discovering the difference in practices among the government agencies studied.

The research closed with a summary of the results, an analysis of the recent trends in launch acquisition procedures, recommendations, and suggestions for further research in the area.

Case Study Pitfalls. There are three distinct disadvantages, or pitfalls, that may occur when employing the case study method. Dr. Eisenhardt warns of the first disadvantage - information bias.

> The danger is that investigators reach premature and even false conclusions as a result of these information biases. Thus, the key to good cross-case comparison is

> counteracting these tendencies by looking at the data in many divergent ways (Eisenhardt, 1989:540).

The researchers' personal bias is this study was a continual subject of concern. Every possible effort was made to keep these inherent biases out of the research, in order to preclude drawing conclusions before all of the data was collected. Once the data was collected, the researchers examined it objectively, and reported only documented facts. Any conclusions reached in the latter part of the research were formulated only after extensive discussion.

Another weakness of the case study approach is that "the intensive use of empirical evidence can yield theory which is overly complex" (Eisenhardt, 1989:547). The empirical evidence obtained by the researchers in this study was comprised primarily of contractual data, and information gathered by telephone interviews. Efforts were made to ensure that the data was thoroughly documented, and presented in a clear, concise fashion. The resultant theories were presented in a similar manner.

The final pitfall in case study research identified by Dr. Eisenhardt is "...building theory from cases may result in narrow and idiosyncratic theory" (Eisenhardt, 1989:547). The three cases in this research represent standard Air Force and NASA Delta II launches, and an innovative SDIO Delta II launch. Because the results may not be applicable to all government space launch acquisition, the researchers have made every effort to keep conclusions broad, and to remind the reader of this limitation.

Data Sources

The competitive nature of the space launch industry makes companies reluctant to supply any information that may be considered proprietary (Rappaport, 1991). This research analyzed launches that were generated by public agencies (USAF, NASA and SDIO), and as a consequence, freedom of information standards make the data more readily available.

Archival data in the form of contract documentation and interoffice memoranda were collected for each launch in the study. Once collected, this written documentation was then segregated by critical sub-task and reviewed for completeness. If a sub-task was not adequately described by the archival data, deficiencies were noted and questions that addressed the needed information were generated. These questions were later compiled and used in personal interviews with the senior launch operation officials for the three launches. Any questions that could not be answered in detail by a senior launch official were noted. The launch official was further queried for contacts that could finalize the unanswered questions. These persons were contacted in order to complete the collection of data.

Data Analysis

Once the survey responses were consolidated and the critical elements and issues of the launch process identified, the researchers undertook an in-depth categorization of the data. First, each launch was identified to include a brief background statement. Next, the critical issues and elements of the launch process were applied to each case. The researchers depicted the similarities and differences of the three launch processes as they related to the critical issues and elements in outline form. A summary matrix was created from the resultant outline, and may be seen in Appendix A. Finally, the researchers offered potential explanations for the differences among the different government launch acquisition practices. They also made recommendations for areas which could be standardized and streamlined, and offered suggestions for additional research in the area.

IV. Findings

Overview

This chapter documents the survey and informational findings resulting from the research methodology outlined in the previous chapter. The research question and objectives detailed in Chapter I were answered and accomplished by analyzing the survey data, and reviewing the contractual data supplied by the three participating government organizations.

Chapter IV is separated into three basic sections. First, the results of the first iteration of the open-ended Delphi survey are presented and discussed. The second section covers the second-iteration of the Delphi survey. Finally, the third section uses the critical issues and elements of the space launch acquisition process identified in the first two sections to compare the three selected launch acquisition processes.

Delphi: First Iteration

Response Rate. The first iteration of the Delphi survey required participants to answer a broad question which asked them to identify the critical issues and elements of the space launch acquisition process (See Appendix C). As discussed in Chapter III, these open-ended surveys were sent out to 25 experts in the field of space launch. Of the 25 surveys mailed, 13 responses were received; a response rate of 52 percent. In an interview w:ith the Deputy Director of the Department of Commerce's Office of Space Commerce, Mr. Scott Pace, one of the researchers in this study discovered that this figure was acceptable. Mr. Pace said, "Considering this crowd, you did very well" (Pace, 1992). He noted that many of the individuals selected to participate in this study were high ranking officials in their respective organizations and were often too busy to work on surveys (Pace, 1992).

Results. Interpreting the results of the open-ended portion of the Delphi survey was a time consuming task. M v of the respondents used bullet/outline format to list their responses, while other individuals used essay format to convey their thoughts. The researchers organized the results based on certain key words or concepts that were repeated by the respondents. When one of these key words or concepts appeared on the answer form, the researchers noted it and kept a running tab on each category. Table 2 on the following page detailed the results of this survey. The number in parenthesis to the right of many of the responses indicated the number of respondents that mentioned the key word or concept. Those words/concepts without numbers were clarifying or sub-category responses that the researchers discovered in the survey comments.

Using this table of responses, the researchers organized the information into 13 separate categories which comprised the second iteration of the Delphi survey. The researchers were encouraged by several positive comments

Table 2

Findings from the First Iteration of the Delphi Survey

- Oversight/Insight (7)
  - -- Specification (8)
    - --- Milspec (vehicle manufacturing)
    - --- Performance (launch)
  - -- Launch Authority (4)
  - -- Security (3)
  - -- Pricing (3)

- Contractor Incentives
  - -- Contract Strategy (7)
    - --- Contract Type
    - --- Contract Clauses

- Liability (5)
  - -- Payload
  - -- Vehicle
  - -- Launch Facility
  - -- Third Person

- Insurance/Self-Insurance (5)
  - -- Reflight (6)
  - -- Third Party

- Launch Performance Considerations
  - -- Cost (9)
  - -- Reliability (4)
  - -- Scheduling (4)
    - --- Availability
    - --- Flexibility

- Payload Considerations (ie. criticality) (5)
  - -- Integration (3)
  - -- Orbit (3)

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regarding the criticality of this study, and the need for reform in the area of government acquisition of space launch services. Many respondents felt that the Government should do everything possible to encourage the development of the commercial space launch industry. Others stressed the importance of maintaining an indigenous space launch capability for the armed forces for national security purposes.

Delphi: Second Iteration

Response Rate. The second iteration of the Delphi survey was comprised of 13 categories and seven sub-categories of critical issues and elements of the space launch acquisition process (See Appendix D). Respondents were asked to score each category and sub-category on its relative criticality using a five point Likert scale from 1 (strongly disagree) to 5 (strongly agree). After each category, respondents were given space for additional comments.

The relative ease of the second survey may be a reason why the response rate was higher than for the first iteration. Of the 25 surveys sent out, the researchers received 16 responses; a response rate of 64 percent. Table 3 on the following page depicts the results of the second iteration of the survey. The individual item mean and mode were computed and listed after each item.

Results-Objective 1: Identify Critical Issues and Elements of the Launch Process that are Relevant to Each Approach. The researchers used the results of these calculations to decide which critical issues and elements of the space launch acquisition process to include in the analysis of the three agencies' contractual data. After examining these figures, the researchers concluded that all of the items included in the second iteration of the Delphi

Table 3

Findings from the Second Iteration of the Delphi Survey

1.	Degree of government oversight.	Mean=4.8125	Mode=5
2.	Requirement to build vehicle to military specification.	Mean=4.4375	Mode=5
3.	Use of performance specification for launch.	Mean=4.6875	Mode=5
4.	Final launch authority.	Mean=4.1250	Mode=5
5.	Range safety requirements and licensing.	Mean=4.0625	Mode=4
6.	Forms of contractor incentives.	Mean=4.0625	Mode=4
7.	Contractual strategy.	Mean=4.2000	Mode=4
8.	Liability with respect to:		
	-- Payload	Mean=3.8125	Mode=5
	-- Vehicle	Mean=3.8750	Mode=5
	-- Launch Facility	Mean=3.8125	Mode=4
	-- Personal and Property	Mean=3.7500	Mode=4,5
9.	Insurance requirements of the contractor.	Mean=4.1429	Mode=5
10.	Government self-insurance.	Mean=3.7300	Mode=4
11.	Cost for services.	Mean=4.2500	Mode=4
12.	Vehicle Reliability.	Mean=4.1875	Mode=4,5
13.	Payload considerations:		
	-- Criticality	Mean=3.5625	Mode=4
	-- Integration	Mean=3.5000	Mode=4
	-- Orbital Characteristics	Mean=3.4375	Mode=4

survey were worthy of inclusion in the research study. All of the calculated item means and modes calculated fell above the Neutral (Likert scale 3) category. This finding suggests that a consensus of the experts felt that most of the items were, to some degree critical. The following list summarizes the results of the second iteration of the Delphi, and was used as the outline by which comparisons were made across the three cases:

1 - Typical Payload Characteristics

2 - Oversight to Include:

    Contractor Required Tasks

    Contract Data Requirements Listing (CDRLs)

    Military Specification

    Insight vs. Approval

    Launch Authority

3 - Contractor Incentives

4 - Liability/Insurance

    Third Party

    Government Property

    Launch Vehicle

5 - Cost of Launch Service

6 - Reliability

Many of the additional comments listed by the respondents were very positive. They felt, for the most part, that the items listed in the second iteration of the Delphi were critical, and should be included when examining the contractual data. Some of these comments dealt with the "routine" nature of some of the items in the survey (ie. licensing and government self-insurance). They felt that while these items may now be routine, examining them could manifest significant differences among different agencies' acquisition practices.

Contract Comparisons

Results-Objective 2: Collect Data (In the Areas Identified as Critical Issues and Elements) on the Approaches, and Categorize the Data into these Critical Sub-Tasks and Objective 3: Analyze, Compare and Contrast the Processes Involved in Implementing the Different Approaches. This section of the research details the different critical issues and elements among the three different cases. Contract documentation was the primary source of information. Clarification on some points was accomplished using telephone interviews.

Typical Payload Characteristics. The Air Force MLV II Follow-on Contract (no. 91-C0031) for multiple Delta II launch services, primarily handles Global Positioning System (GPS) satellites - more frequently called NAVSTAR satellites. Future requirements for GPS include the employment of twenty-one of the $65 million NAVSTAR satellites at an approximate orbit of 10,900 miles and an inclination of 55 degrees. To this date, 14 Navstar Satellites have been placed into orbit. These satellites utilize hyperbolic navigation technology to assist with a multitude of civilian and military navigational purposes. The system determines the position and velocity of various objects on the earth and can measure distances and positions to within 53 feet (Prodigy, 1992). All of the GPS missions are launched from Cape Kennedy.

NASA's MELV (Medium Expendable Launch Vehicle) Contract NAS5-30722 handles the launch of research satellites such as Geotail, Wind, Polar, and Radar-Sat (Gunn, 1992). These NASA satellites perform missions that involve the measurement of high energy particles from the sun, and the interaction of these particles with the Earth's magnetic field (Gunn, 1992). The average cost of these satellites is $200 million (Gunn, 1992). NASA personnel have suggested that one of these launch missions is two-three times more complex than a standard Air Force GPS launch. This is partly due to more sophisticated orbital parameters (Gunn, 1992). These Delta II missions are also launched from Cape Kennedy.

The SDIO LACE-RME mission involved a single contract (SDIO84-89-C-0015) to launch a fairly complex dual payload Delta II launch from the ESMC. The primary purpose of the LACE spacecraft is "to provide a spaceborn target board to measure, as a function of time and spacial distribution, the absolute intensity of low energy ultraviolet, visible, and infrared laser beams transmitted from ground sites" (Strategic Defense Initiative Organization, 1989:1). The secondary mission is to "provide a spaceborn platform and supporting subsystems to carry out other SDI related experiments" (Strategic Defense Initiative Organization, 1989:2). LACE has been designed to measure the results of the Ground Based Laser (GBL) atmospheric compensation experiment concepts, and requires an altitude of approximately 295 nautical miles (Strategic Defense Initiative Organization, 1989:3). The satellite was produced at a cost of $129 million.

The RME spacecraft demonstrates accurate tracking and pointing with a laser relay platform in space (Strategic Defense Initiative Organization, 1989:3). It is "designed to reflect a ground-based laser from space back onto a ground target within stated accuracy limits (Strategic Defense Initiative Organization, 1989:1). Its required orbit is approximately 470 kilometers (Strategic Defense Initiative Organization, 1989:12). The cost of the RME spacecraft is $121 million (Strategic Defense Initiative Organization, 1989:1).

Oversight. Oversight issues, as they pertain to each of the contracts discussed previously, are addressed in this research in a number of different ways. Significant contractor required tasks and submittals have been listed and briefly described for each contract. The researchers have also attempted to compare CDRLs from each contract. The third method of comparison examines the contracts for reliance on military specification and standards. The use of "insight" vs. "approval" in relation to contractor required tasks is a fourth method of compaiison. Finally, the contracts are compared with respect to final launch authority.

Contractor Required Tasks. The following section contains a partial list of plans, programs and tasks that the contractor is required to implement and maintain as required in each contract. Advocates for the commercialization of space launch procurement have called on the Government to purchase "launch services". This would entail the use of a performance contract specification. In its purest form, this specification would require that the Contractor place a payload in a given orbit for a given price, regardless of how the Contractor chooses to do this. Generally, as a contract mandates more tasks and contractor implemented programs, the specification moves away from this basic performance orientation.

The requirements for Air Force MLV (Medium Launch Vehicle) Contract 91C0031 are as follows:

- System Design Baseline - non-recurring and mission peculiar analyses, and qualification history of the launch vehicle systems, subsystems, and components (Space Systems Division, 1991:27).

- Mission Design tasks:
    - Trajectory Simulations
    - Guidance and Targeting Analyses
    - Verification Load Cycle
    - Propulsion Analysis

- Range Safety - "The contractor shall implement a plan to integrate the range safety aspects of new Delta II missions."

- Collision Avoidance Maneuver Analysis - to demonstrate that the vehicle will not impact nor contaminate the spacecraft after separation.

- RF Systems Analysis

- Independent Readiness Reviews - support as necessary prior to the first Delta II launch of each mission peculiar payload.

- Payload Integration tasks:
  - Interface Design - Contractor will hold mission peculiar PDR and CDR.
  - Interface Fixture - "The contractor will produce and provide an interface fixture of the Delta II for fit checking the payload.

- Production related tasks:
  - Prepare data packages on flight hardware to support hardware pedigree reviews.
  - Conduct internal turnover reviews and data package reviews to culminate in a vehicle on-stand/history review presented to the government.
  - Conduct a flight readiness review one week prior to launch that finalizes vehicle readiness to proceed toward launch.

- Launch Site tasks:
  - Support the Government in any environmental impact analyses.
  - Provide a "system integration" capability to support system level reviews of special interest problems.
  - Support Mission Readiness/Launch Readiness Review process.
  - Post-Flight Mission Review - within 45 days of each launch, identify any anomalies mishaps or problems.
  - Conduct an aging and surveillance program - ensures rocket motors and ordinance meet specifications and standards.
  - Systems Effectiveness Program Plan - Encompasses Quality Assurance, Reliability, Maintainability, Specialty Engineering, Contamination Control, Corrosion Control and Parts, Materials and Process.

- Conduct an Integrated Logistics Support (ILS) program to satisfy all logistics requirements identified in the contract.

- Develop and Implement a Delta II System Security Engineering (SSE) program - to address security concerns - consists of:
  - System Security Plan (SSP)
  - Personnel and Information Security Program
  - Operations Security Program
  - ADP Security Program
  - System security threat and vulnerability trade analysis

- Safety - Contractor shall conduct a system safety program

- Conduct and present to the Government quarterly program review and monthly management reviews.

The requirements for the NASA MELV Contract are less numerous than the Air Force contract, and are listed below:

- Briefing Manual of the Launch System - summarizes the design, fabrication, integration, testing, critical hardware and software identification, and operational features of the launch vehicle (National Aeronautics and Space Administration, 1990:3).

- Mission Specification Document - incorporates all mission peculiar and payload requirements. Is incorporated into the contract (National Aeronautics and Space Administration, 1990:7).

- ELV Payload Planners Guide - describes the vehicles performance capability and design restraints, the function and location of individual systems, information on management organization, user's requirements with regard to integrating the payload and documentation (National Aeronautics and Space Administration, 1990:7).

- Special Task Orders - Contractor may be required as a standard service, "to perform special studies and analysis in support of firm and future missions contemplated under this contract" (National Aeronautics and Space Administration, 1990:8).

- Performance Assurance Implementation Plan (PAIP) - includes detailed plans for System Safety, Reliability, Quality Assurance, Inspection, Electrical, Electronic, and Electromechanical Parts Control, Materials and Process Control, Contamination Control, Hardware Configuration Management, and Software Product Assurance. This document is approved by NASA and incorporated into the contract (National Aeronautics and Space Administration, 1990:14).

The list of requirements for the third case, the SDIO LACE-RME Launch Contract, contain fewer requirements than for both the Air Force and NASA contracts. These requirement are as follows:

- Launch Resources Commit Review - "The purpose of this review is for the Contractor to demonstrate to the government that the ELV and associated launch services are on schedule for launching the LACE and RME payloads" (Strategic Defense Initiative Organization, 1989:6).

- Mission Readiness Review - Approximately 14 days prior to launch, the contractor participates in this review by summarizing the status of its ELV and launch support systems. The Contractor attests to the readiness of launching the mission (Strategic Defense Initiative Organization, 1989:6).

- Vehicle Flight Readiness Review

- Post Launch Final Report - Includes final mission briefings, lessons learned; final trajectory and orbital reports; and final anomaly and significant event reports.

Contract Data Requirements Listing. The CDRL is a listing of all the contractor's documentation and planning requirements as stated in the contract. The CDRL also identifies proper distribution channels, frequency of accomplishment, number of copies, and approval/acceptance requirements. A more extensive and complex CDRL listing will naturally lead to a greater paperwork requirement for the Contractor. The following section provides a summary of the contract CDRLs for the three cases studied.

The Air Force MLV II Follow-On contract contained 83 CDRLs (See Appendix H for a complete listing). Every CDRL mandated a signed DD Form 250 in order to verify government acceptance of the submittal. Twenty five of the 83 CDRL's also required a form of government approval. Many of the CDRLs have frequencies that fall into the "As Required" category. Approximately 44 of these CDRLs are mandated when the Contractor is launching a uniquely new spacecraft (other than GPS) under the contract.

The researchers were unable to obtain copies of the NASA MELV contract CDRLs due to a court injunction concerning the release of select MELV information (Marcus, 1992:22). However, procurement people at NASA did allude to the fact that there are approximately 50 CDRLs in the MELV contract.

The SDIO LACE/RME launch contract contained 12 CDRLs. None of these required DD Form 250 acceptance or government approval (See Appendix I for a complete listing of the SDIO LACE-RME CDRLs).

Military Specification. All three contracts were compared with respect to the degree of government specification reliance. Traditionally, a more prolific use of mil-spec and mil-standards equates to stricter requirements, greater levels of oversight, and sometimes higher overall costs. Specifications and standards in a space launch scenario, should be examined from two general views; the production of the vehicle, and the launch services themselves. From the standpoint of production, all Delta II launch vehicles are identical. They are manufactured to the same specifications (most of which are Air Force), are processed on the same assembly lines, and are subject to the same quality program (Smith, 1992). The use of military standards following production, however, differs between the contracts. The following section identifies the differences in mil-standard usage between the contracts.

The Air Force MLV II Follow-On contract contained 30 military and federal standards as compliance documents (See Appendix F for a complete list). The researchers were not able to identify exactly which standards apply to production and which apply to launch services, however, the titles do provide some insight. It appears that a majority of the standards apply to the production of the vehicle.

Analyzing the NASA contract, the researchers identified seven references to military standards in the MELV contract (See Appendix F). Because they were unable to obtain the contract in its entirety, there remains a possibility that some standard are not listed in the appendix.

The SDIO LACE-RME contract contained only one mandatory military standard. The standard dealt with clean room and work station requirements (See Appendix F).

Insight vs. Approval. The NASA and SDIO contracts contain sections that list contractor tasks that require either "insight" or "approval." Both documents use similar definitions for these terms. Insight includes Contractor attendance at meetings, reviews, and tests, and obtaining documentation for certain mission reviews. The Government will provide inputs and comments on these items over which it has insight, but will not have the right of approval (National Aeronautics and Space Administration, 1990:33).

> Approval is defined as providing authority to proceed and/or formal acceptance of requirements, plans, tests, or success criteria in certain areas. Where approval is required, the Contractor shall submit the necessary

documentation to the...Contracting Officer (National Aeronautics and Space Administration, 1990:33).

The Air Force contract did not contain a section listing the tasks that required insight and approval. In fact, the word insight was not used in the contract verbiage. Therefore, the researchers limited their comparison to the NASA and SDIO contracts. The detailed insight vs. approval requirements may be found in Appendix G.

Launch Authority. The Government maintains the final launch authority for Air Force, NASA, and SDIO launches.

Contractor Incentives. This section on contractor incentives focuses on the payment procedures implemented in each contract. The relationship between payment and contract performance is paramount.

The Air Force MLV II Follow-On launch contract was awarded on 12 August 1991 as a Firm Fixed Price - Award Fee Contract. The Contractor received the full contract price for a mission if the launch is deemed a "Mission Success" by the contract PCO. Mission success is defined in the contract as the insertion of the "assigned spacecraft in the prescribed orbit under the conditions specified in the Delta II specification and applicable approved Interface Control Document (ICD)" (Space Systems Division, 1991:42). The Contractor has to accomplish this feat without causing damage to the spacecraft due to Delta II environments (Space Systems Division, 1991:43). A "Degraded Mission" results when "a payload has suffered a partial loss of mission function or lifetime as a result of a launch vehicle malfunction, but is nevertheless partially useful (Space Systems Division, 1991:43). In order to be degraded, the payload has to maintain at least 50% of its functional capacity or useable lifetime (Space Systems Division, 1991:44). If the mission is categorized as degraded, then an algorithm is used to calculate a partial refund of the contract price. If the degradation is less than 30%, then the refund will not be required (Space Systems Division, 1991:45). A "Mission Failure" results when the satellite's functions or lifetime have been reduced by more than 50%. This may trigger a reflight provision in the contract (See Liability/Insurance section for more detail).

The Contractor can earn up to $3,150,000 in award fees during a three year period of performance (Space Systems Division, 1991:77). A board consisting of government personnel rates the contractor's performance in five performance areas including: Program Management, Subcontract Management, Manufacturing, System Effectiveness, and Launch Site Operations. Each performance area is weighted, and a formula is used to determine how much of a possible $1,050,000 will be awarded for a given period (Space Systems Division, 1991:2-3). NOTE: The previous Delta II contract, 87C0005, awarded a 3 million dollar incentive fee for each successful launch. If contractor error resulted in a failed mission, the penalty would consist of the forfeiture of all previous incentive fees with interest. In addition, the Contractor would no longer be eligible for future award fees.

The NASA MELV Contract was awarded on 14 November 1990, as a Fixed Price - Award Fee contract. In addition to the agreed upon fixed price of a launch, the Contractor receives $355,000 for the first Full Mission Success (a launch that met the criteria spelled out in the in accordance with the contract's Vehicle Success Criteria). The Contractor receives a bonus of $1,000,000 for each successive Full Mission Success as long as the string of full successes is not broken. If the string is broken, the $1 million bonus resumes upon the second consecutive full mission success. The Contractor shall pay the Government $5,333,000 for a Failed Mission (a launch that meets less than 50% of the Success Criteria). For a Partial Mission Success (exceeds 50% of the Success Criteria), the Contractor must pay the government $2,666,000 (National Aeronautics and Space Administration, 1990:39).

The SDIO LACE-RME launch contract was awarded on 31 January 1989, as a Fixed Price Contract. The final launch price was locked in at the time of award. The agreement held that the Contractor could invoice for up to $4.5 million of the $35 million in Contract Line Item Number (CLIN) 0001 immediately after award. Up to 50% of the remaining total of CLINs 0001 and 0004 can be invoiced upon satisfactory completion of the Launch Resources Commit

Review. NOTE: as stated in the contract: "The balance of the payment may be invoiced 30 days after vehicle launch and payment will be made whether or not the launch is deemed a success" (Strategic Defense Initiative Organization, 1989:3).

Liability/Insurance. Government and Contractor liabilities during the launch process are examined from three aspects; liability with respect to third parties, government property (including the spacecraft), and launch vehicles. Insurance requirements are also included in this section.

The Air Force third party insurance requirements in the MLV II Follow-on contract require the Contractor to carry $1,000,000,000 of coverage. The Government then indemnifies the Contractor for any additional amount that may be required, or equitably reimburses the Contractor for additional coverage over and above $1 billion, if indemnification is not approved by the Secretary of Defense (Space Systems Division, 1991:59). Indemnification was approved in this circumstance (Arnold, 1992).

The Air Force's Government Property Clause for Fixed Price contracts (Alternate I) is cited in the contract. According to lawyers at Space Systems Division, this clause only comes into play if gross negligence on the part of the Contractor's upper management is the reason behind the damage to the property (Arnold, 1992). Through the approval of the indemnification for unusually hazardous risks under

Public Laws 85-804, the Government self-insures its spacecraft and the launch facilities for each launch.

One mechanism that the Government does have to protect itself in the event of a failed mission, is a reflight provision. A mission that is deemed a "failure" can result in a reflight at no cost to the Government. The reflight can be of the same mission type or can also be applied to a future contract or mission involving similar services. Mission failure occurs if the launch vehicle caused the spacecraft to fail in the accomplishment of less than 50% of its prescribed mission regardless if the spacecraft reached its prescribed orbit (Space Systems Division, 1991:43-44).

With respect to the Air Force's launch vehicle insurance requirements, the Contractor is fully liable for the launch vehicle.

The NASA MELV minimum third party insurance requirements, as stated in the contract, are: 1) "shall protect the Contractor, and, to the extent insurance may be obtained without additional cost to the Government, it shall protect the Government..." 2) "The Contractor shall propose an amount of insurance that is available in the world market at a reasonable premium cost" (National Aeronautics and Space Administration, 1990: 49-51). The Government can take two approaches to this third person insurance. First it can authorize the Contractor to purchase additional insurance and indemnify the Contractor for any liability in excess of such insurance. The Contractor is fully reimbursed for this additional insurance. The second approach is that the Government simply indemnifies the Contractor for any liability in excess of its insurance coverage (National Aeronautics and Space Administration, 1990:50). Indemnification was the chosen route for this contract (Arnold, 1992).

The NASA contract also utilizes the Government Property Clause for Fixed Price contracts (Alt I) for its government property protection requirement. NASA, however, also makes use of a "Cross Waiver of Liability." This clause has been written into the contract in order to release the Contractor of all liability with respect to the payload, and the Government's liability with respect to the launch vehicle, prior to launch (National Aeronautics and Space Administration, 1990:2). NASA also makes use of the clause in NFS 18-52.250-70 entitled "Indemnification Under Public Law 85-804" -- NASA Contracts, published in September, 1989. This provision releases the Contractor from liability with respect to government property during the launch, ie. NASA self-insures the payload.

The SDIO LACE-RME Contract includes no provisions in the firm-fixed price for third party liability insurance. At the time of award, the Contractor maintained $1.1 billion worth of insurance (Strategic Defense Initiative Organization, 1992:1). The Government held the option of fully indemnifying the Contractor for any liability in excess of this amount, or forcing the Contractor to purchase any additional desired insurance and reimburse it for the amount of the premium (Strategic Defense Initiative Organization, 1989:12). Indemnification was approved on 4 January 1990 by the Secretary of Defense, and FAR Clause 52.250-1 "Indemnification Under Public Law 85-804 (dated APR 1984)," was added to the contract.

Had the Contractor been required to purchase additional insurance to cover the liability of the government property during the launch, it was estimated that the necessary coverage would be $500,000,000 at a premium of $500,000, for which the Government would have to pay extra (Strategic Defense Initiative Organization, 1992:2). This requirement disappeared when the indemnification clause was included in the contract.

In the SDIO contract, liability for the vehicle rests solely with the Contractor.

Cost of Launch Services. Exact cost figures for the Air Force MLV II Follow-on were not available due to a pending court injunction (Gunn, 1992). Initial contract award was for the advanced procurement, production, and launch service costs associated with five missions, plus the advanced procurement costs of three additional vehicles. The total price was $193,283,529 (Space Systems Division, 1991:1). When the total is divided into the five missions on the basic contract, the per launch contract cost comes to a value of less than $38.66 million considering the cost of the advanced procurement. One Air Force source placed the total contract value at approximately $860 million for 20 launches - or $43 million dollars per launch (Tasienski, 1992). The contract was awarded 12 Aug 1991.

One interesting aspect of the contract involves a preferred customer clause. The clause states, "The Contractor certifies that the prices offered for those items of supply and/or services (whether or not separately identified) in the contract and/or in accordance with SCR H.12 are no higher than any prices charged to any other customer, including all public, private and Government agencies" (Space Systems Division, 1991:29). The Contractor has to justify in writing, his reasons for giving any public or commercial entity a better price.

The NASA Cost figures are currently not releasable due to a court injunction. Background research indicates that the launch costs are comparable to those of the Air Force MLV II Follow-on contract.

The CLIN figures for the SDIO LACE-RME launch were listed in the contract as follows:

- CLIN 0001 - $35,000,000 for launch services
- ClIN 0004 - $3,000,000 for range support

$38,000,000 total (Strategic Defense Initiative Organization, 1989:2)

Line item 0004 for 3,000,000 was established in order to order to provide the Contractor with sufficient funds to pay other government organizations for necessary support at ESMC.

Reliability. The latest Delta launch on 7 July 1992 marked the 22nd success in a row for the upgraded Delta II rocket (Prodigy, 1992). Of the last 22 launches, 18 have been Air Force launches, three have been NASA launches, one has been a SDIO launch (Smith, 1992). The Delta has an impressive reliability history with the following record:

Last six years: 22/22 Successful launches (100%)

Last 15 years: 75/76 Successful launches (98.7%)

32 year history: 198/210 Successful launches (94.3%)

The last Delta failure occurred 7 years ago when an Air Force launch slipped off the pad (Smith, 1992).

Chapter Summary

This chapter presented the findings of the research. In it, the researchers developed a list of six critical issues and elements of the space launch acquisition process from the responses of both Delphi survey iterations. These issues and elements were then used to compare the Air Force, NASA, and SDIO approaches to space launch acquisition. The researchers found a disparity among the approaches in several areas. These differences are summarized and discussed in greater detail in Chapter Five.

V. Conclusions and Recommendations

Overview

Chapter V closes this research project by summarizing the analysis in Chapter IV, and offering explanations as to possible reasons for the differences among the approaches. First, a significant difference is identified, and then a possible reason for the existence of that difference is postulated by the researchers. Recommendations for more efficient, effective and responsible space launch acquisition procedures are offered. Finally, areas for additional research are presented.

Objective 4: When Possible, Offer Explanations for the Differences Among the Approaches

Typical Payload Characteristics. The intent of the comparison is to determine the relative expendability of the payload. This considers mission complexity, cost, and national security issues. Many Government officials have indicated the need for more oversight involving missions with high complexity, costly payloads, and national security implications.

The Air Force Delta Launch Contract is primarily concerned with launching one satellite, the Navstar/GPS. The standardization that is a result of repeated missions has contributed to decreased mission complexity. The relatively low cost of the satellite ($65 million) coupled with the fact that the system is due to employ a total of 21 satellites and spares, adds to the increased expendability of each mission.

Virtually every payload, thus nearly every launch, under the NASA MELV Contract is unique. Although many scientific payloads do not necessarily have national security implications, most of these one-of-a-kind payloads are expensive. A lost payload can lead to the demise of a program. For these reasons, many NASA missions may be considered to be less expendable than Air Force GPS payloads.

Like many of the NASA missions, the SDIO LACE/RME was a one-shot, highly complex, expensive mission. Unlike NASA, LACE/RME was directly linked with national security concerns. For these reasons, LACE/RME would be considered the least expendable payload of the three cases studied.

It follows that critical missions like LACE/RME should command more oversight throughout the procurement process. As the following analysis indicates, the researchers have perceived this to be the opposite.

Oversight. Of the three cases studied, the Air Force MLV II Follow-On Contract appeared to support the most government involvement and oversight.

Air Force Contractor required tasks were listed in greater number and detail than in both the NASA and SDIO launch contracts. As listed in Chapter IV, the Air Force contract mandated almost every aspect of the launch process.

The NASA MELV contract focused on two critical Contractor requirements, both of which require Government approval and inclusion into the contract as compliance documents. The Mission Specification Document serves as a type of Contractor-prepared statement of work for the payload interface, environmental and vehicle system requirements. The other significant NASA document is the Performance Assurance Implementation Plan (PAIP). It is a Contractor-developed/Government approved document that deals with oversight functions such as safety, configuration management and reliability. The Government approves both of these requirements, and incorporates them into the contract. Through these documents, NASA is able to insure a level of oversight, without specifically noting individual requirements like the Air Force.

The SDIO contract contained the fewest Contractor required mission tasks. The tasks that were listed involved general information for pre and post flight reviews. There was an obvious departure from Government mandated oversight in the launch process.

The comparison of Contract Data Requirements Lists among the three contracts produced similar results. The Air Force, once again, posted the highest number of Contractor required submittals. All of these mandatory documents required acceptance via a DD Form 250, and many required Government approval. This burden is somewhat eased by the fact that many of the 83 CDRLs are only required when the Contractor is launching a unique payload.

Although, the NASA CDRLs were not available, the existence of 50 such submittal requirements approximates the Air Force contract documentation work load. This is especially true if one considers that nearly every NASA mission is unique and that many of the submittals will have to be altered significantly or reaccomplished for each launch.

The SDIO LACE/RME launch contract made use of only 12 CDRLs. None of these submittals required DD Form 250 acceptance or approval. In general, the intent of the CDRLs was to foster communication between the Contractor and the Government, and not dictate requirements. The results of the "insight vs. approval" comparison also support this posture.

Before comparisons are drawn concerning reliance on military specifications and standards, it is important to note that every launch is subjected to many of the same requirements. Specifically, all Delta II vehicles are manufactured under the same quality processes, and to identical specifications (Dickman, 1991). Many of these standards have been implemented by Air Force contracts throughout the history of the system. In fact, McDonnell Douglas often cites the compliance with military specifications as a selling point for prospective commercial customers (Smith, 1992).

The bottom line is that the Air Force has provided the direction for the vehicle production. This is probably due to the fact that the Air Force helped to develop the Delta vehicle, and has continued to be the largest customer for the Delta market. These realities are reflected in the disparity of military standard reliance (Air Force-30, NASA-6, SDIO-1) among the three contracts. The Air Force total is largely comprised of production standards. It is, therefore, difficult to judge degrees of oversight from a military specification/standard perspective. It is also difficult to determine which standards are an unnecessary burden on the Contractor, and which standards have contributed substantially to the overall success of the Delta system.

The Government holds final launch authority in all three cases, whereas, in a commercial launch, the service provider would make final decisions as to launch go/no-go. This is most likely due to the Government's insistence on self-insuring the payloads, and its ownership of all facilities. It would be impractical to give the Contractor the final say when it holds virtually no liability for the success of the mission. This is in contrast with a commercial launch, where the service provider is typically liable for the payload and launch facilities.

Throughout the analysis, it has been readily apparent that the Air Force launch contract interjects Government involvement and oversight into the launch process to a greater degree than the NASA and SDIO contracts. The effect of the Air Force practices is to move away from the procurement of launch services in the pure sense (placement of a payload into a specified orbit for firm price). The SDIO contract, on the other hand has implemented a bona-fide performance specification for the LACE/RME launch. From an oversight perspective, SDIO has utilized commercial space launch procurement techniques. NASA's insistence on documents such as the PAIP have placed it in position somewhere between the Air Force and SDIO on the oversight spectrum.

The most interesting aspect of the comparison in government oversight materializes when the mission and payload characteristics are considered. The Air Force contract deals with the most expendable payloads and the most standardized launch process of the three cases studied. However, it is the most oversight intensive document. Conversely, the oversight-scarce SDIO launch involved the least expendable payload and a fairly sophisticated launch process.

It is safe to conclude that the Air Force has not moved as quickly to commercialize its space launch procurement practices as NASA or SDIO. The reason behind this lag are more difficult to pinpoint. One plausible explanation is that the Air Force has not experienced the same degree of legislative pressure that NASA has. Most of the laws and executive policies handed down since the Commercial Space

Launch Act of 1984 have given the Secretary of Defense the authority to avoid Commercial Space Launch practices in accordance with national security concerns. NASA has not had as much flexibility in this arena.

In this same light, the question now arises, "Why has SDIO chosen the commercial route, when it too had the option of utilizing practices of a less than commercial nature?" In a nutshell, SDIO has cut corners in order to save money at the organizational level. The Air Force could easily launch the SDIO payloads as options to the existing Air Force Delta II launch contract. SDIO has chosen to purchase their launches themselves, and pocket the money that they would have been required to pay the Air Force for its administrative burdens. The assumption that SDIO makes, is that it can purchase the launches with lower administrative expense then the Air Force can. This becomes possible when streamlined commercial-like acquisition procedures are used.

Contractor Incentives. A reasonable hypothesis would hold that a launch process with less oversight would rely on greater levels and varieties of contract/payment incentives to ensure successful performance. Conversely, a contract will relatively higher levels of oversight could get by with less incentivising and still produce a desired outcome. This expected correlation was exactly reversed for this case study. The Air Force contract contained the strongest form of Contractor incentive of the three cases. This was the requirement to re-fly any mission that failed as a result of

Contractor error, at no cost to the Government. This translates into the potential for a contractor loss of approximately $40 million. The NASA contract could penalize the contractor up to $5,330,000 for a mission failure but could not request a reflight. This could be due to the unique nature of each NASA launch mission and payload. Reflight may be a nonviable option for NASA.

In the Air Force and NASA launch agreements, the Contractor could also earn additional sums of money for successful or exceptional performance. The Air Force award fee criteria focused primarily on the processes that the Contractor implements throughout many phases of the contract. If, over time, the Contractor does an exceptional job of complying with the standards that the Air Force has mandated in the contract, the Contractor stands to receive the full $3 million dollar award fee.

NASA's positive incentives differ substantially from the Air Force's. A $1 million dollar bonus is paid for each consecutive full mission success. The award fee is only tied to the final performance of the launch. NASA appears to be more concerned with the outcome of the launch and less concerned with execution of certain launch processes. This is a step in the direction of commercial launch practices.

The SDIO LACE/RME procurement did not employ any special contractual incentives. The Contractor was guaranteed the full contract price regardless of the mission outcome. In fact, the Contractor was immediately paid $4.5

million dollars at contract award. The reasoning for these payment procedures are not listed in the contract. Interestingly, the Advanced Payment Clause which would normally be required in this circumstance, was also missing.

The ramifications of the lack of incentives in the SDIO contract are discussed in further detail in the following section on liability.

Liability/Insurance. With respect to third party liability, all three cases have chosen similar paths. In each contract, the Government relies on the Contractor's current insurance policy to form a base level of coverage, then the Government indemnifies the contractor for any liability over the amount of this coverage. In each circumstance, the Government would have been required to reimburse the Contractor for any additional insurance coverage over the amounts that the Commercial Space Launch Act requires the Contractor to carry. The Government has obviously decided that the risk is not great enough to justify the extra expense.

A similar indemnification process occurs with regard to Government property (the most notable of which is the payload). In all three cases the Government has self-insured the payload and launch facilities. The alternative to this is to pay a higher price per launch to handle the additional insurance requirements that would be forced upon a liable contractor. In the Air Force and NASA launch scenarios, the Contractor still has a significant incentive to carry out the mission to a successful conclusion, even though it has no liability for a lost payload. The Air Force can require a no-cost reflight following a mission failure. A failure can then cost the Contractor upwards of $40 million dollars for the cost of the launch services. It is also likely that the Contractor will lose a significant percentage of the three million dollar contract award fee. NASA, on the other hand, simply refuses to pay the contractor $5.3 million dollars of its expected revenue when the mission is lost due to contractor error.

The SDIO LACE/RME contract does not, however, use mission success as a factor when determining how much to pay or penalize the Contractor. The Contractor receives the full contract price no matter what happens to the payload or facilities. Because, the LACE/RME launch contract also released the Contractor of liability for the payload, there is question as to what incentives are left to steer the Contractor towards a successful conclusion to the mission. This dilemma is accentuated by the fact that the SDIO launch contained relatively little Government involvement or oversight.

Cost of Launch Services. A court injunction limited the researchers' comparison of the three agencies' cost data. The Air Force's bottom line cost figure of $193,283,529 does not provide a breakdown of costs for services, support, or administration, and it includes advanced procurement costs for future missions. It is, therefore, not possible to accurately appraise cost per launch.

NASA officials were adamant about not providing any cost estimate, to include bottom line cost, due to an injunction specifically targeted at the MELV cost data.

The researchers were able to obtain the SDIO cost data, which places the cost for services at $35 million and range support at $3 million.

The researchers originally hoped to try to develop a relationship between the cost of launch services, and amount of Government oversight in the contract. Without detailed cost breakdowns, the researchers were unable to accomplish this task, but feel it is a fruitful area for further research.

Reliability. The Delta II launch vehicle is an extremely reliable ELV, especially in recent history. The relatively small population of Delta II launches and the fact that virtually every launch has been a success, make it difficult to draw a correlation between reliability and procurement method. However, the level of oversight and use of military standards throughout the production of the vehicles, may be a driving force behind the system's success. From the data collected, it is impossible tell which standards and practices might contribute to reliability and which have no affect on system performance.

Finally, one of the most significant factors that may affect the system's reliability is that the Delta has had the opportunity to mature over a span of 3 decades.

Recommendations for Acquisition Process Improvement

The Air Force, NASA, and SDIO Delta II launch acquisition process may not be individually classified as "good" or "bad," "efficient" or "inefficient," "commercial" or "non-commercial." Each of the agencies' processes has aspects that may be desirable if developing "an ideal" Government launch procurement process.

In the following section, the researchers offer some process aspects that they feel would contribute to a more efficient, effective, and responsible approach to the acquisition of Government space launch. These aspects are a compilation of current Air Force, NASA and SDIO practices.

Streamlined Procurement Methods. By employing the streamlined procurement methods prevalent in the SDIO contract, such as decreased Contractor surveillance, fewer paperwork requirements, and the use of a performance oriented specification, the Government would be able to ease the Government and Contractor administrative burdens. It would essentially acknowledge that the Contractor is indeed the true expert. This would allow the Contractor the flexibility to innovate, and thus become more efficient. This increased efficiency could be transferred to the commercial sector, and foster the development of the industry.

Reflight and Award Fees. There are many ways for the Government to inspire successful performance. Reflight provisions and award fees serve as a potent stimuli for Contractor behavior. The Air Force MLV II reflight requirements are a desirable incentive because it could potentially affect the Contractor's profitability. NASA's performance based award fee is also an indispensable incentive that could work in conjunction with a reflight provision. Performance is the bottom line. These positive and negative incentives insure it, while helping build improved, and more trusting relationships with Contractors. This can only lead to more efficiency and effectiveness.

Government Self-Insurance for Payloads. Payload insurance can place a significant monetary burden on the Contractor, which is ultimately passed on in the form of higher fees to the Government. Self-insurance is an acceptable risk for the Government if reliability remains consistently high. However, Government self-insurance must be used in conjunction with Contractor incentives in order to manifest the Contractor's stake in the successful performance of the mission.

The Role of the Air Force. The Air Force is by far, the largest, most influential customer in the domestic space launch market. The Air Force effectively drives the Commercial Space Launch Industry. Therefore, the Air Force must also play the lead role in developing more efficient, effective, and responsible space launch acquisition processes.

Areas for Further Research

It would be beneficial to conduct a case study that concentrates on the oversight issues only. This study could be conducted in greater depth by obtaining and analyzing the full spectrum of Contractor required submittals for four types of launch. The three launch types in this study could be compared against a private commercial Delta launch. It would also be beneficial to consider the differences between the public and private launch strategies in terms of insight versus approval.

A case study tracking the evolution of Air Force or NASA Delta or Atlas launch acquisition strategies would also be beneficial. Researchers could make use of the critical issues and elements and attempt to predict trends toward commercialization of the launch process.

One question that most certainly needs to be addressed is, "How is Space Command's establishment as the primary player in the ELV arena going to affect current launch acquisition practices?" A researcher should analyze the potential effects of Space Command initiatives and directives in relation to the critical issues and elements.

A researcher could measure and compare the differences in organizational thinking as it relates to public space launch ie. How do NASA officials or Academia view launch acquisition as compared to Air Force, Navy, or other government bureaucratic and legislative institutions.

Recent legislative efforts have focused on the perceived need to commercialize public launch acquisition. This would place more of the liability for mission success in the lap of the Contractor. A question that must be considered is, "how will contract insurance costs be affected?" The researcher could analyze levels of liability, insurance coverage, and premiums from a historical perspective.

A comprehensive survey of DoD and McDonnell Douglas Engineers could be accomplished to determine which Military Standards significantly contribute to the reliability of the vehicle. The survey could address the tradeoffs between the inherent costs of a Military Standard and the resultant reliability benefits.

Researchers could also conduct a case study that focuses on the payload procurement. This study could involve the identification of the crit_cal issues and elements of payload acquisition with a subsequent cross-comparison of different government agencies' acquisition methods.

The final area for additional research deals with the issue of government property. Researchers could develop a fictional scenario in which a commercial launch attempt destroys a substantial amount of government and private property. The researchers could then investigate possible paths that the disaster would take through the federal legal system. Questions concerning the sufficiency of the legislation, and liability and insurance issues could be addressed.

Chapter Summary

Chapter V summarized the results presented in Chapter IV, and offered explanations for the differences among the three cases studied. The researchers identified significant variations in the three agencies' approaches to launch procurement. These differences were most apparent in the areas of oversight and contractor incentives. Specifically, the Air Force Delta II Launch Contract relied more heavily on oversight than the SDIO LACE/RME Contract and the NASA MELV Contract. The Air Force Contract also made use of contractor incentives to a greater extent than the other agencies. This was reflected in the reflight provision of the Air Force Contract. In contrast, the SDIO LACE/RME Contract contained no specific contractor incentives.

Considering these differences among the three agencies, the researchers offered recommendations for acquisition process improvements. This hybrid approach included more stringent use of contractor incentives, and more streamlined acquisition methods. The chapter concluded with several recommended areas for further research.

Appendix A: Cross-Case Summary Matrix

	Air Force	NASA	SDIO
Payld Char	Most Expendable	Expendable	Least Expendable
Oversight	Most Oversight	Some Oversight	Least Oversight
Contractor Incentives	Reflight Award Fee/ (positive)	Award Fee/ (positive) (negative)	None
Liability/ Insurance	Third Party: Indemnified Payload: Self-Insured	Third Party: Indemnified Payload: Self-Insured	Third Party: Indemnified Payload: Self-Insured
Cost	Not Available	Not Available	$ 35 Million
Reliability	High	High	High

Appendix B: Introductory Letter

Name
Title
Address
City, Zip Code

Salutation

A current topic of interest in the space launch arena revolves around the government's role in facilitating commercialized space launch. Of specific interest is the level of federal agency involvement required in the launch of public payloads on commercial expendable launch vehicles.

USAF Lieutenants Ken Leeson and Lee Rosen, are researching the potential advantages and disadvantages of current government space launch procurement practices, as part of a master's degree at the School of Systems and Logistics at the Air Force Institute of Technology. The study is being co-sponsored by the Deputy Director of Space Programs, Assistant Air Force Secretary of Acquisition, BGen Robert S. Dickman.

As a part of their research, Lt Leeson and Lt Rosen wish to conduct written surveys with a select group of experts in the area of commercial space launch. These experts will be asked to provide insight into critical issues and elements of the space launch acquisition process. Because of you expertise in this area, Lt Leeson and Lt Rosen would like your input.

In the near future, you will be receiving this survey in the mail. The researchers will compile the results of this survey into a list which will be sent back to you for validation and additions. Thank you for your cooperation in this important research.

If you have any questions regarding the study please contact Lt Leeson at (513) 254-3006, Lt Rosen at (513) 233-0086, or their thesis advisor, Dr. Rita L. Wells, at (513) 255-3944.

WILLIAM C. PURSCH, Ph.D.
Functional Director for Research and Grants
National Contract Management Association

Appendix C: First Iteration of Delphi Survey

Name
Title
Address
City, Zip Code

Salutation

As an expert in the field of space launch, you are being asked to provide input into the selection of critical elements of the space launch acquisition process. A letter describing the arrival of this survey should have reached you approximately one week ago. A quick summary should clear up any questions concerning the purpose behind the enclosed survey.

As graduate students at the Air Force Institute of Technology, we have selected commercial space launch as a topic area for a joint masters thesis. Our intention is to conduct three comprehensive historical case studies of ELV launches involving government spacecraft. These three cases are discussed in greater detail in the following survey.

Our objective, as researchers, is to compare and contrast different government methods of launching similar payloads on a common launch vehicle. Ultimately, the strengths and weaknesses of each approach will be highlighted.

This research is sponsored by BGen Robert S. Dickman, Deputy Director of Space Programs, Assistant Air Force Secretary of Acquisition, and the National Contract Management Association. Your participation in the following survey is greatly appreciated and will contribute immensely to the success of the study. Thank you for your cooperation.

KENNETH R. LEESON, 1Lt, USAF
Graduate Student
AF Institute of Technology

LEE W. ROSEN, 1Lt, USAF
Graduate Student
AF Institute of Technology

Background

The objective of this research is to examine the primary differences among three different approaches to ELV space launch. These launch methods use the Delta launch vehicle and involve the following:

	Agency Requiring Launch	Launch Authority Maintained By	Full Liability For Failure Rests With
1. USAF	USAF	USAF	FEDERAL GOVT
2. NASA	NASA	NASA	FEDERAL GOVT
3. SDIO	SDIO	CONTRACTOR	CONTRACTOR

Issues and Elements of the Space Launch Acquisition Process

Before these three approaches can be analyzed and compared, critical issues and elements of the launch process from inception to acceptance need to be identified. Data that is pertinent to these identified areas of interest can then be collected for each launch case. Final comparisons will focus on these critical issues and elements.

For the purpose of this research and survey instrument, the term "issues and elements of the space launch acquisition process" refers to any pertinent component or characteristic of the launch process that can be compared across launch types. General areas of interest such as cost, liability and insurance would be considered as well as specific launch processes, such as payload integration and range safety.

There is no preferred format for your response. All responses will be kept strictly confidential. The enclosed form and self-addressed envelope are included for your convenience. An initial compilation of survey results will be sent to you for further comment. The final list of issues and elements will also be available at your request.

Any questions concerning this survey can be directed to Lt Ken Leeson, (513) 254-3006 or Lt Lee Rosen (513) 233-0086. Messages may be left at comm. (513) 255-8989 or AV 785-8989. Please mail your responses to:

1Lt Ken Leeson
4317 Woodcliffe Av
Dayton, OH 45420

Once again, we would like to thank you for your time.

SURVEY

What do you consider to be the critical issues and elements of the space launch acquisition process. This input may include such details as identifications and definitions, form and location of pertinent data, and questions and general comments concerning the research.

Appendix D: Second Iteration of Delphi Survey

Name
Title
Address
City, Zip Code

Salutation

In January 1992, an initial survey was sent to you regarding the space launch acquisition process. This survey was part of thesis research being conducted by graduate students at the Air Force Institute of Technology, and is sponsored by Brigadier General Robert S. Dickman, Deputy Director of Space Programs, Assistant Air Force Secretary of Acquisition and the National Contract Management Association.

Responses from the initial open-ended survey were compiled and several critical issues/elements of the space launch acquisition process were identified. These most frequently observed issues/elements have been assembled in a follow-on survey in order to validate the preliminary findings. Your timely participation in this second, and final iteration are critical to the research process.

This second instrument employs a Likert scale to ensure quick and easy survey completion. If you were unable to respond to the initial survey, your input for this survey is still important.

Any questions regarding this survey, or this research can be directed to 1Lt Ken Leeson (513-254-3006), or 1Lt Lee Rosen (513-435-7176). Messages may be left at comm. 513-255-8989 or DSN 785-8989. Thank you for your cooperation and participation.

Kenneth R. Leeson, 1Lt, USAF
Graduate Student
AF Institute of Technology

Lee W. Rosen, 1Lt, USAF
Graduate Student
AF Institute of Technology

2 Atch
1. Research Background
2. Survey

Research Background

Atch 1

Objective of the Research

To examine the primary differences among three different government approaches to ELV space launch.

Methodology

The following government Delta II launch scenarios will be compared using case studies:

Agency Requiring Launch	Launch Authority Maintained By	Full Liability For Failure Rests With
USAF	USAF	FEDERAL GOVT
NASA	NASA	FEDERAL GOVT
SDIO	CONTRACTOR?	CONTRACTOR?

Purpose of the Initial Open Ended Survey

To identify critical issues and elements of the launch acquisition process from inception of the launch to acceptance of the services.

(For the purpose of this research and survey instrument, the term "issues and elements of the acquisition process" refers to any pertinent component or characteristic of the launch process that can be compared across launch types.)

Purpose of the Enclosed Follow-up Survey

To validate the findings of the initial open ended survey.

Please feel free to use the space provided for any additional comments. All responses will be kept strictly confidential. The enclosed form and self-addressed envelope are included for your convenience. Results will also be available at your request.

Any questions concerning this survey can be directed to Lt Ken Leeson, (513) 254-3006 or Lt Lee Rosen (513) 435-7176. Messages may be left at comm. (513) 255-8989 or AV 785-8989. Please send your responses to:

1Lt Ken Leeson
5246 Access Rd.
Dayton, OH 45431

or FAX c/o Dr. Rita Wells
AFIT/LSP
comm. 513-255-8458
DSN 785-8458

Once again, we would like to thank you for your time.

SURVEY

Directions

The following issues and elements of the space launch acquisition process were identified in the initial survey. For those listed below, please indicate on a scale from 1 being STRONGLY DISAGREE to 5 being STRONGLY AGREE, the degree to which each issue satisfies the preliminary statement. Please provide a brief comment if the issue is vague or if your selection is a 1 or 5.

Preliminary Statement

The following issue/element of the space launch acquisition process is critical, and deserves investigation when conducting the aforementioned case study research.

	ISSUE/ELEMENT	STRONGLY DISAGREE 1	DISAGREE 2	NEUTRAL 3	AGREE 4	STRONGLY AGREE 5
1.	Degree of government oversight	1	2	3	4	5
	Comments:______					
2.	Requirement to build vehicle to military specifications	1	2	3	4	5
	Comments:______					
3.	Use of performance specification for launch	1	2	3	4	5
	Comments:______					
4.	Final launch authority	1	2	3	4	5
	Comments:______					
5.	Range safety requirements and licensing	1	2	3	4	5
	Comments:______					

	ISSUE/ELEMENT	STRONGLY DISAGREE 1	DISAGREE 2	NEUTRAL 3	AGREE 4	STRONGLY AGREE 5
6.	Forms of contractor incentives	1	2	3	4	5
	Comments:					
7.	Contractual strategy (ie. contract types and clauses)	1	2	3	4	5
	Comments:					
8.	Liability with respect to:					
	--Payload	1	2	3	4	5
	--Vehicle	1	2	3	4	5
	--Launch Facility	1	2	3	4	5
	--Personal and Property	1	2	3	4	5
	Comments:					
9.	Insurance requirements of the contractor (includes reflight)	1	2	3	4	5
	Comments:					
10.	Government self-insurance	1	2	3	4	5
	Comments:					
11.	Cost for services	1	2	3	4	5
	Comments:					

	ISSUE/ELEMENT	STRONGLY DISAGREE 1	DISAGREE 2	NEUTRAL 3	AGREE 4	STRONGLY AGREE 5
12.	Vehicle reliability	1	2	3	4	5

Comments:____

____

13.	Payload considerations:					
	--Criticality	1	2	3	4	5
	--Integration	1	2	3	4	5
	--Orbital Characteristics	1	2	3	4	5

Comments:____

____

____

Additional Comments:

Appendix E: Follow-Up Letters

Name
Title
Address
City, Zip Code

Salutation

Thank you for participating in our study of the critical issues and elements of the space launch acquisition process. Hopefully you have received the initial survey, and have had a chance to consider it. Your response is a critical part of our research. If you have any questions concerning the survey or the research, please contact one of the following individuals.

1Lt Lee Rosen DSN (messages) 785-8989 Home (513) 233-0086
1Lt Ken Leeson DSN (messages) 785-8989 Home (513) 254- 3006
Dr. Rita Wells DSN 785-3944 Commercial (513) 255-3944

Once again, we would like to thank you for your participation in this research.

KENNETH R. LEESON, 1Lt, USAF
Graduate Student
AF Institute of Technology

LEE W. ROSEN, 1Lt, USAF
Graduate Student
AF Institute of Technolgy

Name
Title
Address
City, Zip Code

Salutation

Thank you for participating in our study of the critical issues and elements of the space launch acquisition process. Hopefully you have received the follow-up survey, and have had a chance to consider it. Your response is a critical part of our research. If you have any questions concerning the survey or the research, please contact one of the following individuals.

1Lt Lee Rosen DSN (messages) 785-8989 Home (513) 233-0086
1Lt Ken Leeson DSN (messages) 785-8989 Home (513) 254-3006
Dr. Rita Wells DSN 785-3944 Commercial (513) 255-3944

Once again, we would like to thank you for your participation in this research.

KENNETH R. LEESON, 1Lt, USAF
Graduate Student
AF Institute of Technology

LEE W. ROSEN, 1Lt, USAF
Graduate Student
AF Institute of Technolgy

Appendix F: Compliance Documents

Strategic Defense Initiative Organization LACE/RME Contract (Strategic Defense Initiative Organization, 1989: LIRD-4):

1.	FED-STD-209B	Clean room and work station requirements, controlled environment.

U.S. Air Force MLV II Contract (Space Systems Division, 1991: Atch 1):

1.	DOD-STD-100L	Engineering Drawing Practices.
2.	DOD-STD-480A	Configuration control, engineering changes, deviations, and waivers.
3.	DOD-STD-2167A	Defense system software development.
4.	DOD-STD-2168	Defense system software quality program.
5.	DOD-E-83578A	Explosive ordinance for space vehicles (metric).
6.	MIL-STD-461C	Electromagnetic emission and susceptibility requirements for control of electromagnetic interference.
7.	MIL-STD-490A	Specification practices
8.	MIL-STD-881A	Work breakdown structure for defense material items.
9.	MIL-STD-1246B	Product cleanliness levels and contamination control program.
10.	MIL-STD-1520B	Corrective action and disposition system for non-conforming material.
11.	MIL-STD-1521B	Technical review and audits for systems, equipment and computer software.
12.	MIL-STD-1522A	General requirements for safe design and operations of pressurized missile and space systems.

13.	MIL-STD-1528A	Manufacturing management program.
14.	MIL-STD-1535A	Supplier quality assurance program requirements.
15.	MIL-STD-1538	Spare parts and maintenance support of space and missile systems undergoing ROT&E.
16.	MIL-STD-1540B	Test requirements for space vehicles.
17.	MIL-STD-1541A	Electromagnetic compatibility requirements for space systems.
18.	MIL-STD-1542A	Electromagnetic compatibility (EMC) and grounding requirements for space system facilities.
19.	MIL-STD-1543B	Reliability program requirements for space and missile systems.
20.	MIL-STD-1546	Parts, materials and processes standardization, control and management program for spacecraft and launch vehicles.
21.	MIL-STD-1547	Parts, materials, and processes for space and launch vehicles, technical requirements.
22.	MIL-STD-1567	Work measurement.
23.	MIL-STD-1574A	System safety program for space and missile systems.
24.	MIL-STD-1576	Electro-explosive subsystem safety requirements and test methods for space systems.
25.	SAMSO-STD-73-56	Quality assurance requirements for space and missile systems.
26.	MIL-E-6051D	Electromagnetic compatibility requirements, systems.

27.	MIL-M-38210B	Mass properties control requirements for missile and space vehicles.
28.	MIL-Q-9858A	Quality program requirements.
29.	AFR-127-12	Air Force occupational safety and health.
30.	AFR-127-100	Explosive safety standards.

<u>National Aeronautics and Space Administration MELV Contract (National Aeronautics and Space Administration, 1990: Atch A-2):</u>

1.	PAIP	
2.	MIL-E-6051D(T)	Electromagnetic compatibility requirements, systems.
3.	MIL-STD-461B	Electromagnetic emission and susceptibility requirements for the control of electromagnetic interface.
4.	MIL-STD-462	Electromagnetic interference characteristics, measurement.
5.	MIL-STD-1522A	General requirements for safe design and operation of pressurized missile and space systems.
6.	MIL-STD-1541	Electromagnetic compatibility requirements for space systems.
7.	MIL-STD-1542	Electromagnetic compatibility (EMC) and grounding requirements for space systems facilities.

Appendix G: Insight vs. Approval Requirements

Approval - NASA MELV Contract (National Aeronautics and Space Administration, 1991: 34-35)

-Mission Integration
- Spacecraft to Launch Vehicle Interface Control Documents
- Decisions and resolutions of action items
- Mission peculiar hardware design, analysis and test

-Vehicle Integrated Systems Test
- Top-Level Test Plan, Requirements, and Success Criteria
- Changes to the PAIP

-Launch Vehicle Assembly and Test at the Launch Site
- Top-Level Test Plan, Requirements, and Success Criteria
- Changes to the PAIP

-Integrated Spacecraft/Vehicle Operations and Launch
- Integrated Vehicle/Spacecraft Assembly and Test

-Procedures
- Integrated Launch Commit Criteria
- Launch

Approval - SDIO LACE/RME Contract (Strategic Defense Initiative Organization, 1989: 15-16)

-Launch Vehicle Assembly and Test at the Launch Site
- Vehicle Launch Commit Criteria
- Launch Resources Commit Review
- Vehicle Flight Readiness Review

-Integrated Spacecraft/Vehicle Operations & Launch
- Integrated Launch Commit Criteria
- Launch

-Post-Flight Mission Analysis
- Anomaly Investigation/Closeout Review

Insight - NASA MELV Contract (National Aeronautics and Space Adminstration, 1990: 34-35)

-Production
- Production Program Reviews
- Flight Hardware Pedigree Reviews
- SR & QA Compliance and Spot Audits
- Preship Reviews (Vehicle Specific)
- Design Reviews
- Qualification Reviews

- Major/Critical Problems

-Vehicle Integrated Systems Test
  - Major Systems Test (Vehicle Specific)
  - Post-Test Data Reviews (Vehicle Specific)
  - Anomaly Resolutions
  - Failure Analysis
  - Major/Critical Problems

-Launch Vehicle Assembly and Test at the Launch Site
  - Launch Site Support Reviews
  - Vehicle Walkdown Inspections
  - SR&QA Compliance and Spot Audits
  - Review of OPS and Procedure Discipline
  - Review of Work Practice/Documentation
  - Post-Test Data Reviews
  - Major/Critical Problems
  - Anomaly Resolutions
  - Failure Analysis
  - Work Schedule/Plans
  - Vehicle Launch Commit Criteria
  - Contractor Vehicle Flight Readiness Review

-Integrated Spacecraft/Vehicle Operations and Launch
  - Major Integrated Systems Tests
  - Anomaly Resolution
  - Failure Analysis

-Post-Flight Mission Analysis
  - Flight Vehicle Data Review
  - Tracking and Range Data
  - Anomaly Investigation/Closeout Review

Insight - SDIO LACE/RME Contract (Strategic Defense Initiative Organization, 1989: 15-16)

-Mission Integration
  - Spacecraft to Launch Vehicle Interface Control

-Documents
  - Decisions and resolutions of action items
  - Mission peculiar hardware design, analysis and test
  - Mission peculiar software design, analysis and test

-Production
  - Production MRB Reviews
  - Production Program Reviews
  - Flight Hardware Pedigree Reviews
  - SR & QA Compliance and Spot Audits
  - Preship Reviews (Vehicle Specific)
  - Design Reviews
  - Qualification Reviews
  - Major/Critical Problems

-Vehicle Integrated Systems Tests
- Major Systems Test (Vehicle Specific)
- System Test MRB Reviews
- Post-Test Data Reviews (Vehicle Specific)
- Anomaly Resolutions
- Failure Analysis
- Top-Level Test Plan, Requirements and Success Criteria
- Major/Critical Problems

-Launch Vehicle Assembly and Test at the Launch Site
- Launch Site Support Reviews
- Vehicle Walkdown Inspections
- SR&QA Compliance and Spot Audits
- Review of OPS and Procedure Discipline
- Review of Work Practice/Documentation
- Post-Test Data Reviews
- Major/Critical Problems
- Anomaly Resolutions
- Failure Analysis
- Work Schedule/Plans
- Vehicle Launch Commit Criteria
- Top-Level Test Plan, Requirements and success Criteria
- Changes to the Systems Effectiveness Program Plan

-Integrated Spacecraft/Vehicle Operations & Launch
- Major Integrated Systems Tests
- Anomaly Resolution
- Failure Analysis
- Integrated Vehicle/Spacecraft Assembly and Test

-Procedures

-Post-Flight Mission Analysis
- Flight Vehicle Data Review
- Tracking and Range Data

Appendix H: Contract Data Requirements Listing Summary for Air Force MLV II Contract (Space Systems Division, 1991: Exhibit A)

(Please see key on last page of Appendix for Approval and Frequency codes.)

NUMBER	PLAN	APPROVAL	FREQ.
A001	CONFIGURATION MANAGEMENT PLAN	AN	ONE/R
A002	REQUEST FOR DEVIATION WAIVER	AN	ASREQ
A003	SPECIFICATION MAINTENANCE DOC (EQUIPMENT/MUNITIONS)	AN	ASREQ
A004	CONTRACT CHANGE PROPOSAL/ TASK CHANGE PROPOSAL	AN	ASREQ
A005	ENGINEERING CHANGE PROPOSALS	AN	ASREQ
A006	RESERVED	--	-----
A007	CONTRACT DATA STATUS REPORT	N	BIMON
A008	CONFIGURATION ITEM DEVELOPMENT SPECIFICATION	AN	ONE/R
A009	NOTICE OF REVISION/SPECIFICATION CHANGE NOTICE	AN	ASREQ
A010	DATA ACCESSION LIST/INTERNAL DATA	N	QRTLY
A011	PROGRAM REQUIREMENTS DOCUMENT	AN	ASREQ
A012	PROGRAM SCHEDULES	N	ASREQ
A013	DESIGN REVIEW DATA PACKAGE	AD	NOTE1
A014	INTERFACE CONTROL DOCUMENT	AN	ONE/R
A015	CONTRACTOR TEST PLANS/PROCEDURES	AN	ASREQ
A016	MANUFACTURING PLAN	N	ASREQ
A017	SYSTEM SAFETY PROGRAM PLAN (SSPP)	AN	ONE/R
A018	LOGISTICS SUPPORT PLAN FOR PREOPERATIONAL SUPPORT (LSPPS)	N	ASREQ
A019	SYSTEM EFFECTIVENESS PROGRAM PLAN (SEPP)	AN	ONE/R
A020	RESERVED	--	-----
A021	REPORT, FAILURE SUMMARY AND ANALYSIS	N	MTHLY
A022	TOR-AERODYNAMIC ANALYSIS REPORT	N	ASREQ
A023	PROGRAM PARTS SELECTION LIST	N	SEMIA
A024	TOR-MANAGEMENT INDICATORS	N	MTHLY
A025	RESERVED	--	-----
A026	TOR-TRAJECTORY DESIGN REPORT	N	ASREQ
A027	RESERVED	--	-----
A028	FLIGHT PLAN APPROVAL PACKAGE-MISSILE	AN	ASREQ
A029	AERODYNAMIC AND THERMODYNAMIC HEATING ANALYSIS REPORT	N	OTIME
A030	TOR-LOADS AND DYNAMICS ANALYSIS REPORTS	N	ASREQ
A031	TOR-STABILITY AND CONTROL ANALYSIS	N	ASREQ
A032	TOR-STRESS ANALYSIS REPORTS	N	ASREQ
A033	TOR-MASS PROPERTIES REPORTS-MISSILES	N	NOTE2
A034	TOR-RF LINK ANALYSIS	N	ASREQ

NUMBER	PLAN	APPROVAL	FREQ.
A035	TOR-GUIDANCE AND TARGETING ANALYSIS	N	NOTE3
A036	TOR-PROPULSION ANALYSIS	N	ASREQ
A037	TEST REPORTS-GENERAL	N	ASREQ
A038	RESERVED	--	-----
A039	TOR-POWER SYSTEMS LOADS ANALYSIS	N	ASREQ
A040	TOR-ELECTRICAL SEQUENCING SYSTEMS	N	ASREQ
A041	TOR-INSTRUMENTATION SYSTEM REQUIREMENTS	N	ASREQ
A042	RESERVED	--	-----
A043	COMPUTER/MACHINE PRODUCTS (SPECIAL)	N	ONE/R
A044	ACCIDENT RISK ASSESSMENT REPORT	AN	ASREQ
A045	SYSTEM SECURITY PLAN (SSP)	AN	OTIME
A046	TOR-DELTA II SECURITY CLASSIFICATION GUIDE	AS	ASREQ
A047	OPERATIONS SECURITY (OPSEC) PLAN	AN	OTIME
A048	SOFTWARE REQUIREMENTS SPECIFICATION	AN	ONE/R
A049	SOFTWARE DESIGN DOCUMENT	N	ONE/R
A050	SOFTWARE DEVELOPMENT PLAN	AN	ONE/R
A051	CONFIGURATION ITEM PRODUCT FABRICATION SPEC	AN	ONE/R
A052	TOR-THERMAL MODEL	N	ASREQ
A053	COUNTDOWN PROCEDURES REPORTS	N	ASREQ
A054	LAUNCH/FLIGHT TEST DIRECTIVE	N	ASREQ
A055	FAILURE MODES AND EFFECTS ANALYSIS REPORT	AN	NOTE1
A056	RESERVED	--	-----
A057	LAUNCH VEHICLE POST FLIGHT ANALYSIS	N	ASREQ
A058	RESERVED	--	-----
A059	TOR-USER'S HANDBOOK	N	ASREQ
A060	FLIGHT TERMINATION SYSTEM REPORT, MISSILES	AN	ASREQ
A061	MISSILE FLIGHT SAFETY DATA, RANGE SAFETY	N	NOTE4
A062	MISSILE FLIGHT SAFETY DATA, RANGE SAFETY	N	NOTE5
A063	RELIABILITY PROGRAM PLAN	N	ASREQ
A064	ELECTROMAGNETIC COMPATIBILITY PLAN	N	ASREQ
A065	CRITICAL ITEM CONTROL PLAN	N	ASREQ
A066	MAINTAINABILITY PROGRAM PLAN	N	ASREQ
A067	PARTS CONTROL PROGRAM PLAN	N	ASREQ
A068	CONTRACT FUNDS STATUS REPORT	AN	MTHLY
A069	CONTRACT WORK BREAKDOWN STRUCTURE INDEX AND DICTIONARY	AN	ONE/R
A070	FUNCTIONAL COST HOUR REPORT	N	ANNLY

NUMBER	PLAN	APPROVAL	FREQ.
A071	COST DATA SUMMARY REPORTING (DD FORM 1921)	N	ANNLY
A072	COST PERFORMANCE REPORT (CPR)	N	MTHLY
A073	WORK MEASUREMENT LABOR PERFORMANCE	N	MTHLY
A074	ALERT/SAFE-ALERT	N	ASREQ
A075	PART APPROVAL REQUEST	AN	ASREQ
A076	RESPONSE TO AN ALERT/ SAFE-ALERT	N	MTHLY
A077	FORECAST OF PROPELLANT REQUIREMENT (MISSILE PROPELLANT) AF FORM 858	N	SEMIA
A078	SOFTWARE QUALITY PROGRAM PLAN	N	NOTE6
A079	MEDICAL INCIDENT MODIFICATION	N	ASREQ
A080	TOR-CONFORMED CONTRACT	N	ASREQ
A081	RESERVED	--	-----
A082	VULNERABILITY ASSESSMENT REPORT	N	ANNLY
A083	PROGRESS CURVE REPORT (DD FORM 1921-3)	N	ANNLY
A084	PLANT-WIDE DATA REPORT (DD FORM 1921-3)	N	ANNLY
A085	TRAINING AND TRAINING EQUIPMENT PLAN	AN	ASREQ
A086	TRAINING AND SUPPORT DATA	AN	OTIME
A087	PRODUCTION ANALYSIS REPORT	N	MTHLY
A088	RESERVED	--	-----
A089	CONFERENCE AGENDA	N	ASREQ
A090	CONFERENCE MINUTES	N	ASREQ
A091	TECHNICAL INFORMATION AND RESEARCH AND DEVELOPMENT PLANNING DATA	N	ASREQ
A092	TOR-SPECIAL STUDIES	N	ASREQ
A093	RESERVED	--	-----
A094	QUALITY PROGRAM PLAN	N	ASREQ

APPROVAL CODE

CODE	WHEN USED
A	Use approval when the data is critical
D	Distribution statement is known to be required
N	AFR 80-45 not applicable to these data (Approval not required)
AD	Approval of draft is required by government. A distribution statement is required.
AN	Approval of draft is required by government. Distribution statement not required.
--	Approval is not required.

FREQUENCY CODE

CODE	FREQUENCY
DAILY	DAILY
WKLY	WEEKLY
BI-WE	EACH TWO WEEKS
MTHLY	MONTHLY
BI-MO	EACH TWO MONTHS
QRTLY	QUARTERLY
ANNLY	ANNUALLY
SEMIA	EACH SIX MONTHS
OTIME	ONE TIME
ONE/R	ONE TIME, AND REVISIONS
R/ASR	REVISIONS AS REQUIRED
ASREQ	AS REQUIRED

NOTES

NOTE	MEANING
1	30 CALENDAR DAYS PRIOR TO EACH SCHEDULED REVIEW
2	MISSION PECULIAR
3	30 CALENDAR DAYS PRIOR TO MISSION UNIQUE CDR
4	CHARTS 15 CALENDAR DAYS PRIOR TO BRIEFING, 30 DAYS PRIOR TO LAUNCH
5	60 CALENDAR DAYS PRIOR TO EACH SCHEDULED LAUNCH
6	SUBMIT AS ANNEX TO CDRL A019

Appendix I: Contract Data Requirements Listing Summary for Strategic Defense Initiative Organization Contract (Strategic Defense Initiative Organization, 1989: Modification P0001)

NUMBER	PLAN	APPROVAL	FREQ.
A001	DESIGN REVIEW	--	ONE
A002	FINAL DESIGN REVIEW	--	ONE
A003	RESERVED	--	-----
A004	PROGRAM MANAGEMENT REVIEW (PMR)	--	MTHLY
A005	INTERFACE CONTROL DOCUMENT (ICD)	--	TWO
A006	MISSION PECULIAR ANALYSIS REPORTS	--	ASREQ
A007	MISSION PECULIAR DRAWINGS AND SCHEMATICS	--	ASREQ
A008	MISSION DESIGN DOCUMENT	--	ASREQ
A009	COPIES OF SUBMITTED RANGE	--	ASREQ
A010	POST LAUNCH FINAL REPORT	--	ONE
A011	LAUNCH RESOURCES COMMENT REVIEW REPORT	--	ONE
A012	MISSION READINESS REVIEW REPORT	--	ONE
A013	MEETING MINUTES AND ACTION ITEMS	--	NOTE1

APPROVAL CODE

CODE	WHEN USED
--	Approval is not required.

FREQUENCY CODE

CODE	FREQUENCY
MTHLY	MONTHLY
ONE	ONE TIME
TWO	TWO TIMES
ASREQ	AS REQUIRED

NOTES

NOTE	MEANING
1	5 DAYS AFTER EACH MEETING BETWEEN THE GOVT AND CONTRACTOR.

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Vita

Captain Kenneth R. Leeson was born on May 24, 1966 in Rudyard, Michigan. He graduated from Slinger High School in Slinger, Wisconsin in May of 1984 and subsequently accepted an appointment to the United States Air Force Academy. In June of 1988, Captain Leeson was awarded a Bachelor of Science degree from the Air Force Academy (distinguished graduate) and was commissioned into the Air Force upon graduation. He was assigned to the McChord AFB Operational Contracting Division, where he served as the Chief of the Management Analysis and Support Branch. He entered the Air Force Institute of Technology in May of 1991.

Permanent Address: 200 Heder Dr.
Slinger, WI 53086

Vita

Captain Lee Wayne Rosen was born on 20 June 1966 in Quincy, Massachusetts. He graduated from Randolph High School, Randolph, Massachusetts in 1984 and attended the U.S. Air Force Academy, graduating (Military Honor Graduate) with a Bachelor of Science in Human Factors Engineering in June 1988. Upon graduation, he received a regular commission in the USAF and served as a Missile Maintenance Officer in the 321 Strategic Missile Wing, Grand Forks AFB, North Dakota. He also received his Master of Science in Space Studies from the University of North Dakota in 1991 before entering AFIT in May of 1991.

Permanent Address: 226 E Isle of Capri
Delray Beach, FL 33484

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Kenneth R. Leeson, Captain, USAF
Lee W. Rosen, Captain, USAF

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13. ABSTRACT (Maximum 200 words)

This study analyzes three commonly practiced approaches to Government acquisition of space launch services. These approaches are employed by the U.S. Air Force, the National Aeronautics and Space Administration, and the Strategic Defense Initiative Organization. The literature review provides a comprehensive overview of the commercial space launch industry and details critical perspectives on commercial launch. Launch contracts which were representative of each organization's acquisition procedures were investigated and evaluated along several critical issues and elements of the space launch acquisition process. These issues included payload characteristics, government oversight, contractor incentives, insurance, liability and cost. The critical issues and elements were determined by using the Delphi method to survey 25 experts in the space launch field. Archival contractual data from the three government agencies were obtained and found many inconsistencies among the different agencies' acquisition procedures. The thesis ends with a recommendation for a hybrid acquisition approach encompassing the strengths of the three cases.

14. SUBJECT TERMS

Space Launch, Acquisition, Expendable Launch Vehicle, Contracting

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   a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

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