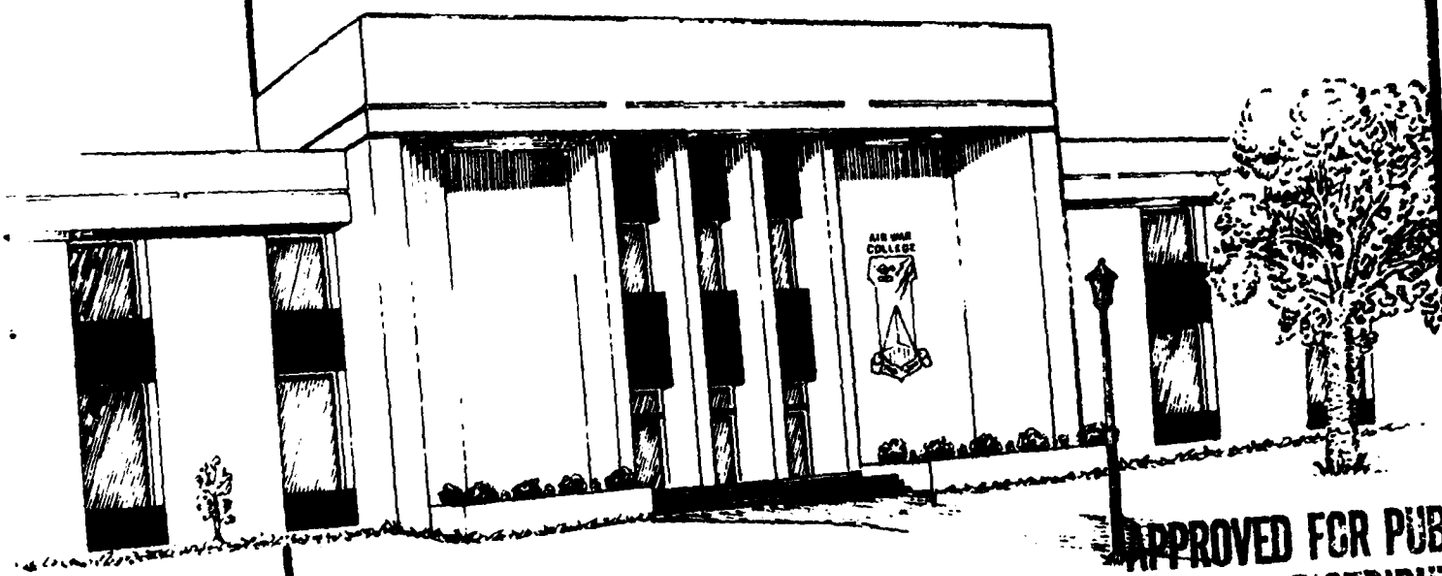
AIR WAR COLLEGE

RESEARCH REPORT

No. AU-AWC-88-149

COMMERCIALIZING SPACE LAUNCH: ONE MILITARY MAN'S PERSPECTIVE

By COLONEL LOUIS A. KOUTS



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COMMERCIALIZING SPACE LAUNCH

ONE MILITARY MAN'S PERSPECTIVE

by

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A RESEARCH REPORT SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE RESEARCH

REQUIREMENT

Research Advisor: Colonel Ted Schroeder

MAXWELL AIR FORCE BASE, ALABAMA

May 1988

TABLE OF CONTENTS

CHAPTER		PAGE
	DISCLAIMER	ii
	ABSTRACT	iii
	BIOGRAPHICAL SKETCH	iv
I	INTRODUCTION	1
II	BACKGROUND	3
	A. Historical Perspective	3
	B. President's Initiative on Commercialization	8
	C. Impact of Challenger	11
III	U.S. GOVERNMENT SUPPORT	15
	A. Actions Taken by the Air Force	16
	B. Industry Response	18
IV	THE MARKETPLACE	22
	A. Buyers	23
	B. Sellers	25
V	DISCUSSION	34
VI	CONCLUSIONS	40
	NOTES	46
	BIBLIOGRAPHY	52

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ABSTRACT

TITLE: Commercializing Space Launch: One Military Man's Perspective

AUTHOR: Louis A. Kouts, Colonel, USAF

A background of the U.S. space launch efforts with emphasis on the Air Force and its role in the shuttle program lays the foundation for a description of the President's initiative on commercializing space launch. A brief discussion follows on the current status of the marketplace, both buyers and sellers. This is followed with a short section providing the personal insights of the author. The conclusions form a backdrop for several recommendations which are proffered by the author for additional consideration by the reader.

BIOGRAPHICAL SKETCH

Colonel Louis A. Kouts was born June 5, 1947, in Washington, D.C. He graduated from the George Washington University in 1969 with a degree in Mechanical Engineering. In 1973, he received a Masters in Business Administration from the University of Montana. He is a graduate of the Air War College, class of 1988.

Colonel Kouts was commissioned from OTS December, 1969. He initially served as a Minuteman Launch Control Officer in the 341st SMW, Malmstrom AFB, Montana, and subsequently as a Titan II Maintenance Officer in the 381st SMW, McConnell AFB, Kansas. From 1976-1978 he was stationed at Los Angeles AFS, California, in the Advanced Ballistic Reentry Systems Program Office. After Air Command and Staff College he was stationed at HQ AFSC serving as Chief, Launch and Orbital Division. In 1983 he was assigned to the Air Staff within the Deputy Chief of Staff, Programs and Resources. In 1985 he was selected to the Air Force Secretariat as Deputy to the Deputy Assistant Secretary, Space Plans and Policy. Here, he helped to implement the President's initiative on commercializing space launch.

Colonel Kouts married the former Kristine Lynn Ellison of Minneapolis, Minnesota. They have three children: Nichole, Tiffany, and Jason.

CHAPTER I

INTRODUCTION

This paper is intended to provide a military man's thoughts on a national initiative which will lay the foundation for our country's future in space, both military and civil: the development of the private, commercial space launch sector.

Our space launch capability is basic to every endeavor this nation makes in that medium. In the past our capability was predicated on government developed launch systems. These government launch systems were derived from existing designs where expediency was paramount, particularly for the military. For the civil, man-rated programs large and highly capable systems were designed for limited use. In both cases, military and civilian, development costs were sunk costs, never having to be amortized. Moreover, for both cultures operational costs were not a primary consideration. Today, with constrained federal budgets, operating costs are the primary consideration, and development funding is increasingly difficult to justify.

The Challenger accident of 28 January 1986 did more than shock the world. It served as a catalyst for a complete rethinking of our plans for space. Two years later the President promulgated a new space policy setting the future course for the nation and reaffirming the goal of space leadership. But in my view, it is just rhetoric unless we significantly improve the way we deal with space launch. More specifically, if we as a nation are to ensure our preeminence in space, space launch must become more affordable and with the goal of making it truly routine. As a necessary step, the government must refocus its attention toward privatizing space launch. In doing so it needs to establish a cooperative and determined effort with industry--which has proven many times the advantages of a free market economy. The airline industry is a primary example. This is a partnership that is long overdue; and, it is one where if we are to assure our access to space, we really have no other choice. Private enterprise is the key to reestablishing and expanding a dormant industrial base, one which holds the talent, enthusiasm, and drive to fuel our nation's space launch recovery, generate the innovative spirit so much a part of our national heritage, create technological opportunities, and ultimately achieve our highest aspirations in space.

CHAPTER II

BACKGROUND

> "...We're doing all we can to encourage space work by American industry. Private enterprise made America great. And if our efforts in space are to show the same energy, imagination, and daring as those in our country, we must involve private enterprise to the full..."[1]

With these words President Reagan took the initial step in establishing a mechanism for the government to facilitate a commercial space launch industry. In order to appreciate fully the forces behind the space commercialization initiative, it is necessary to briefly review the space launch history. I will concentrate my remarks on NASA and the Air Force. These had traditionally been the only organizations, government or private, providing a space launch capability for the nation.

A. Historical Perspective

Since the beginning of the U.S. space program, and I'll choose the National Aeronautics and Space Act of 1958 as the benchmark, our efforts, as defined by the Act, have been in two areas: one civil and one military.[2]

The civilian program to be conducted by the newly formed NASA received its direction from the President; its missions, therefore, were defined largely for politically inspired perceptions of world leadership and national pride. The reaction to Sputnik and the "space race" triggered our reaction. The result was Mercury, Gemini, Apollo and the national goal of putting a man on the moon. Apollo-Soyuz, Skylab, and the shuttle program followed, however with no apparent focus. Significantly, all these programs were manned missions, which was NASA's hallmark. Moreover, except for the early manned efforts there was no real linkage between these missions--as one would expect if folded into an overall plan. Instead, they were based on political fiat. This is not to subordinate NASA's highly successful unmanned planetary programs: Mariner, Pioneer, and Voyager--perhaps no less important in scientific achievement. These were, indeed, significant steps in the exploration of space. The point is, however, that measured in terms of public awareness the former were spectacular performances garnering widespread and positive world opinion. The impact of these successes was enhanced by their manned aspect. The costs involved for the space transportation were just as spectacular. Unfortunately, each existing system for space transportation was set aside for the next generation system which would be bigger and "better," and tied uniquely to the next program.

The military space program, on the other hand, was

driven more by requirement. The DoD missions evolved as the full implications of the advantages of spaceborne assets became technically possible. Achievements were incremental. Communications, navigation, environmental, surveillance, and treaty monitoring satellites provided increasing direct support to field commanders and the national command authority. The military's venture into manned space efforts, principally the Manned Orbiting Laboratory program, was cancelled in the late 1960's due to cost, and the realization that in most cases unmanned systems could do military missions more economically, if not better, than manned systems. This is still holding true today, although we're continually looking at applications for military manned presence. The means of space transportation, by expediency, was provided by modified ICBMs: Atlas and Titan were the workhorses. Additionally, service support, establishing a basis for advocacy and funding, was identified by the DoD when the Air Force was given the "...responsibility for the development, production, and deployment of space systems...including launch and orbital support operations."[5] Air Force expertise expanded; spacecraft and launch vehicle design evolved incrementally with the latter producing a family of launch systems available to meet differing mission requirements. Hence, until the late 1970s NASA and the Air Force developed parallel space launch infrastructures, each suited to meet their respective needs. This all changed with

the advent of the shuttle.

The space shuttle program was born partly of necessity for NASA to maintain momentum in a major development effort, and partly as a compromise to the establishment of a permanently manned space station. It is important to note here that the program could not have been sold to the Congress without the backing and the support of the DoD. Consequently, the DoD (Air Force) became a full partner in the program: NASA had responsibility for the development and operation of the orbiter, mission control, and east coast launch facilities while the Air Force was to develop a shuttle compatible upper stage, capability for secure military flight operations, and west coast launch facilities. Moreover, to help the program become cost effective the DoD was to completely transition all its payloads to the shuttle for launch requirements. Senior civilian Air Force leadership maintained its strong support for the shuttle program throughout the 1970s, albeit over the concerns of the Air Force military--particularly those closest to the launch business, who were largely viewed as heretics. The concerns became more evident as the shuttle program slipped, payload integration necessitated more complex and extensive analyses (in addition to the significant costs of redesigning payloads to fly on the shuttle), the projection for yearly flight rates dropped from 60 to 24, the number of programmed orbiters dwindled from six

to four, and the shuttle performance failed to meet advertised capabilities.[4] It reached a point that the Air Force was compelled to seek approval to maintain one active expendable launch vehicle line through the procurement of ten "shuttle-class," Titan IV boosters. After an uphill struggle and the persistent efforts of then Under Secretary of the Air Force Aldridge, the Congress approved. This came over the strong objections of NASA.[5] The Air Force concession was to commit to at least one-third the available shuttle missions, and to reaffirm that the shuttle was the nation's primary means of access to space.

Up until the early 1980s there was little attempt on the part of industry toward a venture into privatizing space launch. One notable exception was the 9 September 1982, suborbital test flight of the Conestoga I--a vehicle made up of essentially off-the-shelf hardware. A small company named Space Services, Inc. pioneered this effort after having to secure approval of eighteen government agencies prior to the launch.[6] This significant first attempt went largely unnoticed, or was viewed as a novelty, at best. The major launch vehicle manufacturers were phasing down with no motivation to do otherwise. The formidable obstacles of establishing a launch base infrastructure apart from the government facilities and fighting the federal bureaucracy were overshadowed by the larger issue of competing with the shuttle with its low, marginally set prices, and the emerging

overseas competition led by the European backed enterprise, Arianespace. The Reagan Administration sought to change this situation.

B. President's Initiative on Commercialization

President Reagan took the first steps in privatizing space launch activities and stimulating the fading industrial base. After a four month study by the Senior Interagency Group (Space) that recommended a commercial expendable launch vehicle (ELV) industry would benefit the nation, he pronounced a new policy in May 1983. The National Security Decision Directive (NSDD) on "Commercialization of Expendable Launch Vehicles" sought to foster privatization by encouraging the use of underutilized government equipment and allowing access to government launch facilities. From a purely economic standpoint, if successful, this initiative would retain a vital national asset, generate jobs, help the balance of trade, and help sustain U.S. leadership in space transportation.[7]

This new policy was followed in February 1984 by Executive Order 12465. This Presidential document established the Department of Transportation (DoT) as the lead agency for oversight and regulatory responsibilities.[8] Within DoT the Office of Commercial Space Transportation (OCST) was created to perform this task and reported directly to the Secretary. This was followed in October 1984 by the passage of the Commercial Space Launch Act (CSLA): Public Law

98-575 further delineated the responsibilities of DoT as well as other federal agencies, including DoD, for administering this new program. Licensing, government property use including pricing considerations, safety, and liability requirements were placed under the purview of the Secretary of Transportation.[9] This document was significant in that it created a framework for the establishment of a mechanism for proper implementation.

As potentially important as the above documents were, there was no great reaction from the industry. Market and institutional impediments which were there before, still remained. Although the initiative was favorably received by DoT, Department of Commerce (DoC), and the Air Force (which was interested in any effort to keep an ELV capability alive), the bottom line remained the same: industry could not compete with the shuttle.

Meanwhile, NASA was caught in a dilemma. To make the shuttle as efficient as possible it had to fly with full orbiter bays. By marketing its product on the basis of a manned-rated vehicle with a supposed higher reliability than an unmanned system, and by keeping its prices competitive with Arianespace, it could keep its manifest full. Unfortunately, while its pricing may have been competitive with Arianespace, it was not set high enough to "run the railroad." The additional funding necessary to operate the shuttle had to be borne from within NASA; necessarily other

programs including the science efforts had to suffer. The Administration directed that NASA was to charge foreign and commercial customers on the basis of "full cost recovery" beginning in FY 89.[10] It was questionable, however, whether full cost pricing could be implemented and still be competitive with Arianespace--even with a flight rate of 24 missions per year. (It should be noted that the shuttle's operations costs were extremely sensitive to the flight rate). The President, at NASA's insistence, also set the minimum commercial price at $74M in FY 82 dollars for a full shuttle bay equivalent for flights beginning in FY 89.[11] This was actually closer to NASA's marginal cost to fly; i.e. the costs of consumables and direct labor. NASA's pricing arrangement with the DoD was negotiated separately and in consideration that the DoD was a partner in the development of shuttle program. For the three year pricing period for flights beginning in FY 89 the DoD, as negotiated by the Air Force, agreed to reimburse NASA a fixed $270M (FY 82 dollars) per year plus a variable $30M (FY 82 dollars) per DoD flight. Included in this agreement was the commitment to fly at least nine missions. Therefore, the DoD was incentivized to fly more missions, as the average cost per flight would go down. Additionally, it was NASA's hope that the DoD would be less motivated, and the Congress less willing, to support the procurement of additional ELVs.[12]

Hence, NASA's planning for the operational era of the

shuttle called for the DoD and NASA to each accommodate one third of the 24 per year flight manifest. The remaining available space, roughly one third, would be offered to commercial and foreign payloads, and roughly equaling the market share of Arianespace. Given that NASA and Arianespace would fly most if not all available commercial satellites, at prices set below costs, there was little market left for the commercial ELV manufacturers. All this changed on 28 January 1986.

C. Impact of Challenger

The Challenger accident demonstrated in dramatic fashion the fragility of space launch vehicles. What people had mistakenly come to regard as another routine shuttle mission was redefined as a very precise, yet highly hazardous endeavor. This notion was reinforced by subsequent ELV failures: Titan in April 1986 (also August 1985), Delta and Ariane in May 1986, and Atlas in March 1987. Yet it was the destruction of an orbiter that was the most devasting to this nation's space launch endeavor: all our payloads were transitioning to this system, a man-rated system with numerous and redundant safety features, and with an advertised 99+% reliability. The tragic loss of life notwithstanding, coupled with the ELV failures, the nation's ability to orbit payloads, including many critical to national security, was put on indefinite hold. A backlog of over thirty satellites was initially created; and the longer

the shuttle remained grounded, the larger the backlog would become. Scientific and planetary programs, in addition to microgravity experimentation, were set back years. The insurance industry had lost millions, and the confidence it once had in the space business would take time and numerous successful missions to recoup. This is being reflected today in high premium rates and the now stringent conditions for providing coverage. Where choosing between shuttle and Ariane to provide launch services to orbit prior to Challenger was relatively clear, it was now a sellers market with satellite users/manufacturers looking at other alternatives including the Chinese, Japanese, and Soviet sponsored systems.

National as well as civil program leadership soon came under fire. Challenger was viewed as an embarrassment to our prestige and placed us psychologically behind the Soviets. NASA in particular was criticized for mismanagement. The findings of the Rogers Commission included a recommendation for a management review with an emphasis placed on accountability.[13] NASA's problems have been surfaced to public scrutiny and well documented.[14] But, the blame does not lie totally with an agency that made remarkable achievements in spite of tightening fiscal constraints and imposing technological hurdles. The real mistake was made by prior administrations which implemented a flawed, budget driven policy of tying all payloads to a

single and untried launch system. The error was compounded by a complete disregard of the private sector and the potential for developing and expanding upon a then strong and extensive industrial base. Had it not been for the determination of Mr. Aldridge to keep the Titan as the only government ELV production line open, the nation would have been four years rather than two years (post Challenger) away from launching critical national security payloads.

In the aftermath of the Challenger, numerous interest groups contended for a voice in the establishment of a plan for space launch recovery. This was an exception to what once had been the exclusive domain of NASA and DoD. Several NASA advisory councils, Air Force, DoD, SIG (Space) and Economic Policy Council made up of DoT, DoC, OMB, Department of State, Department of Justice, Office of Science and Technology Policy, as well as an impatient Congress in addition to a growing number of ELV manufacturers all vied for a vote. This "process" continues today. However, a most significant policy announcement was made on 15 August 1986 when the President announced that the shuttle would be precluded from competing for future commercial satellite launches.[18] When NASA petitioned the White House to allow 31 of the 44 commercial missions which had contracted for shuttle launch services to remain manifested, the President rejected all but twenty.[19]

This could be viewed as a shift in influence over

non-military space policy determination: from NASA to the commercial ELV advocacy groups. Booster manufacturers would naturally have liked to have seen even fewer commercial satellites approved for shuttle. The decision of the President, however, appears to have been a prudent one, in light of NASA's moral obligation to those concerns whose satellites are configured for shuttle deployment. But, the environment had now significantly changed from the time preceding Challenger. A demand had been created, albeit near term and somewhat tenuous--a constituency was now demanding a voice. The next question was one of commercial pricing competition, endurance, and access to the national ranges. Most importantly, how much support would the U.S. Government provide to the commercial sector?

CHAPTER III

U.S. GOVERNMENT SUPPORT

> "...I want to confirm to you, in no uncertain terms, the U.S. Government support of the commercial expendable launch vehicle initiative. This commitment is a key part of our larger effort to restore our national space launch capability. Thus, today we are working to revitalize the space launch industrial base, to establish a more robust launch capability for assuring access to space."[17]

During his address to the Commercial Launch Vehicle Symposium, now Secretary of the Air Force Aldridge sent a strong signal to ELV manufacturers that the government was prepared to facilitate this new industry in every way possible. While the President had laid the broad policy and the Congress had passed into law an act which outlined responsibilities and requirements, it was up to the concerned federal agencies like NASA, DoT, and the DoD to make it happen. Indeed, the Air Force, as the DoD executive for space launch, became the focus for determining the conditions under which commercial enterprises could operate on the major national ranges. It was not a task that the Air Force petitioned, but one that it was determined to accomplish--the

commitment of the Secretary of the Air Force was sincere.

A. Actions Taken By the Air Force

It should be pointed out that the Air Force was not prepared to accommodate this new initiative, either in mission or in staffing. Prior to Challenger and the procurement of the initial ten Titan IV vehicles, the ELV program office, located at Los Angeles Air Force Station, was in the process of phasing down. Including the operations at the east and west coast ranges (Cape Canaveral AFS and Vandenberg AFB), there was roughly $500M left in the program until termination in the late 1980s. In the post Challenger recovery period the Air Force had to gear up the program office to handle the increased workload: additional Titan IV procurements, the Titan II program for west coast launch operations, the Delta II program for east coast launch operations, failure investigations/corrective actions on the two Titan failures, and the potential for additional launch pad requirements--not to mention the study efforts for future heavy lift vehicles. Within a three year period (1983-1986) the ELV program office had grown to an effort funded in excess of $1B per year in the Five Year Defense Program. Increased program manning did not commensurately follow. The inception of the commercial ELV initiative further taxed the program and field offices' resources. In spite of this the additional task was given a very high priority by the Air Force.

While the field units and the commercial booster manufacturers worked the details of identifying the government facilities, goods , and services that could be utilized, the DoD staffs worked the implementing policy changes. This was in large measure a culture shock to the DoD. In the past it was always the procurer of contractor goods and services. Now, it needed to determine the conditions under which it would be the provider of facilities, goods, and services. The CSLA specified certain criteria and based it on direct cost pricing. Yet, Federal Acquisition Regulations, DoD policy, and Air Force policy had to be tailored to reflect this reverse process. This entailed significant coordination among DoD, NASA, DoT, DoC, Government Services Administration, Headquarters USAF, and field units. The end result was a DoD Directive signed 14 October 1988, after a two year process.

A parallel effort was the establishment of a workable vehicle for allowing commercial "users" access to the national ranges. The precepts of the NSDD on "Commercialization of Expendable Launch Vehicles," Executive Order 12465, and the CSLA were followed as closely and openly as possible with no preconceived notions, and always under the principle to facilitate and not subsidize. While NASA opted to use its traditional method of a "memorandum of agreement" for access to its facilities, the Air Force's practice was a contractual arrangement--which technically

could not be implemented prior to the DoD Directive. This "model contract" (later "model agreement") was the object of much attention as it would determine the conditions for range access: duration, liabilities, preemption, environmental, disputes, safety, interruptions, pricing, and termination.[18] The initial "for comment" issuance of the model agreement was on 22 December 1986. Since that time it has undergone several revisions. The high interest evidenced by the booster industry, DoT, and Congress was understandable as the conditions of the model agreement would ultimately determine the bottom line: price.

B. Industry Response

The initial response of industry was negative. At the request of the OCST, the Commercial Space Transportation Advisory Committee (COMSTAC), made up of leadership in key booster and satellite concerns as well as other related industries, reviewed the model agreement. The 30 January 1987 comments were highly critical with a concern that the model agreement would in no way encourage the privatization of commercial space launch; the recommendation of the COMSTAC was that the model agreement be rewritten to address the specific concerns and to create a more favorable business environment.[19] In retrospect, this was to be expected as what was happening was the first real melding of the two launch vehicle cultures: one dealt with profit as the prime motivator and was the new kid on the block, the other was

tied to military requirements as the motivator, with an establishment spanning thirty years.

The specific concerns of the COMSTAC addressed areas of risk and the limitations of liability, determinations of costs, government access to contractor data, and degree of government involvement in user quality assurence and safety inspections.[20] There were additional concerns over range scheduling and the government's right to preempt. In the eyes of the users these concerns established a negative atmosphere for operations on the ranges. It is important to reemphasize that the Air Force had no preconceived biases. The Air Force could not lose sight of the fact, however, that it was charged with conducting launch operations for national security missions and maintaining the safety of the ranges above all else. Moreover, by definition there was no Air Force appropriated funding to facilitate this effort, particularly when it came to the possibility of damages to the range and to third parties. Hence, many of the provisions of the model agreement may have appeared one-sided.

Subsequent actions on the part of the Air Force and the individual users have reduced the number of areas for disagreement. Perhaps this is more a reflection of both parties gaining a fuller appreciation for the other's constraints. The one substantial and remaining issue, and the one where the Air Force has no recourse is risk.

Currently, the model agreement calls for the user to be responsible for all damage to persons and property: user, government, and third party.[21] Moreover, the user is required to "...be covered, up to the maximum amount of insurance, commercially available at a reasonable price..." as determined by the Air Force.[22] The user was also potentially liable over the insured amount as determined by the courts.[23] Of course, this is an open-ended and largely unpredictable provision, but one which is necessary for the Air Force. While the Secretary of Transportation through the CSLA was given the responsibility for establishing liability limits, DoT has been silent on establishing an amount of insurance. Meanwhile, it is an Air Force contract and Air Force facilities which are largely at risk; consequently, the Air Force had to take a position, albeit a very one-sided one. The problem with the world situation is and will continue to be that the insurance underwriters are still trying to recover from the $1B in claims over recent launch failures.[24] Therefore, insurance costs are high, limited, and short term.[25]

Intense lobbying by insurance companies and booster manufacturers, including open Congressional testimonies in September 1987, resulted in legislative activity. The House Committee on Science, Space, and Technology is taking the initiative to amend the CSLA to include a provision which would serve to essentially cap third party liability in terms

of "maximum probable loss," but would not exceed $500M.[22] This will take the prerogative away from the Air Force to determine limits. Several other provisions of the proposed legislation will also reduce, at least outwardly, the Air Force's authority on the ranges: preemption, launch priorities, and launch date commitments. These provisions are included as a strong statement of intent--it remains to be seen, however, if the operators of the ranges, Air Force and NASA, lose any real control.

CHAPTER IV

THE MARKETPLACE

> "...The private sector, with its ingenuity and cost effectiveness, will be playing an increasingly important role in the American space effort. Free enterprise corporations will become a highly competitive method of launching commercial satellites and doing those things which do not require a manned presence in space. These private firms are essential in clearing away the backlog that has built up during this same time when our shuttles are being modified..."[27]

These words accompanied the President's decision to terminate future use of the shuttle for the deployment of commercial payloads. Instead the shuttle would be dedicated to government requirements, military or civilian, or for those few nationally important commercial payloads already built, and requiring man's presence for deployment. Commercial payloads eliminated from the shuttle flight manifest were faced with the prospect of finding another means of access to space. A demand had been created. However, many analysts question if the immediate demand created by the shuttle standdown would continue past the early 1990s; in other words, is there enough of a market to

sustain private commercial space launch enterprise in the long run? This is the pervasive question facing many industry officials.

A. Buyers

Booster manufacturers are continually evaluating the market availability of satellites requiring launch services. These commercial satellites presently fall into three main categories: communications is by far the largest, followed by earth sensing, and microgravity payloads. To a lesser degree navigation and planetary missions will have commercial application. In assessing future user demand for satellite services, one typically determines the number of satellite starts based on the need for future communications, projections of expected life for orbiting satellites, forecasts of technology breakthroughs, and potential microgravity applications. One should also assess alternatives to satellite capabilities such as fiber optics for communications. While booster manufacturers conduct their own market surveys, there are two credible sources for these highly speculative projections: Euroconsult and Battelle. While Euroconsult takes a more fiscal approach when compared to Battelle's analytical methodology, both have recently yielded similar results.

Euroconsult's 1986 edition of "The World Space Industry Survey: Ten Year Outlook" is a French report providing a breakdown by country and satellite manufacturer

of projected payloads. It concludes that the commercial market is essentially one of geostationary satellites made up of 90% communications and 10% earth observation payloads; moreover, for the period 1989-96 the demand for commercial satellites will require about twenty launches per year.[28]

Battelle is a domestic concern under contract to NASA to provide similar projections. Its "1986 Outside Users Payload Model," while quick to point out the uncertainty created over the Challenger and Ariane failures, nevertheless extrapolates payload demands until the year 2001. It presents the data in terms of a high and a low model: i.e. optimistic and conservative, with history leaning more toward the low (conservative) side. It further suggests greater conservatism by pointing out that of the missions planned during any given year, only 70% are typically flown (this may be based on the military's experience for our launches). Between 1989 and 2001 Battelle projects a high average of 43 and a low average of 25 payloads per year.[29]

This does not equate directly to the Euroconsult forecast which was in launches; that is, multiple payloads could go on a single launcher. However, both projections appear to be in the same ballpark.

The question of a sustaining market is still in doubt. The issue is complicated by foreign competition in addition to Ariane. However, with a launch rate reaching 7-8 per year by 1989, and a capability to grow to nine per year

thereafter, most with multiple payloads, Arianespace will provide strong competition. Some industry analysts concede that Arianespace can achieve 50% of the market.[90] This leaves on the order of 10-15 satellites per year to be launched throughout the 1990's--perhaps not enough to sustain more than one or two entries into the market.[91] Others are even less sanguine: John Koehler, President of Hughes Communications recently stated, "It is not at all clear to us that a viable U.S. expendable launch vehicle industry will emerge."[92]

B. Sellers

Domestic booster manufacturers fall into two general categories: one consists of the three larger, well established companies which have traditionally provided space boosters to the DoD and NASA; the other is made up of the new, more venturesome entrants into the market.

Martin Marietta -- This company has developed a family of Titan boosters for both the DoD's military requirements and NASA's scientific missions. Its current Air Force contract for the delivery of 23 Titan IV vehicles reestablishes a strong and sustainable production base, as there is every indication that Titan IV production will continue into the next century. The refurbishment and modification of an initial 13 Titan II ICBMs for west coast DoD launches, and the potential for additional Titan III vehicles for NASA requirements, add to that base. MMC has

recently signed three commercial contracts (two Intelsat and one Japanese satellite) to fly on the Titan III commercial variant. Additionally, a long term agreement was signed on 26 January 1988 with General Electric's Astro Space Division to launch 15 communications satellites.[33] According to MMC, future projections for additional Titan launches could bring about $.5B in foreign revenue generating $110M in federal and state taxes and creating 2500 additional jobs.[34] Meanwhile, the Titan is being marketed with performance characteristics which envelop most, if not all, commercial payloads with a demonstrated reliability of over 96%.[35] After the two setbacks with DoD payloads, the recent Titan successes, also with DoD payloads, will add to the system's reliability and salability.

McDonnell Douglas -- The Delta program has been noteworthy as the workhorse expendable launch vehicle for NASA sponsored commercial missions. Over the past 27 years the Delta has successfully launched 29 commercial payloads.[36] MDAC's decision to enter the commercial market as an independent was bolstered by its recent Air Force contract. In January 1987 it won the medium launch vehicle competition and with it a contract to launch 20 Global Positioning System (navigation) satellites beginning in October 1988. With a government established production base MDAC, like MMC, has avoided the additional non-recurring or start-up costs necessary for entry into the market. While it has signed

firm contracts to launch four commercial satellites in 1989 and 1990 and can compete for the small to medium sized payloads, MDAC is taking a conservative approach.[37] Its program manager cites the vagaries of national policy changes and the nature of the business itself.[38] This reflects the thinking of Mr. John F. Yardley, president of MDAC, who recently testified to Congress and urged caution.[39] He further warned of the government subsidized competition from foreign concerns and that it would take a concerted and consistent government-industry partnership for a successful U.S. program.[40]

General Dynamics -- GDC's Atlas launch vehicle has carried missions for both the NASA and the DoD, also with a high degree of success. Its Atlas/Centaur version is capable of launching medium sized payloads. Without the benefit of a current government contract to establish a minimum demand, GDC accepted the risk by starting the production line for the build of eighteen boosters, out of the company's investment funding.[41] While GDC has taken a more aggressive approach by putting corporate funds at risk, its management also stressed the importance of government participation as a commercial customer; that is, a procurer of complete launch services rather than as a procurer of solely launch hardware.[42] GDC's willingness to take a chance has brought some dividends in that it has won the NASA sponsored competition to launch, on a commercial basis, three

government National Oceanographic and Atmospheric Administration (NOAA) weather satellites with an option for two more.[43] Additionally, it won a contract to launch the European Telecommunications Satellice #2 in 1990.[44] GDC is continuing to petition for a government contract with the DoD and is an enthusiastic bidder for the Air Force's Medium Launch Vehicle #2 competition.

Space Services, Inc. -- SSI was one of the first entrepreneurial entries into the commercial space launch industry, and it is making a strong bid to become a viable enterprise. With the financial backing of Houston area investors and the engineering expertise of former astronaut Donald "Deke" Slayton, Mr. David Hannah has put together a company which is seeking a niche in the smaller satellite market. Its "Conestoga" launch vehicle is based on proven solid rocket technology and can carry small (400-4000 lbs.) payloads into low earth orbit, with growth capability to put satellites into geosynchronous altitudes.[45] Its recent agreement with Starfind, Inc. calls for the launches of five navigation satellites from Wallops Island, VA, beginning in late 1988. In addition to the commercial benefits, these small navigation satellites may have the potential for military application, as well.[46] SSI is also seeking to provide launch services to the DoD.

American Rocket Company -- AMROC will be the chief competitor of SSI for the smaller payload market. While the

technology it is employing for its "Industrial Launch Vehicle" (ILV) is unsophisticated, it is relatively unproven. Mr. George Koopman, president of AMROC, has faced an uphill struggle in maintaining investment funding and conducting subsystem testing on government ranges. However, if his hybrid engines (part liquid and part solid propellant) prove successful in the test launches of the ILV beginning in 1988 from Vandenberg AFB, I believe it could change the complexion of the space launch industry--if for no other reason than its inherent low cost. Moreover, the applications for the ILV with its simple and modular design, and very low cost to manufacture and operate are, indeed, unlimited--even for the military. This effort has been exciting to watch. AMROC and SSI were started from scratch and, if successful, would reflect significant free enterprise success stories.

A discussion of the sellers of commercial launch services would be far from complete without reference to foreign competition. What used to be the exclusive domain of the U.S., albeit owned and operated by the government, has evolved into a highly competitive international marketplace. As with this country, other nations' prestige will also be measured in terms of their ability to launch missions into space.

Arianespace -- Arianespace is by far the most prominent and well established of the foreign commercial space launch providers. France was the driving force behind

its creation, exerting its influence as a member of the European Space Agency (ESA). Represented by its national space agency called the National Center for Space Studies (CNES), France pressed hard for an independent launch capability during the early 1970s. This was driven by several factors: the U.S. decision to phase out all ELV's and rely solely on the shuttle, the restrictions placed on two particular French satellites to fly on NASA sponsored vehicles, and a growing sense of frustration with the NASA-dominated U.S. monopoly.[47] The French urged ESA for the development of a launch vehicle. Later named Ariane, the new booster was based on earlier versions of France's strategic missile. The ESA membership felt that an independent organization should be formed to conduct the marketing, business, and launch operations of the Ariane launch vehicle. Arianespace was created with headquarters located near the CNES launcher division outside Paris.[48]

This new organization was financed by European aerospace manufacturers, European banks, a European stock offering, and CNES. While Arianespace reports to ESA and has close ties with CNES, it has the flexibility to run the operation independently. Meanwhile, the development of the launch facility (located in Kourou, French Guiana), launch vehicle capabilities, and quality control was provided by CNES and ESA. Hence, Arianespace has the benefits of governmental backing with the ability to function as a

privately run business enterprise, establishing its own pricing structure and marketing strategy. Arianespace maintains that its prices are set by fair and correct pricing practices.[49]

Arianespace has experienced the same type setbacks that U.S. Government launchers went through in the early stages of development, having to endure several launch or deployment failures. A Ford Aerospace Satellite Services study pointed out that the Ariane booster success rate is 77.8% as compared to 93.3% for Delta, 86.2% for Atlas-Centaur, 96.3% for Titan III, and 96% for shuttle.[50] The Ariane program, however, is proceeding with the phasing in of Ariane 4, replacing Ariane 3, and nearly doubling the performance to roughly the equivalent of the Titan III. Future plans call for the development of the Ariane 5 by the mid 1990s which will lift very heavy payloads. This vehicle is also envisioned to provide a man rated capability for orbiting the European "Hermes" space plane. Hermes is envisioned as servicing space stations/man tended space platforms, as well as conducting scientific experiments.[51]

It is interesting to view the European perspectives of the U.S. commercialization initiative. First, they can't understand why it took so long! While there may have been an initial concern that the U.S. Government might dominate the scene, the Europeans now perceive an adversarial relationship between the U.S. Government and industry--not all totally

unfounded, I might add. Second, the U.S. Trade Representative (USTR)/ESA discussions are viewed as a positive step. (See Chapter V, Discussion, page 39). However, the general feeling is that there are no significant issues between the two parties, and that current practices are equitable and should continue in kind. And third, while fair competition is welcomed, there is some concern that the initial U.S. space launch industry success has come at the expense of the Europeans; that is, most of the payloads that will fly on U.S. boosters are coming from outside the U.S. Conversely, up to this point Arianespace has not been allowed to bid on new U.S. business opportunities: NOAA weather satellites and the MLV #2 competition are the latest.[82]

Others -- Finally, there are several other nations that are on the fringes of making an entry into the world commercial market. The Japanese are developing their H-series of space boosters. The H-1, launched for the first time on 13 August 1986, is based essentially on MDAC's Delta technology.[83] The more capable H-2 booster will follow with first launch scheduled for 1992. The vehicle is being developed by Japan's space science agency: Institute of Space and Astronautical Sciences. While no commercial contracts have been awarded, it is expected that Nissan, the manufacturer of the solid propellant motors will participate.[84]

The Chinese are aggressively marketing their Long

March series space boosters for commercial application. These vehicles closely resemble the ICBM configurations and will roughly have the capability of the Ariane 3/4 series in performance. China has signed a long term agreement with an American firm to help market launch services in North and South America as well as the Middle East. In addition, China will establish global marketing offices to help generate sales.[55] However, without an established and successful launch history, it will be difficult for the Chinese, at least initially, to seriously market the Long March.

The Soviets are attempting to make an entry into the world market. The Proton, SL-12 booster, would be used for commercial missions from the Tyuratam launch facility. Serious customers would have access to the launch site. The Soviet space agency, Glavkosmos, has conducted marketing trips through the U.S., France, Japan, and Australia with mixed results. While the State Department would forbid domestic satellites from Soviet launch services on the basis of technology transfer, manufacturers/users such as Hughes would like to keep the option open. Price is the big incentive with the Soviets advertising at roughly half of what the U.S. or Arianespace would charge.[56] The future is unclear; but, in the era of glasnost and perestroika the economic reforms of the Soviet Union could extend into a truly capitalistic and competitive enterprise.[57]

CHAPTER V

DISCUSSION

> "...That wherever possible the private sector be given task of providing specified services or products in space, and be free to determine the most cost-effective ways to satisfy those requirements, consistent with evolving Federal regulations..."[88]

The common denominator in the exploitation of space comes down to transportation, more specifically the cost to launch a payload. By whatever system one chooses to determine the costs, whether it be on a shuttle or Ariane or Proton or Air Force vehicle it is a very exacting and expensive endeavor. For the DoD in particular it is one of the primary reasons why we have grown our satellites both in terms of dimension and costs, simply because the opportunities to launch are few. We needed to pack as much capability and longevity as possible into a satellite, always encroaching upon the performance margins of the space booster--similarly for the scientific and commercial sectors. While satellite technology has made tremendous strides, booster technology, save shuttle, hasn't significantly

evolved since the early ICBM era. The answer to everyone's problem was to be the shuttle. The idea seemed logical: a reuseable space taxi to carry all cargo--it would pay for itself. Events proved otherwise.

In the past this nation has had a marvelous and already built-in mechanism for reducing costs when there was a demand: namely, competition. History is repleat with examples. The aircraft industry, perhaps, provides the closest example to space launch of the government sponsoring a developing industry and where, ultimately, both benefitted. For example, it was government airmail contracts beginning in the 1920s which allowed the growth of the early commercial airline industry. Numerous manufacturers were created with a multitude of ideas and concepts generating designs for any number of purposes. Commensurately, the government benefitted by acquiring aircraft for military purposes with their initial design generated by private initiative. For example, a $15M investment by Boeing to build a prototype aircraft for commercial air transport with the potential for military applications, evolved into the Boeing 707 and the KC-135 Stratotanker.[88] The Civil Reserve Air Fleet is another example. But the key was the private sector involvement and the bottom line criteria for minimizing costs and returning a profit. Can the parallels be made with space transportation?

Messers Bennett and Salin writing for Space Policy

insightfully reasoned that technological achievement in space transportation is related to the development cycle; that is, overly ambitious design goals for a large system requiring a long development cycle will ultimately produce a delayed and less than expected result when compared to programs with less ambitious objectives allowing shorter development cycles.[80] For example, achievements in efficiencies will be greater in those systems developed over a span with several development cycles allowing technology to advance in shorter steps rather than forcing quantum leaps, and with lower developmental costs--direct reference is made to the shuttle.[81] Additionally, by settling in on a particular system requiring a long development cycle, competing and innovative designs typically don't have a chance to be traded off with the baseline system.[82] I couldn't agree more.

The proposed development of the Advanced Launch System (ALS), previously the Heavy Lift Launch Vehicle (HLLV), portends the same mistakes that we made with the shuttle--with a parentage that is just as suspect. Here was a concept with its roots in the NASA/DoD Space Transportation Architecture Study and born of a requirement to orbit the Strategic Defense Initiative (SDI) systems. Another, perhaps equally important, reason for the program was to send a clear, non-provocative signal to the Soviets that the U.S. was serious about the deployment of the SDI. So, what have we created? While the program was not sponsored by the Air

Force nor NASA, it quickly attracted both their support--each concerned about their future role as space transportation provider. With neither agency having a clear requirement for the ALS (except for the familiar and popular requirement to reduce costs), each was intent, however, to sponsor it; requirements were generated as no one wanted to be left at the train station. What is even more bizarre was the advertisement that the vehicle would have commercial applications! I've sat in program review meetings where the ALS was touted to be the "space bus" of the future, carrying any and all payloads to predetermined transportation nodes for subsequent payload self-deployments to individual destinations. I recall the same type arguments being made about the shuttle in meetings ten years ago. This is also reflective of the concerns of Bennett and Salin over the long development cycle of a very large program.

The SDI program has since relieved the near term requirement for the vehicle and the program has been repackaged as a technology effort leading to a full scale development decision milestone in the early 1990s. NASA has subsequently reduced its enthusiasm for the ALS (to the chagrin of the Air Force) in favor of its own shuttle derived technology effort leading to a heavy lift vehicle for space station requirements. What remains, if funding is approved for the program, is a pure technology effort for an advanced system (late 1990s) sponsored by the Air Force, and a more

hardware oriented NASA program for application in the early 1990s.[85] In both programs, aside from directed government contracts, what, if any, are the expectations of private enterprise?

The second point that merits discussion is the need by industry of a sustained government demand to maintain the industrial base. This is not an insurmountable obstacle as the Air Force and to a lesser degree NASA (including NOAA) are procuring launch vehicles; the Air Force, at least, will continue these procurements through the turn of the century. The trick will be for industry to convince these two agencies to procure complete launch service packages with launch vehicles built to commercial standards, launched by commercial crews, and consumated via commercial type contracts. The selling point is that by avoiding extensive documentation and oversight that is part of current government contracting practices, additional savings can be realized--arguably at no loss in reliability. However, this would be a significant departure from the thirty years of tradition and the culture that has evolved in the launch vehicle field. Moreover, from a military perspective a purely commercial type of arrangement must be traded off with other military considerations: survivability, responsiveness, security, etc.

Finally, for a space launch industry to compete on an international level the U.S. Government should strive for

fair competition with foreign suppliers. The U.S. Trade Representative (USTR) was tasked by President Reagan for this purpose. ESA and Arianespace were receptive to the initial overtures by the USTR. Our first meeting with the Europeans in July 1987 in Washington D.C. was most cordial and I discerned a sincere effort on the part of the Europeans to reach an understanding. While there was some concern expressed for the pre-Challenger shuttle pricing, the commercialization initiative was viewed as fair competition. The subsequent meeting in Paris, to my understanding, also went well with a commitment by both parties to exchange information regarding degree of government involvement in all areas of space launch: research and development, production, facilities, risk management, etc. Details of the discussions remain confidential; however, further talks are proposed with both parties, at this point, seeking a level playing field. A possible outcome may be for both parties to agree to hold to the current levels of government participation and to encourage ESA and U.S. satellite manufacturers/users to refrain from seeking launches from nations providing heavy government subsidies: USSR, Japan, and the PRC.[84]

CHAPTER VI

CONCLUSIONS

> "...Given the unprecedented opportunity, it is of paramount importance that our government resolve to strongly support the commercial space launch industry with direction. What we ask from the government is only their support, not subsidies. We as a nation have a rare opportunity to shore up our industrial base which has eroded significantly over recent years. The government, in its capacity to promote and encourage the commercial launch industry, will become the principal beneficiary of its efforts."[88]

Mr. Lovelace of General Dynamics has eloquently expressed the desires of industry. More than anything else, industry is striving for a free market, unencumbered by federal restrictions. To a large degree this is happening, perhaps not as fast as industry would like to see. The Reagan Administration has set the process in motion with a strong commercial space launch policy as well as removing the shuttle as an impediment to privatization. A Washington spokesman and a single regulatory authority for the industry has been established with the OCST, an aggressive group which is continually adding to its technical expertise. Additional advocacy has been evidenced by DoC and the EPC. NASA and the

Air Force are working to establish safe and ready access to the national ranges. Moreover, the proposed legislation amending the CSLA may provide relief in areas of risk management and launch priorities; although the latter may present artificial and unnecessary scheduling problems for the Air Force. A production base has been established for at least two manufacturers by the Air Force along with its continued moral support to the industry. The USTR has opened very important negotiations with the Europeans to ensure international fair trade practices. In all, the government has taken the initial steps to introduce this fledging industry. While its success will ultimately be dependent upon the daring, innovation, tenacity, expertise, and luck of the industry, several additional steps by the government could be taken which may prove to be the difference--especially in the long run.

Commercial Launch Services -- The Congress should facilitate the procurement of commercial launch services by the DoD. The Air Force tried unsuccessfully in 1983 for a commercial approach (incremental or multi-year funding) for the initial buy of ten Titan IVs, then Commercial Expendable Launch Vehicles (CELVs). The Congress would not permit this in favor of a traditional, fully funded approach, requiring additional appropriated funds and yearly Congressional approval. The Air Force, I believe, is willing to pursue a commercial approach for several of what could be termed

unclassified launch requirements: the Defense Satellite Communications System program, the Global Positioning System program, and the Space Test Program which sponsors many small experimental efforts. The SDI may also have unclassified and suitable payloads for a commercial launch services environment. However, to realize the maximum savings, incentivize the Air Force, and be of greatest benefit to the industry, block buys entailing incremental or multi-year funding will have to be authorized, even encouraged by the Congress. The question of procuring launch vehicles versus complete launch services remains open as to the real benefits to both parties. Industry, of course, would like to sell complete launch services entailing much less government oversight and resulting in significant time and cost savings to both parties. The Air Force recognizes this and could, at some point, transition some, if not all, of the above programs. Again, this would be a departure from tradition.

Additional Launch Facilities -- Industry use of government facilities and ranges is being worked in earnest. There may come a time, however, when commercial and government launch activity will begin to choke the capacity of the existing facilities. This is clearly a possibility with the joint use of the Titan facilities on the east coast. A possible remedy is the construction of additional launch facilities. A joint government-industry agreement could be struck whereby the government would participate in the

construction with the guarantee of a certain number of launch opportunities, or vice versa. Facility construction does not have to be limited to existing launching locations as there are other potential sites. Texas and Virginia have been discussed. One of the most attractive alternatives is for a launch site in Hawaii. In addition to a multi-azimuth launch capability, there is a performance benefit for geosynchronous payloads by virtue of the launch site being located closer to the equator. Unfortunately, new launch facilities are expensive. But, a government-industry partnership, perhaps with public support, may be the way to go.

New Technology -- The ALS initiative portends further advancements for space launch, if the effort is run properly. Advanced technology areas such as hydrocarbon engines, lightweight/high performance materials, advanced avionics, and improved ground operations are a few fields where a limited funding expenditure can produce significant results, and where government involvement can produce the high payoffs. Of primary concern is the assurance that a mechanism is established whereby technological achievements, not critical to national security, are passed on immediately to the industry--if proven cost effective, they may be readily incorporated into an existing production line. Harkening back to Bennett and Salin, the development cycles would be numerous and shorter. If the government decided that a large heavy lifter was in the national interest for

defense or civil applications, many of the newer systems will have had the benefit of advanced testing or, better still, flight history. But, the key is baselined private sector involvement. Additionally, the question of who is best qualified to run the effort should be determined by the Administration decision, not predicated by funding nor left to the vagaries of the Congress. The lead agency (Air Force or NASA) will assume a difficult task, one which will involve choices of which technologies, and which vested interests receive the funds. There is no easy answer to this one. I would only hope that if such a program were to be implemented, parochialism would be set aside for the benefit of the nation.

Distinguishing Civil and Military Programs -- Another lesson learned from Challenger is that the military must have an independent space launch capability, distinct from the civilian side, and made up in some instances of complementary systems. This does not mean that there can be no overlap. To the contrary, the advent of the commercial sector introduces another capability, adding to the nation's space launch robustness. From a military perspective, this is a positive step. Moreover, from a parochial standpoint we can regard this as a potential application of the Civil Reserve Air Fleet--only for space systems. In that light the military has an obligation to ensure that those systems which show potential use for augmentation in a national crisis are

designed and built for the possibility of integrating DoD payloads. Today, this is being accomplished on three of the commercial systems (Titan, Atlas, and Delta) where the vehicles are being built to existing military specifications and government quality control. This has advantages not only in crisis situations but also in peacetime conditions where there is built-in flexibility in the production line, so that subsystems can be mixed and matched between commercial and military boosters. This is a practice that must be allowed to continue, even at the risk of being identified as a government subsidy of the industry. Additionally, this practice should be expanded, where appropriate, to those entrepreneurial systems developed that show military application.

NOTES

1. Remarks by the President on signing Executive Order 12465, Washington D.C., Weekly Compilation of Presidential Documents, Vol. 20, No. 8, 24 February 1984.

2. National Aeronautics and Space Act of 1958, 85, sec. 102(b) (1958).

3. Department of Defense Directive, Development of Space Systems, No. 5160.32, Washington D.C., U.S. Department of Defense, (1970), p. 1.

4. The Air Force had its own problems delivering the Inertial Upper Stage. NASA terminated its share of the planetary development in 1981 in favor of its own modified Centaur upper stage, previously flown on expendable launch vehicles. Post Challenger, NASA determined that Centaur would not fly on the shuttle due to safety considerations, reverting back to the IUS. Additionally, largely due to the ongoing modifications at the Kennedy Space Center, the development of the shuttle facilities at Vandenberg was overbudget and several years late. Today, fleet size limitations and reduced shuttle performance make Vandenberg's use as a future shuttle launch base unclear, at best.

5. It is interesting to note that there were two Titan IV (then CELV) competitions held: one with industry and the second between the industry winner and a NASA design based on shuttle derived components. The industry alternative won primarily on development simplicity and its differences from the shuttle--thereby retaining complementary launch systems for the nation and assuring access to space.

6. James E. Davidson, Project Manager, Space Services, Inc., letter to Lt Col Kouts, 2 November 1987.

7. U.S., President, "Commercialization of Expendable Launch Vehicles," National Security Decision Directive, 16 May 1983.

8. Commercial Expendable Launch Vehicle Activities, Executive Order 12465, Washington D.C., The White House, 24 February 1984.

9. Commercial Space Launch Act, 98, secs. 1-20 (1984).

10. U.S., President, "Shuttle Pricing for Foreign and Commercial Users," National Security Decision Directive, 30 July 1985.

11. Ibid.

12. In this timeframe (1985-1986), NASA moved to kill the Air Force's Titan II space launch vehicle program. Although approved for certain missions (Defense Meteorological Satellite Program, NOAA Tiros weather satellites, and a classified program), use of Titan IIs from Vandenberg AFB was viewed as a threat to the shuttle program at the west coast. Even though these small payloads were launch-on-demand (which could mean flying alone), designated for unique orbits, and took up a small portion of the orbiter bay, NASA needed these launches to help maintain the shuttle flight rate. To this end, the FY 86 Appropriations Conference Report placed the NASA Administrator in a co-equal status with SECDEF in determining which Air Force payloads could be launched on a Titan II. Negotiations with NASA began in early January 1986 and were only concluded in March 1986, after Challenger, and when NASA realized that the probability of shuttle launches from Vandenberg AFB was minimal. At that point, NASA agreed to let the Air Force use its own boosters to launch its own payloads.

13. Report of the Presidential Commission on the Space Shuttle Challenger Accident (Washington D.C.: GPO, 6 June 1986), p. 199.

14. The Air Force would have come under the same intense public scrutiny in light of the Titan failures if the public had not been drawn to the Challenger accident. The Air Force did, however, conduct its own recovery effort with exhaustive analyses of the two failed missions, investigating hardware manufacturing procedures, material review board practices, inspection criteria, and quality control standards to name the most salient. Significant was the effort to build non-destructive test facilities at both the east and west coast launch sites for the purpose of conducting a final screening of the solid rocket motor segments.

15. Statement by the President, Washington D.C., Office of the Press Secretary, 15 August 1986.

16. Theresa M. Foley, "Reagan Rejects NASA Bid to Honor 31 Shuttle Contracts," Aviation Week and Space Technology, 13 October 1986, p. 23.

17. Remarks by the Honorable Edward C. Aldridge, Jr., Secretary of the Air Force, to the Commercial Launch Vehicle

Symposium, Cape Canaveral, Florida, 17 December 1986.

18. Department of the Air Force Model Expendable Launch Vehicle Commercialization Agreement (Draft), Los Angeles AFS, California, 20 July 1987

19. Comments on the Draft U.S. Air Force "Expendable Launch Vehicle Commercialization Agreement", by T. Allen McArtor, Chairman of COMSTAC, (Memphis, Tennessee, 30 January 1987), cover letter.

20. Ibid., pp. 1-3.

21. Model Agreement, p. 5.

22. Ibid.

23. Ibid.

24. "Insurance Companies Defend Higher Pricing Policy," Aviation Week and Space Technology, 7 September 1987, p. 61.

25. Ibid.

26. Congress, House, Commercial Space Launch Act Amendments, (Draft), 100th Congress, 1st Session, H.R. 3765 (December 1987), p. 4.

27. Statement by the President, 15 August 1986.

28. Euroconsult's 1986 edition of "The World Space Industry Survey: Ten Year Outlook," edited by Space Policy, August 1987, pp. 252-253.

29. Battelle, Columbus Division's "1986 Outside Users Payload Model," edited by Space Policy, August 1987, pp. 253-257.

30. Theresa Foley, "ELVs," Commercial Space, Winter 1987, p. 20.

31. Ibid.

32. Shannon Shutak, "Willing and Able: Expendable Vehicle Manufacturers Gear for Anticipated Launch Demand," Commercial Space, Winter 1987, p. 25.

33. "Fact Sheet on Commercial Titan," Martin Marietta, Commercial Titan, Inc., February 1988.

34. Testimony of Richard E. Brackeen, President of

Martin Marietta Commercial Titan, Inc., before the House Committee on Science, Space, and Technology, Washington D.C., 15 September 1987.

35. "Fact Sheet on Commercial Titan."

36. J. K. Little, Manager, Commercial Delta Programs, letter to Lt Col Kouts, 13 November 1987.

37. Ibid.

38. Ibid.

39. Testimony of John F. Yardley, President of McDonnell Douglas Astronautics Company, before the House Committee on Science, Space, and Technology, Washington D.C., 15 September 1987.

40. Ibid.

41. Statement of Dr. Alan M. Lovelace, Corporate Vice President and General Manager, General Dynamics--Space Systems Division, before the House Committee on Science, Space, and Technology, 15 September 1987, p. 1.

42. Ibid., p. 4.

43. "Atlas to Launch Weather Satellites," Aviation Week and Space Technology, 26 October 1987, p. 30.

44. Ibid.

45. Davidson, letter to Lt Col Kouts.

46. Press Release, Starfind, Inc., Laguna Niguel, California, 11 May 1987.

47. Douglas A. Hayden, Executive Vice President and General Manager, Arianespace, Inc., "Ariane and Arianespace," International Space Business Review, undated.

48. Jeffrey M. Lenorovitz, "Europe's Ariane," Commercial Space, Fall 1985, pp. 22-23.

49. Ibid., pp. 23-25.

50. "Ford Urges Federal Intervention in Launch Insurance Market," Aviation Week and Space Technology, 25 August 1986, pp. 24-25.

51. Lenorovitz, p. 25.

52. Douglas A. Hayden, President, Arianespace, Inc., letter w/ atchs to Col Kouts, 22 March 1988.

53. "H-1 Proves Japanese Launch Capability," Aviation Week and Space Technology, 25 August 1986, p. 25.

54. "Japan Will Develop New Three Stage Booster," Aviation Week and Space Technology, 20 July 1987, p. 24.

55. Craig Covault, "New Chinese Heavy Rocket Spurs Effort to Win Launch Contracts," Aviation Week and Space Technology, 4 May 1987, pp. 20-21.

56. "Proton Marketing Team Finds U.S. Interest, Opposition," Aviation Week and Space Technology, 25 May 1987, pp. 20-21.

57. Note the ramifications of the Soviets entering the commercial space launch business with our willing participation--assuming international fair trade practices. The issue of technology transfer notwithstanding, perhaps all would benefit to some degree: commercial satellite owners/users would have another access to space; U.S. owned communications transponders would generate additional revenue (that may not be readily available if they are without access to space) adding to our GNP; the communist system would be further stretched by becoming more closely aligned to a capitalist endeavor; and, the entire world community would realize the advantages of further space development.

58. National Commission on Space, Pioneering the Space Frontier (New York: Bantam Books, May 1986), p. 11.

59. George E. Luck, Lt Col, USAF, The KC-135A Tanker Development, Fleet History, and Future Capabilities, (Air University: Air War College, April 1976), p. 11., citing "Why a Jet Prototype?" The Boeing Company, (Seattle, Washington, n.d.), p. 1.

60. James Bennett and Phillip Salin, "The Private Solution to the Space Transportation Crisis," Space Policy, August 1987, pp. 193-195.

61. Ibid.

62. Ibid.

63. It makes for interesting speculation on what will happen if NASA succeeds in building a heavy lift launch vehicle (for space station), vis-a-vis the SDI which is helping to fund the ALS. It is easy to conceive a scenario where the SDI, if it requires the heavy lift launch

capability, reverting to an at hand NASA booster.

64. Discussion with Lt Col James Beale, Deputy to the Deputy Assistant Secretary, Space Plans and Policy, SAF/AX, Washington D.C. 29 December 1987.

65. Lovelace, p. 5.

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