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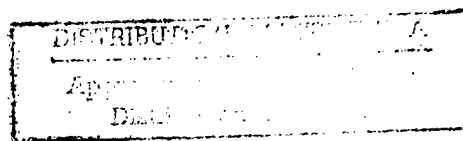
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Wright-Patterson Air Force Base, Ohio

AFIT/GCM/LAL/98S-4

THE COMMERCIALIZATION OF SPACE
TRANSPORTATION:
EXPLORING THE IMPACT OF THE NATIONAL
SPACE TRANSPORTATION POLICY

THESIS

Thomas L. Johnson, 1st Lieutenant, USAF

AFIT/GCM/LAL/98S-4

Approved for public release; distribution unlimited

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AFIT/GCM/LAL/98S-4

THE COMMERCIALIZATION OF SPACE TRANSPORTATION:
EXPLORING THE IMPACT OF THE NATIONAL
SPACE TRANSPORTATION POLICY

THESIS

Presented to the Faculty of the Graduate School of Logistics
and Acquisition Management of the Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Contracting Management

Thomas L. Johnson, B.S.

First Lieutenant, USAF

September 1998

Approved for public release; distribution unlimited

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Thomas Lee Johnson

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Abstract

The 1994 National Space Transportation Policy designates the roles of the DoD, NASA and the Departments of Transportation and Commerce to “identify and promote innovative types of arrangements between the US government and the private sector in order to reduce the cost to access space.” DoD, civil and commercial industry leaders agree that the price to access space is currently “exorbitantly expensive.” The solution to this expense, which the USG is relying upon, is the commercialization of space transportation technology. This research focuses on investigating the industry and policy commercialization trends which led to the 1994 NSTP, and reports on compliance with the policy. Through policy literature review, case study analysis and interviews, the impact of the National Space Transportation Policy on commercializing space transportation is determined. Research focuses on space transportation participants who have done the most to shape the commercialization policy over the past decade. Results indicate that the 1988-1994 period, leading to the 1994 NSTP, was shaped by the NASA and DoD stakeholders’ assertions for expanded bureaucratic control of the nation’s space transportation resources. After the 1994 NSTP, in the period of 1995-1998, the commercialization of space technology has been increasing slowly, with innovative arrangements evolving each year.

THE COMMERCIALIZATION OF SPACE TRANSPORTATION:
EXPLORING THE IMPACT OF THE NATIONAL SPACE
TRANSPORTATION POLICY

I. Introduction

Setting the Stage for Commercialization

The United States space transportation program began with US intercontinental ballistic missiles (ICBM) in the 1960s. The payload for the first spacelift vehicle was high kilo tonnage nuclear warheads. The United States Government (USG) developed the Redstone, Atlas and Titan ICBM spacelift vehicles prioritizing performance and reliability, not cost (Coston, 1998). The USG developed these spacelift vehicles in a zealous oversight environment with tedious requirements in specifications and documentation (Kim, 1998). USG space transportation acquisition programs typically ran over schedule and budget because of operational requirements (Roberts, 1998). These requirements demanded expensive, highly specialized aerospace materials. The characteristics of the USG acquired spacelift vehicles were “overly sophisticated relative to the task at hand, very intensive and demanding maintenance requirements, and virtually hand-tooled uniqueness” (Handberg: 62).

Proponents for commercialization within the space transportation industry and the USG assert that commercialization will reduce the cost of space transportation vehicles and operations. Commercialization is defined as privately operating a space transportation asset for profit, with authority and ownership transferred into the privately

owned company. Proponents for commercialization advocate their position, because commercial space transportation vehicles are interchangeable, versatile and usually operate just inside the cutting edge of technology where the operating devices tend to be tested and considered reasonably reliable and less expensive (Handberg: 62). Table 1 describes the current launch vehicle costs in the space transportation industry. The table indicates that most current technologies within America's government acquisition spacelift cost between \$12,428-\$13,710/lb to LEO. America's only purely commercial firm, Orbital Sciences Corporation (OSC) has designed a commercially operated and owned spacelift vehicle, the Taurus, which costs \$7,666/lb to LEO. Also, the Department of Transportation performed a study on the Atlas Centaur and found the commercially operated vehicle (\$59M) costed 26% less than the USG operated spacelift vehicle (\$80M).

The 1994 NSTP

The fact that launch service costs remained "exorbitantly expensive" despite the commercialization of vehicles like the Titan family, indicated that the USG did not have a consolidated, coherent plan for commercialization policy between 1990-1994. The 1994 National Space Transportation Policy is touted by the Clinton Administration as the only document in recent history which consolidates commercialization policy and focuses our space transportation industry on the goal of reducing cost to access space. The 1994 NSTP was designed to sharpen the types of commercialization efforts that were occurring between USG stakeholders and industry. The fact that launch service costs remained

Table 1. Current Cost Figures for Spacelift Inventory

Launch System	Company(Class)		Payload to LEO (lbs)	Price (Millions)	Cost (per lb)
Scout	LTV	C	460	\$12.0	\$26,100
MSLS	LMA	C/X	800	\$5.0	\$6,250
Pegasus	OSC	C/N	900	\$13.0	\$14,400
LLV 1	LMA	C/N	1,200	\$15.0	\$12,500
K-1	Kistler	C/X	2,000	\$7.0	\$3,500
Pathfinder	Pioneer	C/X	2,200	\$4.5	\$2,045
Pathfinder	Pioneer	C/X	2,920	\$4.5	\$1,541
ROTON	HMX	C/X	?	?	?
Taurus	OSC	C	3,000	\$23.0	\$7,666
Titan II	Lockheed	N/M	4,200	\$27.0	\$12,428
Eclipse	Kelly	C/X	4,250	?	?
Med-Lite	MDA	C/X	5,000	\$36.0	\$7,200
Delta 7920	MDA	C	10,000	\$58.0	\$5,800
Long March 3	GW/China		11,000	\$33.0	\$3,000
Soyuz	Korolev/Russia		15,000	\$30.0	\$2,000
Ariane 44L	CNES/France		16,900	\$110.0	\$6,508
Atlas 2AS	LMA	C/N	17,000	\$90.0	\$5,300
Sea Launch	Boeing	C/X	22,000	\$77.0	\$3,500
Ariane 5	CNES/France		26,400	\$130.0	\$4,924
Titan IV	LMA	N/M	35,000	\$160.0	\$13,710
Proton	LKE/Russia		35,000	\$70.0	\$2,000
Shuttle	NASA	N/M	40,000	\$500.0	\$12,500

Note: Listings are civil (N), military (M), or commercial (C) experimental (X).

“exorbitantly expensive” despite the commercialization of vehicles like the Titan family, indicated that the USG did not have a consolidated, coherent plan for commercialization policy between 1990-1994. It was only logical for the USG to pick up the tab for exploring the capital intensive, highly unpredictable environment of space. Until the end of 1988, the USG demonstrated its willingness to provide a steady stream of funding for building and tasking spacelift vehicles. Orders from the Air Force and NASA satisfied the need for launch business to keep production lines open and funding flowing (McLucas: 98).

Ideal commercial spacelift programs, such as the Orbital Sciences Corporation Taurus, have the characteristics of reduced costs which the 1994 NSTP is pursuing. The Congress supports commercialization policy which attempts to reduce costs to access space without government subsidies. The February 1993 Space Subcommittee report recommends the federal government improve industry's position without spending an exorbitant amount of money (Sensenbrenner: 1). Some leaders in the USG and the space transportation industry think that government subsidies are the only way the US industry can keep up with the international competition, which is heavily subsidized. This is contrary to the trend of commercialization and exemplifies that some among the USG stakeholders and industry dependence on central oversight and control.

Commercialization policies, affecting the USG stakeholders, NASA, DoD and private industry in total, were designed to increase creativity in spacecraft and space vehicle design, build business in space commerce and decrease costs in accessing space.

The theory of commercialization of space transportation is founded on the 1994 NSTP philosophy approved by President Clinton. President Clinton's philosophy of commercialization is:

US Government agencies shall purchase commercially available US space transportation products and services to the fullest extent feasible that meet mission requirements and shall not conduct activities with commercial applications that preclude or deter commercial space activities, except for national security or public safety reasons. (Clinton: 3)

The provisions for commercialization of space transportation within the 1994 NSTP are:

1. USG will, to the extent feasible, involve the private sector in the design and development of space transportation capabilities and encourage private sector financing.
2. Emphasize procurement strategies that are based on the use of commercial US space transportation products and services.
3. USG shall purchase commercially available US space transportation products and services to the fullest extent feasible that meet mission requirements and shall not conduct activities with commercial applications that preclude or deter commercial space activities. (Clinton: 4)

Specific Problem

The specific problem is that space transportation is too expensive at its current rates. With a few, limited exceptions, USG and commercial industry spacelift vehicle acquisitions and operations are more costly than they should be. This thesis investigates what has been done historically to reduce the cost of access to space through commercialization.

Research Objective

The objective of this thesis research is to explore the executive and legislative policy which has shaped commercialization efforts to reduce the cost to access space. Policy-makers in Congress and the White House agree on the concept of commercialization of the space transportation industry to reduce cost to access space. Language regarding the definition and theory of commercialization is similar between the historical acts of Space Commercialization in Congress from 1989 and 1992 and the language within the Presidential Decision Directives from the Bush (1992 NSPD-2) and Clinton Administrations (1994 NSTP). The 1994 NSTP acts as the consolidating

document which parlays previous policy into more focused and creative direction to reduce the cost to access space.

Research Question

This thesis explores common historical ground, between the White House and Congress, that affects key space transportation commercialization, to reduce cost to access space. The research question this thesis investigates is, how has space transportation commercialization been affected by the 1994 National Space Transportation Policy?

To answer the research question appropriately, the following investigative questions are addressed:

1. What were the historical characteristics of the space transportation policy, as it evolved from 1988?
2. What people, forces or events caused space transportation policy to move towards commercialization?
3. How has commercialization policy changed from 1988 to the 1994 National Space Transportation Policy and to the current day, 1998?
4. What impact has the 1994 National Space Transportation Policy had on current space transportation (USG and commercial) industry?

Scope

There are many more provisions within the 1994 NSTP which have not been addressed. These provisions include data rights, technology transfer, dual-use programs, exploiting foreign competition and evaluating the national security impacts of continued commercialization of our payloads (especially satellite imaging technology). Any of the aforementioned details would provide a rich and rewarding opportunity for continued research on the impact of the NSTP to reduce the cost to access space for the USG and industry. The laws which I explore do provide detail regarding these provisions; however, they are outside of the scope of this thesis.

Summary

Chapter II describes the methodology for compiling and investigating the evidence which accumulated through a review of policy case study. Chapter III investigates the industry and policy commercialization trends, which led to the 1994 NSTP. Chapter IV reports on the USG and industry stakeholders' compliance with that document. Chapter V presents analysis of the policy and discusses how commercialization has affected space transportation.

II. Methodology

Overview

This thesis is a policy review case study of the commercialization of space transportation as a result of National Space Transportation Policy (NSTP). The case is analyzed from two perspectives. First it is segmented chronologically. The 1988-1994 events indicate the movement towards commercialization leading to the 1994 NSTP. The 1995-1998 events are described as the events resulting from the 1994 NSTP. The second perspective focuses on the differentiation between the USG and commercial industry impacts from the 1994 NSTP. The investigative questions establish the logic and structure of this policy review. The investigative questions are:

1. What were the historical characteristics of the space transportation policy, as it evolved from 1988?
2. What people, forces or events caused space transportation policy to move towards commercialization?
3. How has commercialization policy changed from 1988 to the 1994 National Space Transportation Policy and to the current day?
4. What impact has the 1994 National Space Transportation Policy had on current space transportation (USG and commercial) industry?

Yin's Single-Case Design

The most robust method for exploratory investigation of investigative questions involves single-case design (Yin: 47). The single case design utilizes interviewing (for information from influential or well-informed people in an organization or community) and document analysis (to evaluate historical or contemporary confidential or public records, reports, government documents, and opinion (Cooper and Emory: 119). Chapter III and IV is a policy case study using Yin's single-case design.

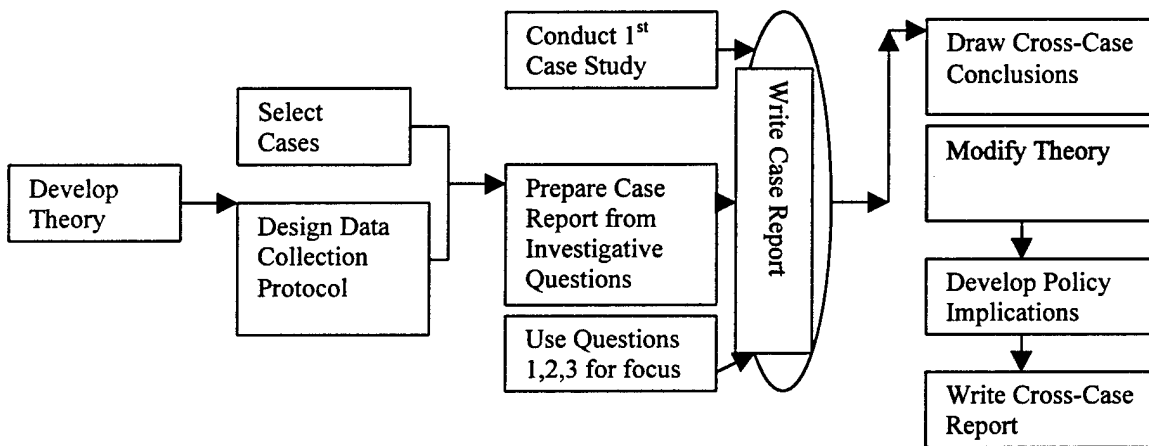


Figure 1. Yin's Case Study

Approach

The logical link between the questions and the data collection is single case analysis. The unit of analysis includes an individual person (elite interviewing) and organizations (Yin: 31) According to Yin, "the case also can be some event or entity that is less well defined than a single individual. Case studies have been done about decisions, about programs, and about the implementation process" (Yin: 31). The case study which is examined in this thesis is the commercialization policy of the space transportation industry. This is case confined to the USG stakeholders and commercial

Table 2. Methodology Overview

Activity	Method
Develop Theory	Theory on commercialization policy is described in policy literature review in Chapters III and IV.
Select Cases -(Design Data Collection Protocol)	Interviews, Congressional hearings, Industry trade periodicals, WWWeb sources, selected based on chronological relevance to the events in commercializing space transportation and the impact that the 1994 NSTP was having on space transportation and USG stakeholders.
Conduct Case Study -(Prepare Case Report from Investigative Questions) -(Use Questions 1,2,3 for focus)	Chapter III and IV policy review represents the chronological and differentiated (USG/Industry) material for commercialization in space transportation. It is assembled logically as pre-1988, 1988-1994, 1995-1998 and the reactions are accounted for as USG and industry.
Case Report -(Use Questions 1,2,3 for focus)	Chapter III and IV uses the case to answer the investigative questions as the commercialization unfolds as the chapters describe events.
Develop Policy Implications	Chapter V Analysis uses the Chapter III and IV case study to answer the questions and determine how effective NSTP has been on commercialization in the American space transportation industry.

industry participants who have shaped commercialization policy from 1988 to 1998. The ten year time span of 1988-1998 represents the period of the most dynamic policy changes and technological innovations in the space industry compared to any other period. The single case design incorporates policy from the executive and legislative branches from this time span. The evidence from single case, long time span analysis is often considered more compelling, and the overall study is therefore regarded as more robust (Yin: 52).

The justification for the single-case study approach is two-fold: a) each element within the case must be selected based on its similarities in results (literal replication in commercialization) and b) it produces contrary results but for predictable reasons (theoretical replication events contrary to commercialization, i.e. continued bureaucratic control) (Yin: 53). The analysis is organized according to the case results generated in the policy review conducted in Chapters III and IV.

Table 2 indicates the accepted levels for commercialization in the space transportation industry. Table 3 describes the classification of commercialization which is appropriate for the extensive number of programs used in the policy review case in Chapter III and IV. Table 3 guides reader understanding of the various levels of commercialization which are currently in place in our space transportation industry. Data are collected focusing on the government compliance and industry reaction to the 1994 NSTP. Compliance with commercialization is defined as a commercial launch (CL) rating within a program, and commercial-like launch (CLL) or government launch (GL) is considered partially compliant. The evidence gathered is neither exhaustive nor unbiased.

Method

The investigative questions focus on the policy evaluation portion of the policy process. Rogene Buchholz's model of the policy process depicts the systematic resolution of the investigative questions. The basic blocks of the model also serve as a methodology by which policy can be analyzed as well as developed.

Table 3. Three Classifications of Commercialization in Space Transportation
(Chow p.xiv)

Activity	Level of Commercialization	USG (Civil/Defense) Role	Commercial Role	Example
Government Launches (GL)	None. Traditional Procurement	Oversight	Provide launch vehicle/hardware according to specifications and government control and oversight	All Titan, Atlas and Delta acquisitions in the DoD inventory
Commercial Launches (CL)	Full.	Purchase launch services from contractor. Little USG control.	Provide launch services for USG payload at market price. Contractor makes final decision on launch.	Orbital Sciences Corporation Taurus Rocket
Commercial-like Launches (CLL)	Partial.	Purchase launch hardware or services with more government monitoring than a CL arrangement. Government makes final decision on launch.	Follow USG lead on launch requirements and delivery schedule	Privatization of the Space Shuttle Operations through United Space Alliance (USA)

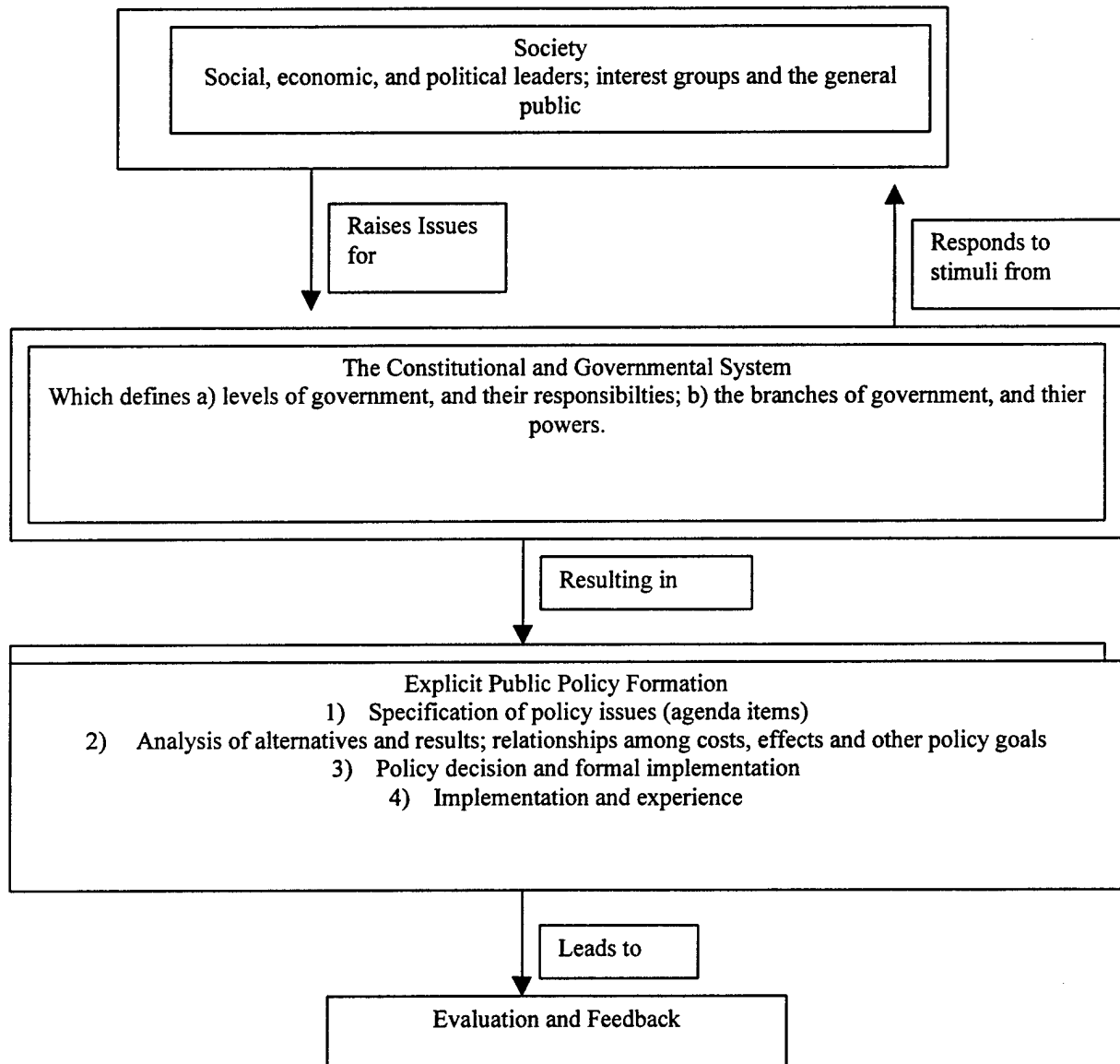


Figure 2. Buchholz Policy Process Model (Buchholz, p. 117).

Buchholz Policy Process Model

The Buchholz Society block can be used to model the 1988-1994 chronological segment which Chapter III documents as events leading to the 1994 NSTP. The Constitutional and Governmental System block represents the policy and directives as presented in shown in Tables 4 and 5. These documents, from 1988-1997, include the formative years for the 1994 NSTP 1988-1994 and the years during which an impact in the USG and industry may be observed (1995-1998). The four blocks of the Buchholz model represent the “Institutional Systems Model of Public Policy Process.” The Explicit Public Policy Formation block represents the 1994 NSTP commercialization agenda for the USG. The subheadings may be interpreted as follows:

1) commercialization of spacelift as commercial launch (CL) items is the specification of policy issues; 2) industry’s efforts to shape commercialization policy goals leading to and away from 1994 NSTP; 3) the actual NSTP document represents the policy decision, and finally 4) the NASA, DoD and Commerce and Transportation stakeholders’ execution of the President’s order as the implementation of the NSTP. The Evaluation and Feedback block is linked to analysis of the impact of the 1994 NSTP on the commercialization of space transportation.

Interview Method

The interviews conducted on participants of the National Space Symposium and the National Space Foundation Conference reflect the Rubin Model of Qualitative Interviews:

With an unstructured format, the researcher suggests the subject for discussion but has few specific questions in mind. When researchers want more specific information, they use a semistructured (also called focused) format. The interviewer introduces the topic, then guides the discussion by asking specific questions. (Rubin: 5)

The purpose of the interviews was to gather cogent information regarding the historical characteristics of the space transportation policy, as it evolved from 1988 and to ascertain what people, forces or events caused space transportation policy to move towards commercialization. The single case design indicated methodical selection of those who would be contacted for interviewing. Yin's data collection protocol requires researchers to seek the most knowledgeable and most influential participants in a case study's activities and work down the ladder of authority and responsibility. These participants were sought out at the key space transportation events which occurred in 1998. The events were the National Space Symposium in April in Colorado Springs, Colorado and the National Space Foundation Conference in June in Milwaukee, Wisconsin. In applying the data collection protocol to these events, the case study included comments from NASA and Air Force senior executives, former Congressional committee staffers, leaders of industry trade groups, and the leadership of major spacelift corporations and smaller spacelift firms.

Reliability

The policy review is analyzed in Chapter V to compare the empirical results of the policy case study (Yin: 38). To demonstrate external validity, Chapter V generalizes analysis of the 1994 NSTP theory, analogous to the way a scientist generalizes from

experimental results to theory (Yin: 44). The reliability of this exploratory, single case design is considered equable. Equable reliability can be expected from this methodology because the procedures from data acquisition, open-ended interviews and data resources are properly documented. The reliability is not extraordinary because data are based on purely human reactions to policy. These reactions and reflections on the policy change as the space transportation industry changes. Therefore, a precise time span for the data findings and analysis is critical to the research's overall reliability.

Evaluation of the space industry and USG compliance with the 1994 NSTP is predicated on whether or not the policy was implemented. According to Buchholz, policy implementation is the actual application of an adopted policy:

The administrative agencies are the primary implementors of public policy, but the courts and Congress are also involved. Congress may override the decisions of an agency such as the Federal Trade Commission, and the courts interpret statutes and administrative rules and regulations when there is a question about a specific application. The agencies, often delegated substantial authority by Congress, have a wide range of discretion in implementing policy because their mandates are often broad and ill-defined in their enabling legislation. (Buchholz: 115)

Policy evaluation attempts to gather the answers to the simple question: Did the 1994 NSTP work? The answer to this question lies in the answers to the stated investigative questions.

The following two chapters implement the methodology. The policy review is separated chronologically. Chapter III discusses the early space transportation policy, from 1988-1994, and Chapter IV presents the recent space transportation policy, from 1995-1998.

Definitions

The following definitions pertain to the space policy review:

Anchor Tenancy is a government investment in a private firms project which is granted under the stipulation that the private firm has other private funding in the project. The investment is given with the stipulation that the federal government will get back what it invested in the form of services rendered from the completed project (Kim, 1998).

Civil Space Program refers to those space operations conducted by the USG for expanding the knowledge of the Earth, its environment, the solar system, and the universe for the purpose of scientific application (National Space Policy, 1982: 3).

Commercial Space Program refers to those space operations conducted by private industry for the express purpose of gaining profit. This thesis concerns the US commercial space program provider, meaning a corporation organized under the laws of the US and owned by more than 50% US nationals with investments in the US in long-term research, development and manufacturing, including the manufacture of major components and subassemblies (HR 1702, Section 2).

Commercialization is operationally defined as utilizing privately owned, privately operated resources for reducing costs in mission execution.

Dual Use is having defense and commercial application, whether as a technology, process or product. Dual-use technology refers to fields of research and development that have potential application to both defense and commercial production (Defense Conversion Commission, 1992:30-31).

Military Space Program refers to those space operations conducted by the DoD or its surrogates for the exploitation of space for offensive or defensive capability.

Payload means anything that is to be transported to, from, or within outer space, or in suborbital trajectory, by means of a space transportation vehicle, but does not include the space transportation vehicle itself except for its components which are specifically designed or adapted for that payload (HR 1702, Section 2).

Space technology is any system of devices or mechanisms intended for the development or mission of spacecraft.

Space transportation includes the systems and subsystems which are required to place spacecraft of any kind into orbit. This includes the launch systems, range complex as well as the booster phases. A space transportation vehicle means any vehicle constructed for the purpose of operating in, or transporting a payload to, from, or within, outer space, or in suborbital trajectory, and includes any component of such vehicle not specifically designed or adapted for a payload (HR 1702, Section 2).

Space transportation service is used synonymously with the term commercial launch service, which is spacelift provided by commercially owned and operated vendors.

III. Early Space Transportation Policy Development, 1988-1994

Introduction

To determine the evolution of the movement towards commercialization of space policy, the documents which represent the “tide” of commercialization policy from 1988 to 1994, which led to the National Space Transportation Policy (also termed the PDD/NSTC-4), must be reviewed. The events in the space transportation industry leading to the 1994 NSTP are also explored.

An important distinction must be made regarding the precise definition of commercialization and the various means through which it may be implemented in the commercial, civil and defense sectors. It is important to understand the concepts behind commercialization because it represents the aim of the 1994 NSTP: to “Emphasize [civil and defense] procurement strategies that are based on the use of commercial US space transportation products and services” (Clinton: 4).

Background

The United States space program began with a race against the Russians in the 1950s to put sub-orbital vehicles in earth’s lower atmosphere and eventually to put a man on the moon. Since the time of the Kennedy Space Initiative in 1968, the United States government has led an estimated \$1 trillion of public and commercial investment to ensure that America remains first in space.

In the beginning of the space age, US intercontinental ballistic missiles such as the Redstone, Atlas and the Titan were the only reliable space transporters. These

vehicles were modified and employed to launch satellites and humans into Earth orbit. In 1965, the Delta liquid rocket was used to launch one of the first communications satellites, the Intelsat Early Bird, marking the dawn of a new era in telecommunications (Myers and Ball: 1).

The Presidential Decision Directive of 1981 and the 1984 Commercial Space Launch Act attempted to maximize the shuttle's launch frequency and, therefore, reduce costs, by taking advantage of the newly acquired technological gains in hybrid rockets. The directive and act required all future government payloads to be launched on the shuttle. The directive to launch all future government payloads on the shuttle forced private expendable launch vehicle manufacturers to face a future without a sizable government market.

The first executive order or National Security Decision Directive for space (NSDD-8, 13 Nov 1981) organized policy within the USG to reflect the president's convictions regarding centralized control of space transportation. President Reagan decided that federal control and funding were critical to the space shuttle's long term success (Claybaugh, 1998).

The 1986 Challenger accident left the White House paralyzed regarding space transportation for three years. The White House announced that commercial payloads would no longer be welcome on the shuttle. The families of the deceased astronauts and the civilian had successfully argued with the administration that "human life would not be put at risk for purely commercial purposes" (McLucas: 94). Also, the nascent spacelift vehicle manufacturers had argued successfully with the Reagan Administration to not have to use NASA as an intermediary between themselves and the spacelift

customer (payload owner). "Companies that wished to operate satellites would solicit bids for launches directly from rocket builders; they would not have to go through NASA as an intermediary" (McLucas: 94).

The 1986 Challenger space shuttle accident forced intense re-analysis of the federal control of space transportation and the dominant space shuttle mission profile (Miller, 1998). Congressman Sensenbrenner stated that, "In the 1980s, the government drove the US commercial launch industry out of the market by competing with it and launching commercial payloads on the space shuttle. That made us dependent on the shuttle, with disastrous consequences when we lost the Challenger" (Sensenbrenner: 1). NASA competed with private launch companies, like Space Services of Texas or Orbital Sciences Corporation, for commercial spacecraft customers. NASA's success and budget were indomitable factors, which temporarily inhibited commercial growth of commercial space transportation services. NASA failed with the Challenger and the consequences were that America did not launch another payload into space for three years.

Historically, NASA and the Air Force have controlled spacelift assets in the United States (Chow: xiii). After the January 1986 Challenger accident revealed the danger of heavy reliance on space shuttles, both national and DoD space policies were changed. The 1986-1989 time lapse was filled by Arianespace, which decided to fill the vacuum with the Ariane-3 and Ariane-4 lift vehicles. At the time of the Challenger accident, Ariane had a worse reliability record than the shuttle (McLucas: 93). Ariane began picking up orders for launches of American satellites by companies willing to take a risk (McLucas: 93). America lost confidence and its technological and market advantage. Arianespace, the marketing agency for Ariane, solicited so aggressively for

business that it eventually garnered half of the world's launch business, including many orders from the United States (McLucas: 93).

The forces which caused space transportation commercialization resulted from efforts of executive and legislative branch leaders who wanted to reduce the cost to access space. The commercialization policies between 1988 and 1994 are typified by their call for an exclusive USG use of commercial launch services for spacelift and ever narrowing exceptions to direction. However, as commercial launch service providers were gaining more control over the launch industry, as a whole, they still continued to lobby Congress for federal funds to cover insurance premiums above the levels the industry had underwritten already. In analyzing the two critical pieces of legislation, the 1989 Launch Services Purchase Act and the 1992 Omnibus Commercialization Bill, which preceded the 1994 NSTP, the trends in commercialization as well as the counter current become evident.

Table 4 and Table 5 introduce the presidential directives and congressional legislation which played formative roles in the 1994 National Space Transportation Policy. The evolution of the policy is noted on the impact column on the right hand side of each table.

Table 4. Presidential Space Documents Impacting Space Transportation

DATES/ADMINISTRATON	DOCUMENT	IMPACT
1989/Bush	National Security Policy Directive [NSPD]-1	"National Space Policy" articulated the Bush policy for US purposes and activities in space. A 15 point commercial space initiative addressed commercial launch service purchase and shared liability for launch disasters.
1990/Bush	NSPD-2	"Commercial Space Launch Policy" reflected commitment to develop a thriving commercial space sector by establishing long term goal of free/fair space launch market for US industry
1990/Bush	NSPD-3	Elaborated Bush administration commercial space policy with guidelines aimed at expanding private sector investment in space by market driven commercial space sector
1990/Bush	NSPD-4	Assured access to space as key element of National Space Launch Policy
1992/Bush	NSPD-5	Maintaining a continuity of Landsat-type remote sensing data was the principal objective of this NSPD
1992/Bush	NSPD-6	"Space Exploration Initiative" announced the strongest White House commitment to an ambitious program of human space exploration since Kennedy
1992/Bush	NSPD-7	Ensure well coordinated planning and implementation of a US program to examine natural and human induced changes to the Earth ecosphere
1994/Clinton	Presidential Decision Directive/National Science and Technology Council PDD/NSTC-1	Clinton space policy to reduce cost of acquisition and operating polar-orbiting environmental satellite systems
1994/Clinton	PDD/NSTC-2	Calls for Departments of Commerce and Defense to integrate space program into a single, converged, national polar-orbiting operational environmental satellite system. Established integrated program office
1994/Clinton	PDD/NSTC-3	Superseded NSPD-5 from Bush. Continuity of Landsat-type and quality of data and reduce risk of data gap
1994/Clinton	PDD/NSTC-4	National Space Transportation Policy created requirement for anchor tenancy and termination liability for the USG to industry
1996/Clinton	PDD/NSTC	"National Space Policy" first comprehensive space policy directive of any administration

Table 5. Congressional Acts Which Direct Space Transportation

CONGRESSIONAL SESSION	DOCUMENT	IMPACT
100 TH	Launch Services Purchase Act of 1989	<ul style="list-style-type: none"> -Requires USG to purchase space transportation services from commercial providers, unless waived -Requires USG to acquire only space transportation vehicle from US made components -Competitive bidding among commercial space transportation providers
101 ST	Omnibus Space Commercialization Act of 1990	<ul style="list-style-type: none"> -Inventoried all space launch and launch support facilities -Directs Sec Transportation to establish commercial space centers
101 ST	II. Space Transportation Service Purchase Act of 1990	<ul style="list-style-type: none"> -Requires USG to purchase space transportation service commercially -Reiterates 1989 Act on competitive bidding as well
101 ST	III. Intellectual Property Disposition	<ul style="list-style-type: none"> -If a space lift or payload is created in US then is US property and subject to US jurisdiction and control in outerspace. Amended Stevenson-Wydler Technology Innovation Act of 1980
101 ST	IV. Miscellaneous	<ul style="list-style-type: none"> -Federally provides injunctive relief to USG under space accident litigation -Requires USG to indemnify and save commercial STS providers for harm against US payloads except gross negligence -Space Commerce is <u>tax-free</u> -Creates National Award for the Commercialization of Space
102 ND	Omnibus Space Commercialization Act of 1992	<ul style="list-style-type: none"> Amends the Commercial Space Launch Act/Launch Services Purchase Act of 1990 -Creates vouchers for launch for researchers of small scientific payloads. -Revolutionizes how space transportation infrastructure is improved -First anchor tenancy legislation
103 RD	Omnibus Space Commercialization Act of 1993	<ul style="list-style-type: none"> -Updates comprehensive list of inventory and 101ST Omnibus Act -Changes <u>tax-free</u> exemption on common stock sale or exchange
104 TH	Space Commercialization Promotion Act of 1996	<ul style="list-style-type: none"> -Examine commercial ventures to assist International Space Station -Makes reentry provisions for space transportation -Ends commercial launch voucher demonstration program from 102ND Omnibus Space Act
105 TH	Commercial Space Act of 1997	<ul style="list-style-type: none"> -Updates LSPA 1990 -Commercial payloads can not be primary payload on STS -Prohibits ICMBs conversion to space transportation or sale to ANY other user

1988-1994 Formative Space Policy

The 1989 NSPD-1 delineated the points which the Bush Administration wanted to emphasize in its national space policy. This national space policy served as the outline for the Bush Presidency space goals, with the details to come later in Bush's term. The 1990 NSPD-2 stated the USG would commit to develop a "thriving" commercial space sector in a "free and fair" space launch market.

By applying the Buchholz "Institutional Systems Model of the Public Policy Process," insight into the historical characteristics of space transportation policy, as it evolved from 1988, might be gained. Also, the Buchholz Model may identify the people, forces or events which cause space transportation policy to move toward commercialization. The 100th Congress was a hotbed of debate regarding the role of the USG and the early commercial spacelift industry. The February 16, 1988 hearings for the Launch Services Purchase Act of 1989 were strong indicators of the key role which industry and industry trade groups played in policy formation and evaluation.

John Yardley, the President of McDonnell Douglas Astronautics, testified on February 16, before the Science Committee of the 100th Congress that: "We believe, if we can figure out a way to attack this (Arianespace) subsidy, that we can retain our position over the long haul as the world leader in commercial launch services" (100th Congress:114,Yardley). Yardley asserts that McDonnell Douglas is not seeking a free ride, but an equitable distribution of risk so that it will be able to compete in the long run. The liability coverage for commercial space launch firms is set, by statute, at \$500M.

According to Yardley as well as the American Institute of Aeronautics and Astronautics (AIAA), the problem for American commercial launch service firms is that the international competition is heavily subsidized. "We have heard--and we can't verify--that the Russians have offered one foreign nation to launch them for free, to get them involved, and it's hard for us to figure any subsidy program that can match that" (100th Congress:114, Yardley).

As of 1989, the agreement between private companies and the Air Force was to require private companies to obtain the maximum amount of insurance commercially available. According to Richard Brackeen, President of Martin Marietta Commercial Titan, Inc., "the current (insurance) situation puts us at a competitive disadvantage internationally" (100th Congress:114, Brackeen). Brackeen asserts in his testimony that foreign competitors realize savings, by their governments assuming risks, and pass on cost reductions to their customers.

The AIAA, which designated a Subcommittee on Allocation of Space Launch Risks, made up of engineers, scientists and other aerospace professionals, found that Brackeen and Yardley were correct. Daniel Cassidy of the AIAA testified that if the 1989 insurance liability arrangement continued, then the commercial spacelift industry would be in serious jeopardy for long term financial viability of the private companies involved. The result of the 1989 scheme for commercial expendable launch was that the industry would be financially vulnerable in undertaking commercial launch service (100th Congress:114, Cassidy).

The AIAA suggested:

A solution that would protect USG interests and at the same time be manageable by the US expendable launch vehicle industry. Allocate risk between the industry and the government on a layered or horizontal basis. The US ELV industry assumes the first layer of risk, covering the probable maximum loss up to the level of reasonably available insurance at no cost to the USG. The USG assumes the second layer of risk, the unlikely maximum possible loss, over and above the reasonably available insurance level. (100th Congress:114, Cassidy)

The 100th Congress responded to the above testimony when the Subcommittee on Space Science and Applications Chairman Bill Nelson (D-Fl) asserted that “the USG is doing an abysmal job implementing space transportation policies despite their major consequences for the US launch and satellite industries” (100th Congress:114, Nelson). Nelson thought that the matters of commercial spacelift insurance and the commercial spacelift “general health” are far too important to leave to chance. Nelson told the committee and the witnesses that “this faulty implementation could threaten the very survival of this new launch industry and drive offshore the one pride and joy this Nation has in commercial space, the American satellite industry” (100th Congress:114, Nelson).

The Launch Service Purchase Act of 1989

The explicit policies which are formed are the articles of the Launch Services Purchase Act of 1989: 1) the USG will purchase, when at all possible, in exception cases of national security or service secretary discretion, commercial launch services;

2) commercial launch service providers will not be required to maintain more than a \$500M layer of liability insurance; 3) the US industry will launch competitively designed and priced vehicles to be internationally competitive, without USG regulation.

The only alternative which the Subcommittee on Space considered for provision 1 was to commercialize the spacelift industry by having the USG purchase commercial launch services. The alternatives which were considered for provision 2 were to leave the possible and maximum insurance liability fully on the commercial firms or have the government pick up liability coverage over \$500M or the \$750M liability which the industry currently covers. Congressman David Skaggs (D-Co) asserted that the \$500,000 premium for the \$500M coverage per launch was not excessive and that the industry could bear more. However, Brackeen and Yardley persuaded him that, if the USG covered the space shuttle over and above \$500M, why shouldn't the commercial ELV market be held to the same standard? Chairman Nelson concurred with the corporate presidents and asserted the need for the federal government to level the playing field for American commercial firms and the international competition.

The only provision 3 alternative was to present commercial launch service providers the guidance that the commercial division's product design is to reflect demands such as cost, efficiency and reliability. Commercial firms are to be encouraged to avoid the traditional procurement methods of the federal government and the specifications of NASA or the military (Packard: 2). These traditional methods are identified with the burdensome and unnecessarily costly accounting procedures for the industry.

Government acquisition of space transportation vehicles might allow inefficient, bureaucratic solutions leading to exorbitant space transportation cost. The only alternatives for heavy and very heavy lift are those ICBM conversion from the 1950s, in the form of the Titan IV and the space shuttle. These options exemplify the inefficient, bureaucratic solutions which Congressman Ron Packard derides in his extended remarks for the Launch Service Purchase Act of 1989 on June 15, 1989.

The implementation and experience of the Launch Service Purchase Act of 1989 set the framework for reducing the cost to access space by moving USG stakeholders away from government acquired launch vehicles and moving toward commercializing launch services. According to Mark Hopkins, President of Spacecause, Space Business Consumer Advocacy Group: "It may well be true that more can be gained, in terms of our advancement into space, from an extra tax dollar not collected as a result of a space tax incentive, than because of an extra government dollar spent on a space program" (Hopkins: 45).

Rand Commercialization Study of 1988

According to a 1988 study performed by Dr. Brian Chow of Rand for the National Defense Research Institute: "1988 Titan II launch vehicle procurement may have been substituted with a commercial launch (CL) service purchase at cost savings of 25% or a reduction of total program costs from \$1.120 billion to \$840 million" (Chow: 65). Chow analyzed the reliability, research, development and manufacturing and operation costs associated with the launch vehicles in question and evaluated them according to government versus commercial operating procedures (Chow: 65). Chow found that Ultra

High Frequency-Follow On satellites for the Navy were always lifted on McDonnell Douglass commercial launches. The use of commercial launch services saved the Navy up to 16% off the program costs for an acquired spacelift vehicle for each launch (Chow estimates around \$53M). In 1989, corporations such as Martin Marietta, General Dynamics and McDonnell Douglas began using refitted ICBMs for commercial launch. Space Services of Texas performed the first licensed commercial launch on 29 March 1989 aboard a sounding rocket (Myers and Ball: 2). America lost research and development ground to Europe's Arianspace because of the 1981-1988 injunction against commercial space transportation for government payloads. The preceding hearing from the 100th Congress, and specifically the comments by Congressman Nelson, indicate that Congress was postured to end the injunction and commercialize launch services early in 1988.

Orbital Sciences Corporation Pegasus

In 1989, the 100th Congress legislated that the USG was to launch all government payloads using commercial launch services. In a policy trend counter to commercialization, the 100th Congress also legislated that the insurance risk for commercial launchers should be shared between the government and commercial industry.

Orbital Sciences Corporation of Dulles, Virginia, launched a Department of Defense satellite aboard its air-launched Pegasus in 1990, marking the first privately developed space launch vehicle and launch to be sold to the government on a commercial basis (Myers and Ball: 2). The subsequent policies and legislation from the White House

and Capitol Hill were attempts at commercializing the space transportation market. The intent was to reduce the cost of access to space by allowing market forces in the commercial sector to shape aerospace prices instead of bureaucrats among the USG stakeholders.

The first space transportation vehicle to benefit from the Launch Service Purchase Act of 1989 was the Pegasus. The Pegasus benefited from the legislation which encouraged DoD and NASA to utilize the services it and other spacelift manufacturers provided. Orbital Sciences Corporation developed the Pegasus as an air-launched vehicle, carrying a small payload of 700 lbs into a lower earth orbit 500 miles above the earth launch vehicle. Although the Pegasus was developed fully, commercially successful, it was still too small and limited in capability to handle the enormous payloads and orbits which the Defense Department missions required, typically greater than 30,000 lbs, to distances 22,000 miles above the earth. This meant more research and development would be required to explore cost effective, commercial options for space transportation. Orbital Science asserts that it remains in the small lift vehicle business because there is a larger customer base with a larger volume of scheduled flights for revenue (Mosbacher: 7). Larger satellites tend to be scientific or national security in nature and therefore in the domain of the organic Air Force or NASA spacelift services. The larger payloads have historically been the domain of the space shuttle for NASA or the Titan IV for the Air Force.

“Shuttle Mafia”

Richard Trully, a member of the first space shuttle team and the NASA Administrator during the Bush presidency, was determined to find ways to expand the shuttle program using the “unique capabilities of the space shuttle are required” clause of the Launch Service Purchase Act of 1989. It was rumored, among Washington insiders, that Dick Trully was so interested in keeping the shuttle from being competed against with other commercial transporters that he routinely countermanded executive and congressional oversight of NASA (Anderman, 1998). Trully was the reason NASA became known as the “shuttle mafia” to commercial space transportation companies like Rockwell, Lockheed and Martin Marietta (Miller, 1998). Trully campaigned relentlessly in 1990, 1991 and early 1992 to secure funding requests in the President’s budget for a 5th shuttle vehicle (Miller, 1998). He was aware of the rising tide in favor of commercialization of space transportation taking place in telecommunications and mass communications payload market.

Hughes Space Corporation realized in the late 1980s that it would cost more to launch its telecommunications (cable television, network television) payloads using the expensive US spacelift Titan rockets (\$13,710/lb to LEO) or the shuttle (\$12,500/lb to LEO). Hughes decided to use foreign spacelift as a substitute. Arianespace and the Chinese Proton vehicles were \$4,924/lb to LEO or \$3,000/lb to LEO respectively, ten thousand dollars cheaper than the American alternatives (Kim, 1998). Former President Bush foresaw this and addressed it in the 1989 NSPD-1 and directed the Departments of State and Commerce to confer with the DoD to determine export analysis criteria and waivers (reference Table 4). It is important to note that the DoD plays a smaller role in

the Clinton administration export decisions than it did in the Bush administration. Space industry analysts suggest that President Clinton decreased the role of the DoD in the export decision process to allow more technologies to transfer overseas (Miller, 1998). The DoD had a veto power for technology export decisions in the Bush administration, whereas in the Clinton administration they have a smaller level of input (Miller, 1998).

In 1989, Trully butted heads many times with Vice President Dan Quayle's National Space Council. Gary Hudson, an advocate of Single Stage to Orbit (SSTO, an early concept which was the progenitor of the National Aerospace Plane and other manned single stage to space aircraft) testified at the National Space Council. Gary Hudson, along with Hunter, Graham and Pernell (members of the High Frontier Space Advocacy Group) presented an idea which would directly compete with the space shuttle's hegemony over the reusable space vehicle market (Miller, 1998). The idea they presented was the DCX, a reusable, single stage to orbit, space plane. Vice President Quayle thought the idea was an excellent source for jobs and positive political press and would flow nicely with the soon to be published NSPD-1 of 1989. However, Quayle underestimated the power of the "shuttle mafia." In 1989, Vice-President Quayle attempted to follow the advice of Space Frontier foundation lobbyists and Air Force officials and set up an acquisition program for the military space plane. However, Trully waged war against his efforts by submitting reports and studies to Congress, citing NASA's space shuttle continued need for complete autonomy without intra-government competition in designing experimental spacelift and missions. The Air Force could not compete with NASA's takeover attempt. According to Miller, the Vice-President backed down from NASA and allowed the classified acquisition community to take the military

space plane (Miller, 1998). The Air Force was forced to classify the project and make it a part of the Strategic Defense Initiative Office (SDIO) classified request for FY91 (Kim, 1998). The original request for the DC-XA was to be competed for full and open bidding. However, the classification of the project permitted the DoD to use a sole-source, locking out competition (Miller, 1998).

Trully and his advocates on Capitol Hill went after the DCX aggressively and were the forces behind the reapportioned funding under the DoD Strategic Defense Initiative Office (SDIO) (Miller, 1998). Trully was upset that the Bush administration was considering using another reusable vehicle in the government fleet instead of simply funding another space shuttle. Trully insisted upon acquiring another government space transportation vehicle. Trully may not have understood the greater level of efficiency and reduced costs that would be realized if he had complied with the Launch Services Purchase Act of 1990 and simply purchased commercial launch services (Anderman, 1998). There is little tangible evidence to support David Anderman's claim. The proprietary nature of launch firms cost numbers remains sensitive, even though costs from a decade ago are a matter of history. Chow and Stadd (see following paragraph) prepared the only numerical analysis which appears in hearings or publications of the period. However, federal acquisitions have typically been plagued by excessive overheads and intimidating regulations (Kim, 1998).

The level of oversight is directly related to the final cost of the program, which can be directly linked to the bottom line in spacelift providers' costs. Courtney Stadd, Director, Office of Commercial Space Transportation, US Department of Transportation, testified to the Congress that the government promoted spacelift providers cost reduction

when the USG buys launch services (100th Congress:114, Stadd). Stadd argued this was because “the enormous amount of documentation government requires of its contractors when it acquires vehicles instead of purchasing services is built into the contractors’ cost structures” (100th Congress:114, Stadd). Stadd provided an example, with two 1985 cost scenarios. Stadd stated that a Navy-acquired Atlas Centaur spacelift vehicle cost the Navy \$80M, whereas a commercial launch service from General Dynamics on the Centaur costs \$59M, a 26% reduction in cost due to commercial service purchase.

NASA Administrator Trully bucked the trend of commercialization to protect his perceived “marquee” program, the space shuttle. Trully’s insistence on prioritizing the shuttle was incredible. He was forced to resign because he was perceived as insolent and replaced by Dan Goldin a few months before the Bush Administration in 1990.

The Goldin Era

Dan Goldin was open to the idea, but not an advocate, of acquiring other spacelift vehicles, like the DCX, in addition to the space shuttle. His support was tepid. Although the DCX was yet another federal acquisition instead of a purchase of commercial launch services, proponents of NASA insisted the USG should demonstrate and testbed the technology which commercial firms could mimic in the outyears (Claybaugh, 1998). This demonstration philosophy merely justified the status quo of continued federal control of space transportation technology progress. According to critics, the federal government would have done better to wholeheartedly commercialize its spacelift vehicles rather than legislate and direct conflicting trends of commercialization and continued government control.

In 1990, the DCX was about to die. Vice-President Quayle was not able to produce enough funding for it and there were not enough supporters on Capitol Hill. A small group of lobbyists, including Pro Space lobbyist Charles Miller literally marched into Dan Goldin's office and pleaded for money, on behalf of McDonnell Douglas, so that the program would not die in the research and development phase. Although Goldin was not an advocate of shuttle alternatives, he felt he needed to make the right impression on the Bush administration (Miller, 1998). Goldin funded the DCX \$1M for funding and incorporated a research venture between NASA and McDonnell Douglas (Miller, 1998). This research venture was to spawn a next generation, reusable, space transportation vehicle. Miller remembers that Congress did not look favorably on having NASA select corporations to do business with, based on preferences and not competition (Miller, 1998).

When the Launch Services Purchase Act was passed by Congress in 1990, the Bush Administration issued the directive, NSPD-2 "Commercial Space Launch Policy," for USG stakeholders to comply with the legislation. NASA and DoD complied with the NSPD-2 by "giving" Lockheed Martin the Titan family of expendable launch vehicles at no cost. In this instance, NASA and DoD reimbursed Lockheed Martin the market rate for each spacelift for their spacecraft. NASA and DoD became purchasers of commercial launch services instead of acquirers of commercial launch vehicles.

The 1990 space security positions, NSPD-3 and NSPD-4, reflect President Bush's assurances to the commercial industry that the White House was convinced that the commercial space transportation market was a matter of national economic health.

The 100th Congress attempted to head off USG spacecraft stakeholders seeking less expensive, European, Russian, or Chinese vendors for space transportation to protect American economic health. The provisions of the NSPD-3 and 4 mimic the legislation Congress passed strengthening US commercial stakeholder ability to compete internationally. The provisions of the Launch Services Purchase Act of 1990 included the requirement that space transportation services were to be purchased domestically and commercially, unless national security was at stake. The Omnibus Space Commercialization Act of 1990 required that US spacecraft were required to use US spacelift. And, furthermore, US spacecraft and space transportation vehicles were considered national assets once they were deployed from the launchpad. This meant that they would be protected as components of the US national security and that they were subject to US jurisdiction and control in outer space.

The tax-free provisions for all space commerce and launch vouchers were examples of Congress' attempts at space industry stimulation. The tax-free provision from the 101st Congress was fairly radical. It allowed all profits from the sale or exchange of space transportation, spacecraft research, development and production and integration to be tax-free. This tax exemption included the capitalization of the assets which were required to manufacture this space equipment. The 103rd Congress modified this last exemption, so that the sale and exchange of common stock were subject to capital gains tax. The launch vouchers were subsidies and were provided for any US firm which was engaging in the demonstration of small scientific satellites for USG acquisitions. This allowed many more firms to compete for the scientific satellite payloads for lower earth orbit (LEO) while not having to balance expensive space

transportation costs. This stimulated scientific spacecraft research, however, did nothing for space transportation technology. The investment was in the research and development of scientific spacecraft not improving spacelift. Indeed, the Republican 104th Congress realized the setback which the Democratic 102nd Congress legislation set up and repealed the launch voucher program.

The Omnibus Space Commercialization Act of 1992

The 102nd Congress made the most revolutionary strides in the commercialization of space transportation technology. The ideas of anchor tenancy, improving space transportation infrastructure and limiting the effects of cost and price on launch bidding for USG acquisitions all came from this Congress. Anchor tenancy is the idea that the USG acts as the “tenant,” who apportions the most capital to space transportation technology. The 102nd Congress defines anchor tenancy as “an arrangement in which the USG agrees to procure sufficient quantities of a commercial space product or service needed to meet USG mission requirements so that a commercial venture is made viable” (HR 3848, Sec. 102). The USG then receives a payback according to predetermined scheduling and program success over the long term.

Congressman Robert Walker (R-Pa) was an early, outspoken voice for commercializing space transportation. Walker used his position on the Science Committee to further commercialization. Walker asserted, at the beginning of the January 1991 hearings, from the review and implementation of the report of the Advisory Committee on the Future on the US Space Program, that Norm Augustine and his committee of former government and corporate employees de-emphasized the role of

commercial space ventures. Walker believes that the Omnibus Space Commercialization Act of 1992 should have reflected the critical cost reductions in accessing space in heavy and very heavy lift vehicles, which space commercialization could lead to (102nd Congress:12, Walker). Norm Augustine, then the chairman of the government-funded Advisory Committee and formerly the CEO of Lockheed Martin Corporation, asserted that a new, unmanned, less costly, less complex heavy lift launch vehicle was necessary. He was pessimistic, however that a complete commercial development of heavy vehicles was possible (102nd Congress:12, Augustine).

Congressman Walker pressed Augustine to explain why heavy vehicles could not be completely commercially developed and operated. Augustine responded that the question of totally commercial development tended to hang up on the question of financing, and that in turn tended to get involved in issues of whether the government can borrow money more cheaply than the private sector, and who takes the long-term commitment for flight rates (102nd Congress:12, Augustine). Augustine conceded that the commercial sector could play a great role in the development and operation of heavy lift vehicle commercialization; however, he was guarded in terms of discussing financing the commercialization.

Augustine's response to Congressman Walker's question was suspect. If he was pessimistic about the financing for a commercial heavy lift vehicle, how could he concede that the commercial sector could play a great role if there were no commercial ventures for heavy lift in 1991 or previously? The only way a commercial firm would consider commercial heavy lift vehicle development would be if the government took the

commitment for long-term flight rates and loaned the firm the capital, which the USG can borrow more cheaply than the private sector.

This testimony set up the logic for anchor tenancy, which appeared as section 401 of the Omnibus Space Commercialization Act of 1992. It is also interesting to note that Augustine's future company, Lockheed Martin, received the first major anchor tenancy arrangement with NASA, in the form of the X-33/Venture Star.

The hearings for the legislation leading up to the Omnibus Space Commercialization Act of 1992 also included testimony from Congressman Dana Rohrbacher (R-Ca) who was the self-proclaimed "apostle of space commercialization." He represented many aerospace industry constituents from his Southern California district. Congressman Rohrbacher asked James Rose, the Assistant Administrator, Office of Commercial Programs, NASA aggressive, pointed questions regarding the NASAs use of commercial launch services: "I hope that as our technological capabilities progress, that we don't find that in this land of free enterprises that NASA becomes a trap for commercialization rather than someone that's promoting commercialization" (102nd Congress:29, Rohrbacher). Rose responded that the commercial world would be responsible to commercialize space, not NASA and that he was convinced that current NASA programs of purchasing launch services were helping to move in that direction (102nd Congress:29, Rose).

The result of this testimony was legislation that culminated in the 1992 Commercialization of Space Act. Section 101 reflected notion that commercially available launch services were to be procured. Section 101 also reflected the 100th Congress concern that third party liabilities over \$500M should remain a government

responsibility. Finally, the critical provision for anchor tenancy was reflected in Section 401 to “increase the viability of a commercial space venture, as long as private capital is at risk in the venture and the long-term viability of the venture is not dependent upon a continued USG market or nonreimbursable USG support.” (HR 3848, Sec. 401).

Bush Legacy in Space

NASA argued that the Kennedy clarion call for putting a man on the moon was what got the space transportation moving. In 1992, President Bush made another clarion call to put men on Mars. Space experts argue that we did not learn the correct lesson from the first clarion call, the Apollo missions (Miller, 1998). According to Miller, the correct lesson was that the USG space programs were layered with bureaucracy and were to be avoided. The bureaucracy layers added time, inefficiency in process, and overhead expense to the space transportation system acquisition (Miller, 1998).

The 1992 NSPD-6 was the “Space Exploration Initiative” which announced the White House’s commitment to an ambitious program of human space exploration (Anderman, 1998). This program did not attempt to foster commercialization to access Mars. Instead it created a Deep Space Program Office in NASA for yet another federally acquired spacelift vehicle. President Bush hoped for a place in history and his attempts to be re-elected are thought to play the largest factor in the formulation of the NSPD-6 (Miller, 1998). Although exploration was a public good, taxpayers were not comfortable with paying the \$500 billion it was going to cost for four astronauts to spend a month on Mars (Miller, 1998). Table 6 identifies the spacelift vehicles programs that began during the Bush administration and afterwards.

Table 6. USG Acquired Space Transportation Vehicles

Vehicle	Lifespan	Description
STS	1981-2017	CLL/NASA/United Space Alliance manages approximately one-third of NASA's \$3.2 billion annual Shuttle budget
DC-XA	1988-1996	GL/DoD. SDIO the first-ever, large-scale composite liquid hydrogen tank, together with composite fuel lines and valves, was flown on the DC-XA in the summer of 1996.
X-34	1996-1999	CL/NASA. The X-34 is an advanced technology demonstration vehicle which will fly at speeds up to Mach 8. The vehicle contains composite primary structures, composite control surfaces, and a composite fuel tank, and will fly and land autonomously.
X-33	1996-?	CL/NASA. . It combines business planning with ground and flight demonstrations of advanced structures, materials, and propulsion system technologies to The X-33 program will combine its results with those of the DC-XA and X-34 to provide an unprecedented 40-50 flight tests of new technologies
SMV	1995-?	GL-CLL/DoD The 22-foot-long vehicle with its 12-foot wing span is a 90-percent-scale version of later-generation unpiloted space maneuver vehicles. (Air Force)
EELV	1995-2020	CLL/DoD The underlying principles of the EELV program are to develop an expendable launch system evolved from current systems, or components thereof, to satisfy current medium and heavy space-lift requirements within a limited \$2 billion development budget (Air Force)

[All Contents Excerpted from Programs Respective Homepages on WWWeb]

The NSPD-6 directive was overcome by events as the International Space Station took the center stage for new space exploration. The ISS overcame the Mars mission because the international interest had already presented an impressive mock up in the form of the SkyLab venture between America and Russia. Neither of these programs, the ISS nor the Mars mission, attempted to incorporate commercialization policy. It is important to note that neither of these programs was considered for commercial sector ownership or launch service opportunity.

The USG sent the signal that commercial launches services were to be sought for the routine missions of USG stakeholders, but not the scientific exploration of deep space or collaborative scientific arrangements with international aerospace community. The scientific gain of exploration and collaboration, may best be defined as public goods. This means that President Bush did have solid reasoning not to seek a fully commercial solution to the Mars mission. There is no comparative corporation or even group of corporations which has the research expertise, funding, or ability to absorb the risk of a Mars mission, as NASA does (Claybaugh, 1998). However, Bush's other space policies, including his most influential policies, 1989 NSPD-1 and 1990 NSPD-2, did little to further commercialization, other than mimic the policies which Congress passed in the LSPA of 1989 and the Space Commercialization Act of 1992. The Congress is probably the most responsive branch of the USG to the commercial space industries, NASA and DoD, for the continued request for commercialization. This is not surprising since most proponents of space transportation commercialization come from congressional districts which are replete with aerospace corporations.

1992 NSPD-6 was intended to stimulate creative solutions to the space transportation barriers between Earth and Mars. The space transportation industry reacted with paper studies, proposals and a bit of hype (Miller, 1998). NASA reacted by creating a Deep Space Transportation office which collects ideas and proposals from various commercial and scientific sources. There were no long term, capital intensive commitments to the Mars exploration because of the outrageous expense (\$500 billion) and unknown human sacrifice that would it could cost us to get there (Miller, 1998). As a result the NSPD-6 flopped.

The corporations and trade groups which were present at the congressional hearings researched between 1988 and 1992 reflect the major corporations, McDonnell Douglass, Lockheed, Martin Marietta, General Dynamics and exclude small, start up space transportation firms like Orbital Sciences Corporation. This indicates that commercialization was not inclusively defined in a way that smaller, spacelift firms could compete in or with the larger corporations. The policies of the Bush Administration left the space industry with mixed signals regarding the USG commitment to full commercialization of space transportation. The Congress also sent mixed signals regarding when it was appropriate for the USG stakeholders (NASA, DoD, Department of Commerce) to subsidize commercial space activity. The LSPA of 1989 and Space Commercialization Act of 1992 both call for commercial launch services to be pursued to the fullest extent feasible, yet it also allows the USG to underwrite launch liability coverage over \$500M for each space vehicle launched in America.

The 1994 NSTP attempted to consolidate the various policy documents of the Bush Administration and focus the commercialization efforts that Congress mapped out.

President Clinton attempted to sharpen the trend of commercialization to reduce the cost of space access.

IV. Recent Space Transportation Policy Review, 1994-1998

1994 NSTP

This section describes the direct influence the 1994 NSTP had on the USG stakeholders (NASA, DoD and the Department of Commerce). The 1994 National Space Transportation Policy was an attempt to “sustain and revitalize US space transportation capabilities” (Clinton, p.1). The 1994 NSTP outlined strategic provisions for both federal (civil or NASA, defense or DoD) and commercial ventures in space transportation. Virtually all of the provisions of the 1994 NSTP evolved from either Congressional legislation or the Bush Administration’s NSPD-1.

According to Bruce Dunn, an aerospace industry journalist, in July of 1994, six aerospace companies got together in a partnership with NASA's Langley Research Center to look at the markets for future commercial space launch vehicles (Dunn: 2). The study had the objective of examining individual market segments to see how they expand if lower prices were charged to customers. The important provisions of the 1994 NSTP can be found in the commercial space transportation industry section. These provisions are in Appendix A. The final report of the Commercial Space Transportation Study (CSTS), done by Boeing, General Dynamics, Lockheed, Martin Marietta, McDonnell Douglas and Rockwell, was released as of the winter of 1994. The information of interest in Figure 3 is an overall market model for future commercial space transportation (Dunn: 2). The market model is separately presented for an assumed new launcher of four payload classes (10,000, 30,000, 55,000 and 100,000 pounds) (Dunn, p.2). The Cost category

describes the dollar cost per pound for the spacelift vehicle to launch from the pad to reach lower earth orbit. The Total Cost (\$M) describes the complete costs which the launch firm incurs to put the entire payload into orbit. The Annual Flights category describes the CSTS predicted demand for the spacelift vehicle at the cost per pound. The Annual Revenue is an estimate of the spacelift venture's revenue for the stated demand and cost level.

Vehicle payload capability 10,000 lb to low earth orbit			
Cost (\$/lb)	Total Cost (\$M)	Annual Flights	Annual Revenue (\$M)
5000	50	5	250
1000	10	48	480
600	6	81	486
400	4	269	1,076

Vehicle payload capability 30,000 lb to low earth orbit			
Cost (\$/lb)	Total Cost (\$M)	Annual Flights	Annual Revenue (\$M)
5000	150	5	750
1000	30	38	1,140
600	18	82	1,476
400	12	161	1,932

Vehicle payload capability 55,000 lb to low earth orbit			
Cost (\$/lb)	Total Cost (\$M)	Annual Flights	Annual Revenue (\$M)
5000	275	3	825
1000	55	21	1,155
600	33	70	2,310
400	22	95	2,090

Vehicle payload capability 100,000 lb orbit			
Cost (\$/lb)	Total Cost (\$M)	Annual Flights	Annual Revenue (\$M)
5000	500	2	1,000
1000	100	10	1,000
600	60	41	2,460
400	40	41	1,640

Figure 3. Dunn Vehicle Capability Chart (Dunn: 3-4)

The CSTS found that for all launch vehicle classes, there is a sharp increase in payloads captured in moving from \$5000 per pound (current costs) to \$1000 per pound (Dunn: 3). Dunn thinks this presumably results not only from the generation of new business due to market elasticity, but from the capturing of payloads from other launchers so that the new launcher controls most or all of a market segment (Dunn: 4). The aerospace corporations found that lowering the cost of flights to \$600 or \$400 per pound generates additional flights by attracting new payloads. However, when the cost of flights is very low, the larger launchers suffer a reversal in fortune as the cheaper they are priced, the less revenue is gained (Dunn: 4).

The CSTS study, in addition to the trends already established by the Augustine testimony for the 1992 Space Commercialization Act, in favor of anchor tenancy, has had the greatest influence on shaping the National Space Transportation Policy. This subpart encourages "innovative types of arrangements" to support the provisions of the NSTP. Section 1, subpart 4 of the NSTP identifies "anchor tenancy as considered where appropriate by the USG, when there are commensurate benefits of such arrangements (Clinton: 2).

The anchor tenancy was the most relevant for heavy (55,000 lb) and very heavy (100,000 lb) spacelift because, as Norm Augustine testified in 1991 and the 1994 CSTS study found, financing these extremely expensive spacelift vehicles is difficult. The Augustine committee testified to Congress that the USG had the essential startup capital for such ventures as well as the commitment for predictable payload requirements. The 1994 NSTP responds to these commercial pressures by encouraging the Departments of Commerce and Transportation as well as NASA and the DoD to use innovative

arrangements to reduce the costs to access space. The NSTP makes its aim of cost reduction of accessing space apparent to space transportation stakeholders at the beginning of the document: "Promote the reduction in the cost of current space transportation systems" (Clinton: 1) The 1994 NSTP refines the commercialization policy which preceded it in the 1989 LSPA and 1992 SCA as well as the 1989 NSPD-1 by focusing efforts to reduce cost by using innovative arrangements in the form of anchor tenancy. According to Jeffery Cassidy of the US Aviation Underwriters, the USG is unique in its resistance to fully underwriting its launch vehicles, because the French, Russians and Chinese do so (Cassidy: 1).

The US government is unique because it does not purchase insurance despite having lost six spacecraft in the period 1993-1994 (Cassidy: 1). It is important to note that the 1994 NSTP does not continue the trend of insuring commercial launches above the \$500M possible liability, which it had since 1989. This may be because of the loss of the Ariane V64 booster early in 1994 and the recent loss of the Telstar 402 satellite (Cassidy: 2). By breaking the insurance subsidy, the 1994 NSTP moved the space transportation, against its will, closer to commercialization. According to Cassidy, the space insurance business will be significantly in the red for 1994, with losses of over \$500 million versus premiums of only \$300-350 million. Many satellite manufacturers, owners, and communication satellite transponder users, as well as launch vehicle manufacturers, purchase insurance (Cassidy: 2).

1994 NSTP Impact

The NSTP commercialization policy has shaped USG spacelift vehicle acquisition, purchase of launch services, and innovative arrangements. The arrangements of 1995 are business as usual, with lip service or minor adjustments in the direction of commercialization. 1995 NSTP impacts were largely the result of the March Storm lobbyists camping out on Capitol Hill and advocating commercialization to Congressmen en masse. 1996 NSTP impacts were far reaching and were the result of another March Storm lobbying campaign regarding FY97 funding issues, as well as the McDonnell Douglas and Rockwell corporations lobbying for the privatization of the shuttle. 1996 NSTP impacts were also the result of the Augustine and CSTC committee influence on Congress to legislate anchor tenancy which in turn the NSTP advocated and became the X-33/Venture Star program. 1997 NSTP impacts are on another piece of benchmark legislation, the Commercial Space Act of 1997, which deepens the USG commitment to commercialize more organic USG functions, including the International Space Station.

1995 Commercialization

The President and Congress have collaborated their policy efforts to define a national standard of commercial purchase for launch services. Although the Air Force and NASA acquisitions of the X-33/X-34 are commercially supported, some industry analysts argue that *any* government involvement in space transportation is detrimental.

Michael Kelly, the CEO of Kelly Space and Technology, argues that by funding the Evolved Expendable Launch Vehicle (EELV) or the Venture Star (an inexpensive access to space program which pushes our known technology envelope), the government

is impeding progress in the commercial launch industry (Kelly: 6). Kelly asserts that the EELV is an update of a commercially non-viable approach to space transportation (Kelly: 6). Kelly believes that current cost savings can be experienced by commercializing and expanding our technological envelope (Kelly: 6). Small entrepreneurs allege that the billions in R&D for the EELV or the Venture Star will not discover the new technology that will contribute to any substantial reduction in marginal costs per launch. Their dissent may be a function of not being selected for vehicle acquisitions rather than dissention with USG methods.

The federal government's insistence on control has led to exorbitant costs for spacelift. As the USG cedes control in its new cooperative and innovative arrangements, cheap access to space may be obtainable. However, DoD still has non commercialization efforts within its vehicle acquisition cycle.

Policy-makers continued to issue orders and public law, which mandated the USG to take full advantage of the commercial space launch services in the US. However, DoD and NASA desire to control their own vehicles and payload integration kept the large, bureaucratic, inefficient, federally acquired, space vehicle industry alive (Anderman, 1998). Officials within the government admit that oversight of all vehicle acquisitions over the last decade has been with the intent of maintaining control over their (DoD or NASA) perceived areas of responsibility (Kim, 1998). DoD's current programs, such as EELV and SMV, are examples of recent appropriations that were not directed to "commercial launch services to the fullest extent feasible" (Clinton: 4). Both the DoD and NASA appear to prefer to acquire space transportation vehicles that allow them the greatest latitude in program oversight and outcome.

Claybaugh feels that Dan Goldin is justified in acquiring space vehicles as long as there are no commercial alternatives. However, Claybaugh's logic is circular. If the USG never allows commercial industry to participate in commercially developing a heavy lift vehicle it will never have the endemic experience and capacity to handle a NASA or DoD payload that is heavy. Claybaugh is demonstrating a controlling philosophy, which is based on a sense of duty that the USG stakeholders have in the space transportation industry. His premise is correct; however he does not always reach the most logical conclusions. The USG stakeholders must play a central role in how space transportation is to evolve from a macro perspective.

The President and Congress have made commercialization and reduction of cost to access space a priority, not the maintenance of the central role of the USG stakeholders. The clash of ideals and even contradictions within the Congress and Presidential Decision Directives are apparent. Yet their first and loudest signal is to commercialize space, to reduce the cost to access space, including the heavy and very heavy spacelift vehicle arena.

Industry trade groups for small entrepreneurs like the Space Frontier Foundation decry Claybaugh and his philosophy as "bureaucratic protectionism" (Anderman, 1998). Industry trade groups and non-profit think tanks like the Space Transportation Association indicate the government must play a key role in the exploration and development of any new frontier of endeavor (Stallmer, 1998). The argument appears to be over the amount of control government and commercial firms may have in shaping the industry. The Contract with America was made in 1995 by the GOP. GOP leadership was cutting programs, threatening to close entire agencies and wrangled with President

Clinton regarding every major funding authorization in his budget. This dramatic situation led to the first March Storm from industry activists, for the military space plane.

The March Storm was a citizens' rally, in which citizens mobilized to lobby around a particular space cause and petition Capitol Hill en masse. In the 1995 March Storm nine advocates visited 53 congressional offices in the space of five days. The March Storm created such a ground swell of support from the congressional offices which gave them audience that the military space plane was written into the president's budget a week later and Congress authorized half of the funding the president asked for. This anecdote depicts the effectiveness of the Pro Space-organized, citizen space lobby, one of many industry trade groups consulted, on Table 7.

Table 7. Key Industry Trade Groups for the Space Transportation Industry

Name	Contact	Position Advocating:
Aerospace Industry Advisory Agency (AIAA)	Periodicals	AIAA advocates the international competitiveness of the USG with subsidies and other non commercialization
Pro Space Lobby Group	Charles Miller, President of Pro Space	Pro Space advocates the political interests of American citizens. This means they may support small, strictly commercial firms or Lockheed or Boeing. They lobby for congressional and NASA, DoD support and contracts.
Space Frontier Foundation	Rick Tumlinson, President David Anderman, Chairman of the Board of Directors	SFF is an advocate of small, commercial entrepreneurs for providing launch services to the satellite industry & USG. SFF initiated the clarion call of 'cheap access to space'.
US Space Transportation Association	Eric Stallmer, Executive Director	STA is the non profit, objective trade association aimed at bridging the gap between industry leaders [eg Boeing, Lockheed Martin] and policy makers.

1996 Commercialization

The Departments of Commerce and Transportation were ordered to create bureaus which were to provide oversight and create “innovative arrangements” for the US spacelift industry (Clinton: 3). The Departments of Commerce, Transportation along with NASA, DoD and the Intelligence Community created a “National Spacelift Requirements Process” in response to the this mandate (Commerce Department, Technology Administration Homepage, 1998).

Toward this end, an interagency working group consisting of representatives from the Departments of Defense, Commerce, and Transportation, NASA, and the Intelligence Community worked to ensure that the commercial voice was heard throughout the vehicle design and acquisition process. This group created the National Spacelift Requirements Process (NSRP) to develop and regularly update a common set of spacelift system requirements that captured the needs of the defense, intelligence, civil, and commercial space sectors. These common requirements, ranging from "mass to orbit" to "customer satisfaction," aimed to improve the capability, operability, responsiveness, and economy (CORE) of future vehicles. Under the President's policy, the Transportation Department was also responsible for licensing, facilitating and promoting commercial launch operations as set forth in the Commercial Space Launch Act and Executive Order 12465.

The NSRP also advocated the paper study of the anchor tenancy arrangement for the X-33 spacecraft. The X-33/Venture Star program is not a vehicle acquisition, but an

experimental spacecraft which is to be converted into a commercial, reusable launch vehicle (Kim, 1998). The X-33/Venture Star program is the closest NASA has come to using an anchor tenancy arrangement prescribed by commercialization policy. NASA business advisor Bill Claybaugh designed the contract which utilized the cooperative agreement provisions of the CRDA law passed by Congress.

The cooperative agreement provision of the CRDA law allows NASA independent authority to design a contract "any way you want it" for the purpose of creative research and development (Claybaugh, 1998). This allowed certain shortcuts to be made, excluded Federal Acquisition Regulation (FAR) jurisdiction, a five month release-award period, and reduced delays in government oversight (Claybaugh, 1998).

The X-33/Venture Star is an example of anchor tenancy. NASA is the anchor tenant for the Venture Star commercial, reusable launch system. NASA used the cooperative agreement to exchange \$941M over an incremental time period in exchange for progress reports from Lockheed Martin Skunk Works division (Claybaugh, 1998). Lockheed Martin invested \$220M in the Skunk Works division for the Venture Star program. Over the next several economic quarters the Skunk Works division will be responsible for executing predetermined milestones to receive either NASA or corporate Lockheed Martin dollars (Claybaugh, 1998). The ownership and operating authority of the X-33/Venture Star will remain with Lockheed Martin after it is approved for full operations from the FAA, scheduled for 2004. The Lockheed Skunk Works has already failed to meet one milestone in the spring of 1998, which led to \$75M being taken out of its budget. NASA expects to recoup its investment in the experimental X-33 by Lockheed Martin successfully operating the Venture Star commercial, reusable launch

vehicle. NASA expects a payoff in an incremental, long term repayment program (Claybaugh, 1998). This repayment will be for NASA to recover the \$941M which it invested in 1996-2002 by the year 2007. The recovery will be in estimable spacelift payload space aboard the then operational X-33/Venture Star.

Although the specifics of the milestone and repayment program for the X-33/Venture Star are considered proprietary, they may appear something like those shown in Table 8. The X-33 program office claims that Lockheed Martin estimates it will cost around \$5 billion to research, experiment, develop, test and evaluate the X-33 and release the Venture Star for commercial spacelift.

The X-33/Venture Star contract is unlike any other in American space transportation history (Claybaugh, 1998). According to the above approximations, the Lockheed Martin investment will be over \$4.695 billion. In addition, the X-33/Venture Star contract requires Lockheed Martin Skunk Works to cover all cost overruns. The details of the cooperative agreement are considered extremely sensitive and proprietary. The actual quarterly increments of payments and details of milestones are considered sensitive, corporate knowledge. The outyear return on investment which NASA expects to reap is also considered proprietary and not publicly releasable. Table 8 reflects research from interviews from anonymous NASA employees, publicly released information on the World Wide Web, and estimation.

William Claybaugh believes the prequalifications and limited bidding allowed NASA to select a contractor as resourceful as Skunk Works, quickly. NASA may have experienced more significant cost and schedule overruns if Skunk Works was not the X-33 experimental spacecraft designer. "The design team was able to draw upon its own

Table 8. Projected X-33/Venture Star Investment and NASA Payoff

Year	Review	Milestone	NASA \$/Lockheed \$ Invested
1996	Quarter 3 Review Quarter 4 Review	Paper Study Feasibility Study	\$5M/\$5M
1997	Biannual 1 Biannual 2	Program Design Review PDR/Mockup of X-33	\$10M/\$75M \$200M*/\$50M *Skunkworks failed this milestone and did not receive NASA \$200M
1998	Biannual 1 Biannual 2	X-33 Flight/Range Tests X-33 Payload Modulation	\$200M*/\$10M \$200M/\$50M *Skunkworks slipped the schedule on this because linear aerospike engines are not performing as expected
1999	Biannual 1 Biannual 2	X-33 Flight Battery X-33 Final Flight Tests	\$200M/\$50M \$100M/\$200M
2000	Biannual 1 Biannual 2	Final Design Aerospike Engine Manufacture	\$10M/\$800M \$4M/\$1 billion
2001	Biannual 1 Biannual 2	Airframe Finalization Airframe Manufacture	\$4M/\$750M \$1M/\$1 billion
2002	Biannual 1 Biannual 2	Venture Star Integration Venture Star Integration	\$1M/\$250M \$1M/\$250M
2003	Biannual 1 Biannual 2	Venture Star Flight Test FAA License Submission	Lockheed Martin finances the Venture Star Program without government assistance.
2004	Review Process ends. Lockheed Martin owns and authorizes Venture Star operations	Venture Star puts first payload into LEO for \$3000/lb	Lockheed Martin finances Venture Star operations and charges \$3000/lb to LEO.
2005			NASA receives 4 flights to LEO or GEO at a value of \$100M each, for free.
2006			NASA receives 4 flights to LEO or GEO at a value of \$100M each, for free.
2007			NASA receives 2 flights to LEO or GEO at a value of \$100M each, for free.

wealth of classified data to create the unconventional X-33 design" (ARI Homepage).

The Space Frontier Foundation is concerned that cheap access to space is not in the current purview of the X-33 program. Foundation President Rick Tumlinson asserts that NASA must demonstrate single stage to orbit (SSTO) as well as create a competitive commercial marketplace in space transportation (Tumlinson, p.1). Tumlinson thinks that plentiful and reliable access to space will only be achieved in a more competitive, privatized atmosphere. The Space Frontier Foundation asserts these goals can be accomplished by the following plan for NASA:

1. Triple the X-33 program's overall funding to provide monies for two parallel, competing X-33 development teams, with a flyoff of their vehicles starting in the year 1999.
2. Buy two copies of each X-33 design so they can be aggressively tested.
3. Buy X-vehicles which are capable of reaching orbit.
4. Front-load the budget profile of the X-33 program in the technology- and hardware-intensive early years so its schedule does not slip.
5. Pay for increases in the X-33 program by accelerating the consolidation of the Space Shuttle's operation under a single prime contractor and aggressively managing that contract to produce cost savings within acceptable safety levels.
6. Move the Shuttle operations contract as close as possible to true privatization as quickly as possible, so that market forces (and not bureaucratic decisions) determine the timing and speed of transition from a quasi-commercial Shuttle to fully - commercial RLVs. (Tumlinson, p.1)

Slow, incremental commercialization appears to be the wisest progression for space transportation vehicles, because organizations like Space Frontier Foundation clamor for more business, and do so without the financial capital to reasonably execute the contracts available.

According to Tumlinson, true privatization of the shuttle is required for gains in cost reduction and increases in efficiency (Tumlinson: 1). The Space Frontier Foundation foresees multiple fleets of cheap, reliable, reusable spaceships in the future. This would be accomplished via advanced technology demonstrations and market-based reforms (Tumlinson: 1). But neither Tumlinson nor SFF have commercially viable alternatives to what NASA is currently doing.

Industry experts are not surprised at the NAC's (NASA Advisory Council) favoring incrementalism in its interpretation of the National Space Transportation Policy of commercialization: "The NAC is a hand picked collection of old-style traditional space officials and groups" (Tumlinson: 2).

The cost of placing payloads into orbit appeared to be the primary concern among industry and (NAC, DoD) policymakers in 1996. Mr. Charles Ordahl, Vice President and General Manager of New Space and Defense Programs, McDonnell Douglas Aerospace, Boeing Corporation, asserted, "Full exploitation of the scientific, technological and commercial benefits of space is dependent on continued reduction in the cost of launch services and continued improvement in the reliability and ease of access to space" (Ordahl: 1). Ordahl claimed that Boeing (McDonnell Douglas) and NASA dramatically increased payload lift capability while improving vehicle reliability and substantially reducing the cost per pound of the launch (Ordahl: 2). The claims which Mr. Ordahl made to the Subcommittee on Space and Aeronautics did not reflect the opinions of NASA. NASA believed that the cost per pound of launch must be radically reduced for "Cheap Access to Space" to be a reality. This may be a question of degrees or may point to a deeper dichotomy over industry and government's interpretation of Cheap Access.

Ordahl believed that McDonnell Douglas played a pivotal role in integrated government/industry development teams for the DC-XA and the X-33:

We entered into a contract with what is now the Ballistic Missile Defense Organization to build the DC-X single-stage rocket. It was the world's first fully reusable vertical take-off and vertical landing rocket. Faced with a tight schedule and budget limitations, we applied a highly streamlined management process using an integrated government/industry development team. With our "rapid prototyping" method of new product development, this radical new vehicle was designed and built in less than 20 months. (Ordahl: 2)

Ordahl believed that the NASA doctrine of incremental commercialization allowed technology to be proven. Ordahl believed that the X vehicle was an outstanding test-bed for evaluating a wide range of technology options (Ordahl: 2). He believed that the technology options presented the spacelift industry a realistic set of flight profile and ground operating conditions (Ordahl: 2). Ordahl told the Congressmen of the Committee on Science that, "the incremental path in building and testing DC-X, DC-XA and X-33 is a prudent path. The 'fly-a-little, test-a-little, learn-a-lot' approach employed in the nation's proud history of X plane flying is proven approach for demonstrating new technologies and concepts" (Ordahl: 3).

The X-33 is managed in the NASA Marshall Space Flight Center in Huntsville, Alabama and the engine testing will be performed at the Stennis Space Center in Mississippi. The first flight of the X-33 is to focus in the fall of 1999 and the flight test series is scheduled to end in December 1999 (X-33 Homepage). The X-33 program administration represents NASA's interpretation of commercialization:

A Cooperative Agreement is used between NASA and the industry partner to describe the responsibilities of both NASA and the industry partner as well as milestones and criteria for payment to the partner (through payment milestones). Implementation of this program will require both NASA centers and the industry

partner to commit to technical task accomplishment within a fixed set of cost and schedule constraints. Teamwork between NASA and the industry partner must be accomplished through insight by NASA instead of traditional oversight. (X-33 Homepage)

NASA administrator Dan Goldin believes that NASA's current partnership with manufacturers, airlines, the industry, DoD and the FAA will lead to cheap access to space as the spacelift industry incorporates the technology NASA discovers (Goldin: 1).

Goldin plans to reduce the cost of accessing space by spending more money on NASA vehicle acquisitions not investing dollars into commercial ventures. He asserts that his partnerships will reduce the cost of the access to space through the Reusable Launch Vehicle (RLV) program (Goldin: 1). The RLV will progress toward Cheap Access because of system study capabilities, the airframe, materials and propulsion technology available through aeronautics enterprises (Goldin: 1). Although Goldin asserts that NASA is making industry-wide improvements, his focus appears to be within NASA programs and budgets themselves. He says the major benefits from the RLV are reductions in program cost and risk (Goldin: 1). He does say the aeronautics program will benefit by expansion of its capabilities and technological horizons (Goldin: 1).

The X-34 is technological test bed for the follow-on X-33 and the military space plane, currently referred to as the space maneuver vehicle (SMV): On August 28, 1996, NASA awarded to Orbital Sciences Corporation (OSC) a contract for the design, development, and testing of the X-34 technology testbed demonstrator vehicle. The intent of the X-34 program is to demonstrate "key technologies" integratable to the Reusable Launch Vehicle program. This vehicle is the bridge between the Clipper Graham (DC-XA) and the X-33. This contract will be managed by the Marshall Center. The objective of the X-34 is flight demonstration of key reusable launch vehicle operations and technologies directed at the RLV goals of low-cost space access and commercial space launch competitiveness. The vehicle is being designed and developed by Orbital Sciences. (NASA Website for X-34)

It appears that one of the dangers of the vehicle acquisition paradigm is that no matter how far the technology goes, the costs increase instead of decrease as the programs continue. NASA is pursuing all of its acquisitions with "Cheap Access" in mind, yet the program budgets continue to burgeon. The cost of the vehicle and its launch operations continue to increase. The original X-34 contract was for \$50M and was let in August of 1996. Since that time the contract has been increased \$7.7M for long lead-time hardware (wing, fuselage, avionics set, hydraulic pump and actuator system) and \$2M for WPAFB use of the wind tunnel facilities and thermal protections system (NASA Website for X-34).

There is an ambitious program at NASA which is exploring the issue of efficiency in a practical application to spacelift in response to the 1994 NSTP provision "foster technology that greatly reduces the cost of access to space" (Clinton, p.1). The Low-Cost Technologies (LCT) project is primarily focused on removing the complexity from launch vehicles, and disproving the notion that high performance (speed and pulse thrust) is essential to space launch (NASA Website for LCT). "LCT is focused on design to cost, low-cost technologies commercial manufacturing, aerospace applications of COTS hardware, robust margins, and simple operations" (NASA Website for LCT). The concept is laudable. However, does this concept belong in a government testbed or private sector test fleet? NASA claims that the test of the LCT is flight demonstration of a small launch system that could set the stage for the commercial development of a small payload launch capability (NASA Website for LCT). "LCT is systematically attacking the hardware cost drivers, starting with the boost stage propulsion system, the highest

cost system, then to the rocket engine, the propulsion system cost driver, and finally to engine subsystems, turbopumps, thrust chambers and valves” (NASA Website for LCT).

The 1996 United Space Alliance

Six Members of Congress participated in advocating the 1996 “March Stormers” position, including Speaker of the House, Newt Gingrich. Within six months of the March Storm the space shuttle was privatized.

Prime responsibility under the Space Flight Operations Contract (SFOC) for conducting launch and flight operations for NASA's Space Shuttle, the mainstay of human space flight transport. NASA Administrator Daniel Goldin “privatize” Shuttle launch and flight operations – to turn the reins over to one aerospace company and make it solely responsible for what dozens had done previously – a bold move to reduce the overall cost of human space flight while at the same time maintaining the most demanding standards for safety and mission success. (USA Homepage)

USA was a consortium of Rockwell, Lockheed Martin and smaller subcontractors to operate, maintain and incorporate new technologies into the space shuttle until 2012. The Space Shuttle was operated and maintained by NASA employees with 70% of the workforce contracted out to Lockheed Martin or Boeing. The Lockheed Martin, Boeing Rocketdyne contract team performs the technology development, operations and maintenance and astronaut training which NASA employees accomplished until 1996. The USA receives NASA mission profiles from the USG employees and then makes the ancillary decision regarding flight planning and trajectory design and mission control. United Space Alliance (USA) privatization of the space shuttle is another incremental step toward commercialization. The privatization is the USA consolidation of the 28 separate contracts which NASA oversaw. The USA and NASA signed agreements for

two major contracts, 12 April 1998, designating USA as the prime contractor for launch processing and mission operations work for NASA's space shuttle fleet (Black: 1).

According to Mr. Kent Black, the CEO of USA in testimony to the House Subcommittee on Space and Aeronautics, privatization is really a consolidation of many different contracts to eliminate overhead. The Satellite Facility Operations Contracts will be implemented in two phases. Phase I is the consolidation of all shuttle operations contracts (SOC) already held by the USA parent companies of Rockwell International and Lockheed Martin under the management of USA (Black: 1). This phase also includes as subcontracts work performed by Rockwell's space system division for shuttle systems and payload cargo engineering, shuttle orbiter production, operations and sustaining engineering and orbiter logistics (Black: 1). USA will continue the work presently being performed on these contracts, with incentives for improving efficiency and reducing cost (Black: 1). Employees working under the existing contracts will follow on as subcontractors to USA or switch badges (Black: 1).

Mr. Black defined the new privatization as insight from NASA, no longer government oversight: "After the start of the SFOC contract, the space shuttle program will remain NASA managed but NASA's role will shift from one of program oversight to insight. Oversight is defined as daily management of work [200 NASA employees] while insight [6 NASA employees] allows NASA audit and surveillance of work to a level of detail that enables independent assessment of anomalies should such occur" (Black: 2).

On 30 September 1996 the USA became the official single, prime contractor for the SFOC space shuttle (Zelon: 1). The specific duties of the USA are:

The SFOC includes responsibility for the orbiter, flight and ground operations, and logistics support. USA's operations at the Kennedy Space Center in Florida encompass ground processing of the space shuttle including preparing the vehicles for flight, stacking the solid rocket boosters and mounting the external tank, mating these elements to the orbiter to complete the launch-ready vehicle, conducting launch operations, and deservicing the vehicles after landing. Mission operations performed in Houston include training the astronauts, operating the shuttle flight simulators, maintaining facilities at the Johnson Space Center including the Mission Control Center (MCC) as well as operating, planning mission schedules and performing flight design. (Zelon: 1)

The wisdom of the space shuttle contract privatization or consolidation seems evident. The overhead of 28 separate contracts has been reduced to overhead for just one contract. "Twelve previous contracts are being terminated or closed out as a result of this action. In Phase 2 of the contract, work from 18 additional contracts will be brought under the management of the USA" (Zelon: 1). The shuttle privatization is a step in the direction of commercialization. However, the space shuttle cannot be considered commercialized because the USG still owns and funds its operations.

NASA built an unprecedented incentive to perform in the SFOC. NASA built a 40% award fee rate into the fee structure of the cost plus incentive fee/award fee contract. "About 40% of USA's potential fee is award fee. About 16% results from achieving cost targets. If the award fee score drops below certain safety and quality gates, USA can lose the target fee for that six-month period as well as any incentive earned as a result of a cost underrun" (Zelon: 2).

The DoD, specifically the Air Force, is acquiring space vehicles which should, at least, be joint ventures or some form of innovative arrangement outlined in the National Space Transportation Policy (Kim, 1998). The Air Force policy excludes

commercialization for security reasons. However, according to Kim, their justification is suspect, but indeterminable, because their mission profiles are all classified.

The Air Force is pursuing innovative commercial off the shelf (COTS) solutions which follow industry feedback and guidance to acquire a reusable spaceplane. The Air Force is still maintaining ownership of the reusable space vehicles it acquires instead of attempting to commercialize. The progression of military spaceplane projects is shown in Table 9.

Table 9. Military Space Plane Project Progression

TIMESPAN	PROJECT	OBJECTIVE
1950-1960s	1 st Aerospaceplane program Dyna-Soar/X-20 program	Base technology deveopment, design and mission studies
1950-1970s	X-15 and X-24 lifting body	Flight test programs demonstrating lifting bodies and hypersonic flight
Early 1980s	Advanced Military Space Flight Capability (AMSC) Transatmospheric Vehicle (TAV) and SMV	Airbreathing, SSTO, feasibility assessment and technology demonstration programs
Late 1980s	DC-X, DC-XA	Experimental reusable spaceplance
1984-1992	SCIENCE DAWN, SCIENCE REALM AND HAVE REGION	Rocket powered SSTO feasibility assessments and technology demonstration

DoD incentive for industry appears to be to push the envelope technologically while maintaining the same pricing arrangements. The technology is being furthered at the cost of efficient and cost effective operation. Kiger gave an example, which exemplified the lower cost effectiveness of government acquisitions (Kiger, 1998). Tim Kiger, former space analyst for Congressman Dana Rohrbacher (R-Ca), "Found that parts

outside the industry are $1/5^{\text{th}}$ to $1/25^{\text{th}}$ the price of those within the aerospace industry.” Kiger gave an example of pressurized tank pumps, which release liquid oxygen into a larger mixture cell for thrust ignition. Kiger asserts that the exact same pump, with the same weight, rigidity, temperature endurance, was \$5,000 from a Lockheed Martin supplier, whereas it was \$200 from a scuba diving equipment company (Kiger, 1998).

The DoD is more concerned with its “competent” contractors than the commercialization of the spacelift industry: “Due to constrained budgets, the Air Force is seeking to ensure a viable, competitive military spaceplane industrial base is retained on and in the future” (FAS Website). The DoD contrast with NASA is that NASA allows innovation within its acquisition program, but DoD specifically regulates and sets detailed specifications for its space vehicle acquisition. This intensive oversight resists the tide of commercialization as well as acquisition reform lightning bolts from Vice-President Al Gore.

The primary intent of the 1994 NSTP was to shape the actions of the NASA, DoD, Commerce and Transportation Department stakeholders in space transportation. Claybaugh claims that “Private firms do not need to heed the NSTP because they answer to their board of directors and stockholders” (Claybaugh, 1998). Claybaugh’s comments are contrary to the definition of public policy. If his comments are true, why does industry complain about NSTP implementation and Congressional legislation in hearings and reports? Industry has responded to the trend toward commercialization with innovation and aggressive positioning for current and future contracts.

1996 Industry Efforts to Reduce Cost to Access Space

The spacelift industry has the vision for cheap access by utilizing the historically proven means to determine the best: competition. The X-Prize competition represents one of the space transportation industries attempts at reducing the cost to access space. The X-Prize competition began in May of 1996, in an attempt to revolutionize space transportation technology:

On May 18, 1996, an exciting new era in human spaceflight began. Visionaries, astronauts, and dignitaries from around the world gathered in St. Louis to celebrate the official announcement of the X PRIZE. The X PRIZE will stimulate the development of commercial space tourism by awarding a \$10 million prize to the first private team to build and fly a reusable spaceship capable of carrying three individuals on a sub-orbital flight. (Diamandis, X-Prize Homepage)

The X-Prize has been put together by corporate leadership in the St. Louis area to build enthusiasm and capital to invest in space tourism and cheap access to space. The commercial industry has mixed reactions to the X-Prize. Some small, spacelift companies see this as an exciting opportunity to claim a foothold in improving space transportation technology:

The X PRIZE competition, more than anything else on this Earth, has the ability to help make private spaceflight and space tourism a reality. By creating the X PRIZE, the St. Louis leaders have taken an important page from aviation history and created an opportunity for a modern day Orteig to step forward and open the door to a whole new industry. (Rutan Homepage)

The X-Prize deals with the economic crisis of spacelift by pushing innovation through new starts in the space transportation industry. The President of Pioneer Rocketplane Corporation argues that the X-Prize may change "the economics of space transportation" (X-Prize Homepage). The \$10M prize is attempting to reward a

spaceplane design an order of magnitude cheaper than the \$1 billion that NASA spends on reusable, commercial space transportation technology which has the same long term objective: "cheap access to space."

The X-Prize appears to have an objective similar to the Office of Air and Space Commercialization at the Department of Commerce. This objective is the consumer exploitation of space for products and services (Kim, 1998). The X-Prize field of contestants represents many engineering philosophies, including technology transferred from NASA space transportation two decades ago. The PA-X2 uses a liquid oxygen, kerosene pressure fed engine modified from a twenty year old NASA design.

X PRIZE is about demonstrating feasibility. The X PRIZE will demonstrate that the technologies and talents are at hand to provide space transportation products to the consumer market. X PRIZE will reveal the intense interest broadly held in America in the opportunity for virtually any person to participate in space. These two ingredients are critical to opening an exciting new commercial frontier in space. (X-Prize Homepage)

Some claim the \$10M for the X-Prize is an adequate start: "To the start up launcher, the X-Prize provides encouragement with publicity, financial opportunity and the romance of competition" (X-Prize Homepage). Bill Claybaugh thinks the effort is laudable but a publicity stunt. The \$10M prize is not enough to create and operate a safe, reusable space transportation system that can operate as effectively as a \$1 billion (NASA investment in the X-33/Venture Star) space vehicle which has the same objective: cheap, reusable access to space (Claybaugh, 1998). It is important to note that the X-Prize firms must find private capitalization on their own. Of the 30 participants, only one has fully capitalized its research and development and test and evaluation phases. Beall Aerospace company enjoys the lead in the X-Prize competition because of

its wealthy proprietor and financial connections with investment bankers. Beall Aerospace is said to have raised the \$500M necessary to successfully test its spaceplane (Kiger, 1998). The \$10M prize is only a single reward for the winner of the competition.

Entrepreneurs in the space transportation industry see the X-Prize as a commercial increment in the direction toward reducing access to space. The cost reduction will be aided by the technological innovation which will be awarded by the prize. The space transportation technology will continue to migrate toward private sector leadership and the X-Prize is a way to increase the prevalence of space commerce. Space tourism will take rather large investments before vehicles are suitable for the general public are developed. However, the X-Prize should be an important step along the way, since the initial goal set for the X-Prize is achievable with relatively small investment. Moreover, efforts expended on trying to win the X-Prize will likely prove important for advancing the cause of commercial space transportation in general (X-Prize Homepage).

This X prize competition indicates that industry is attempting to push technology forward without government intervention. The progress which is being made is forced to be efficient, which is the critical factor in the push toward Cheap Access. The X-Prize is attempting to reduce barriers to commercial participation in commercial space transportation. It stimulates investment in low cost technologies and reduces risk. Some X-Prize contestants claim, "Risk has been the major stumbling block on private enterprises entering this potentially huge commercial market" (X-Prize Homepage). It is indeterminable if the risk itself is reduced by the X-Prize. However, the risk may remain the same and more attention is given to the innovative solutions that mitigate the risk.

Dr. Marshall Kaplan labels X-prize entrepreneurs, "EIHs, or Entrepreneurs In Heat" (Kaplan, 1998). Many of these EIHs are members of the Space Frontier and Pro Space organizations. According to Kiger, "Half of these X-prize participants are quixotic and uninformed, I mean they have great paper designs but nothing more than that" (Kiger, 1998). The purely commercial firms, excluding OSC, in America's space transportation industry do not demonstrate the market maturity of Lockheed Martin or Boeing. While Kiger's characterization may be an overstatement, it is important to note that all of the leading participants in commercial industry, particularly in the X-prize competition, are undercapitalized with an exception of Beall Aerospace (~\$250M). Kistler, Pioneer Rocketplane, Kelly Space Corporation, Rotary Rocket and Universal Space Lines all do not maintain enough public or private capitalization to fully execute their suborbital missions (Kiger, 1998).

The OSC Example of Successful Commercial Spacelift

Orbital Sciences Corporation (OSC) is a purely commercial firm which is evidence that cheap access to space in the commercial sector is obtainable. A purely CL or commercial venture in launch services includes OSC and Kelly Space Corporation. OSC has proven that the commercial barriers can be broken.

OSC surmounted high barriers and has become the only successful, commercially owned, launch service provider that does not rely on federal contracts (Claybaugh, 1998). OSC may be an example that not all space transportation has to be federally funded and guided.

Orbital has become a world-recognized leader in conceiving and developing innovative space technologies and pioneering business approaches, leading to the design and production of revolutionary, low-cost small space systems. With this extraordinarily complete capability for space-related product development and manufacturing. Orbital now possess a degree of related vertical integration that is simply without precedent in our industry. No other company, large or small, anywhere in the world is capable of doing everything we do in our space-technology sector. (OSC 1995 Annual Report)

In April 1982, three Harvard Business School graduates formed Orbital Sciences Corporation. David Thompson, Bruce Ferguson and Scott Webster organized OSC with the philosophy, "OSC is to think like its customers. We have to build a spirit that prizes low cost ways of doing things" (Mosbacher: 32). Fred Alcorn was the wealthy friend of a friend of Thompson, who enabled OSC to get a \$2M credit line through InterFirst Bank of Houston. This \$2M enabled OSC to organize and design its own vision for "low cost, small space systems." OSC then aggressively competed for venture capital to fund its corporate limited R&D partnership. A front page article on the New York Times business section brought OSC to the attention of Nathaniel Rothschild. "Rothschild was interested in beating the French (Ariane) [Europe's leading spacelift firm] because Mitterand [Prime Minister of France] had nationalized some family concerns, and, later that week, the head of Rothschild's venture capital operations in New York City called [Thompson]" (Mosbacher: 35). Rothschild invested \$1.8M in OSC for a 35% stake in the company. This \$1.8M investment allowed OSC to enter into a contract with Martin Marietta for project definition (Mosbacher: 35).

In August of 1983, OSC picked Shearson/American Express as the offeror of the limited R&D partnership (Mosbacher: 36). "Shearson was chosen by OSC because of its established reputation for marketing tax-advantaged investments" (Mosbacher: 36). J.

Paul Kinloch, the Shearson principal on the partnership offering, felt that OSC was the only pure space commercialization project in which Shearson was interested. Kinloch stated, "What attracted us to Orbital was that Orbital was attempting to develop characteristics which lessened its risk to the investor. Those included an agreement with NASA that the agency would not fund a competing product, and well-defined, developing market for a medium-capacity stage for commercial and USG customers," (Mosbacher, p.36). The Shearson offering for the limited R&D partnership raised gross proceeds of \$50M in December 1983 and June 1984 from a private offering of 1,000 Class A Partnership units (Mosbacher: 37).

OSC continued to expand its product line to increase its market share. By November 9, 1988 OSC had entered into a Stock Purchase Agreement with Hercules Incorporated (the manufacturer of solid rocket propulsion systems and subcontractor to Martin Marietta and McDonnell Douglas) for 803, 421 shares of OSC's common stock. \$32,136,840 of capital was raised with the stipulation that \$10M was to be used to fund the development of the Pegasus vehicle (small launcher 700lbs/LEO) (Mosbacher, p.38). Orbital Sciences Corporation has proven that these barriers of market capitalization are surmountable (~\$330.5M in stockholder equity), yet Kelly Space and Technology, the Cosmos Mariner, Kistler Aerospace, Space Access, Pioneer Rocketplane and Rutan Rotary Rocket as well as scores of others claim that the government picks winners and leaves them searching for scraps. Since 1982, OSC demonstrated that foresight into the space transportation industry, insight into the small payload spacelift market with the Pegasus, and good fortune from wealthy investors, like Nathaniel Rothschild, are key ingredients to long term success.

1996 Space Industry Seeking Independence From USG

OSC is a lone example of a company that is not dependent upon federal business. Kelly Space is attempting to join OSC in its independence from federal vehicle acquisitions or partnerships. Kelly Space has constructed prototypes of its Eclipse Astroliner, which is scheduled to put 20 Iridium satellites in LEO in 2001. Kelly's Eclipse is a Reusable Launch Vehicle similar in purpose with NASA/Lockheed Martin's X-33. However, the Eclipse is to be much smaller and cheaper to operate (Miller, 1998). It uses technology which is available in the current marketplace from aviation and rocket hardware. The impact of the Eclipse Astroliner is still unknown since it is unproven in operational testing and payload deployment. Federal industry experts such as Jason Kim, of the Department of Commerce, Office of Air and Space Commercialization and Bill Claybaugh of NASA assert that Kelly and small companies like it are more hype than legitimate participants in the industry. The evidence of their legitimacy is seen in their income statement. The amount of capital assets among this group is far below the levels they themselves require to perform (Kiger, 1998). With the exception of Beall Aerospace, none of the new generation reusable launch vehicle (RLV) developers has enough capital to supply commercially viable space transportation (Kiger, 1998).

The Case for the X-33/Venture Star

Another impact of commercialization policy is innovative arrangements, like joint ventures. The joint venture is a recent phenomenon in the space transportation industry. It is NASA's reaction to the NSTP provision for "innovative types of arrangements

between the USG and the private sector” (Clinton, p.3). NASA has joined its research and design team with the experimental aircraft team from Lockheed Martin’s “Skunkworks” (Claybaugh, 1998). NASA used the cooperative arrangement to avoid the federal acquisition regulation (FAR) provisions that drive up the time and cost of acquisitions. NASA will give \$941M, over a five year period, to Lockheed Martin to produce hardware and reports at specified gates. NASA is the anchor tenant for the X-33. The anchor tenancy provision allows for NASA to receive a long term return on the \$941M it invested incrementally since 1996 (Claybaugh, 1998).

Claybaugh asserts that NASA is not acquiring the X-33/Venture Star but is acting as a cooperative arrangement partner with Lockheed Martin. Once the X-33 is produced, the data acquired from the experiments will be incorporated into the Lockheed Martin Venture Star and used commercially. The data will also be placed in the public domain for other commercial launch service providers.

David Andermann, an executive with ProSpace lobbying group, states that anchor tenancy contradicts the free market selection of the lowest bidder and favors whoever the USG invested in. The contract provisions for the X-33 allow NASA to recoup \$941M of money it invested in the X-33/Venture Star incrementally once the Lockheed Martin Venture Star becomes commercially operational. One can only speculate at how effective the anchor tenancy is going to be for the X-33. The evidence presented in Table 8 suggests that the X-33 is a firm fixed cost contract which Lockheed Martin is finding it harder and harder to control costs (Claybaugh, 1998). Anchor tenancy or at least the X-33 is only an incremental point, not the terminus along the commercialization spectrum for America (Kim, 1998).

Michael Kelly, president and chief executive officer of Kelly Space and Technology, Inc., asserts that government acquisition of launch vehicles actually impedes capital investment for commercial launch vehicles (Kelly: 23). Kelly argues that in funding programs such as Evolved Expendable Launch Vehicle and Venture Star, the government is actually impeding progress (Kelly: 23). Kelly states that EELV is an update of a commercially non-viable approach to space transportation (Kelly: 23). This non-viable approach is typified by extremely expensive, inconvenient space transportation systems (Kelly: 23). The political and economic and technological environment, in which policymakers first developed space transportation, justified this "non-viable" approach. Policymakers' initial objective was to demonstrate superiority over the Soviet Union. There were no commercial profits expected from America's first moon shot. America sought to gain global recognition as the premier technical prowess in space. At the time (1970s) America had hegemony in space. However, American firms represent only 33% of the current international space transportation market.

Policymakers developed space transportation with the design philosophy that it would do whatever the nation must to accomplish the mission objectives. According to Kelly,

Cost, convenience, and other attributes of a commercial transportation system were not considered, because they were not an important part of the objective. The result was an extremely expensive, inconvenient space transportation system. Any commercial use would have to be fantastically remunerative. Our current efforts are being hampered by a continuation of the same mistaken national policy that has locked us in to the current approach to space transportation. (Kelly: 23)

In the early stages of space transportation technology development, America did not have cost as an independent variable (CAIV). Most programs ran over budget by

100-200% (Roberts, 1998). At the time, overbudget was standard, because policymakers were results oriented. The typical acquisition of a space transportation is bureaucratic and filled with minutiae requirements (Roberts, 1998). Each requirement was worked individually and then integrated on the launch pad. This usually led to excessive integration times, work arounds and schedule slippages. The USG does not spend its dollars on space transportation as efficiently as the commercial sector.

Commercial space transportation companies that were entertaining viable solutions for NASA acquisitions and commercially competed payloads were not able to secure market capitalization. According to David Anderman, an executive lobbyist for ProSpace and a member of the board of trustees for the Space Frontier foundation, Wall Street decides who commercializes successfully because the investors allow or disallow capitalization (Anderman, 1998). The congressional legislation did not prevent NASA from choosing favorites and those favorites charging outrageous prices per launch. The competition was not allowed in the market because investors were frightened away by government overregulation, the shuttle mafia, or tepid support from the financial establishment (Miller, 1998). Notwithstanding, the government continued to engage the launch industry by offering vouchers for scientific payloads. It hoped to foster more spacecraft development by footing the launch bill for demonstration.

Establishes in the Treasury the Commercial Space Transportation Trust Fund, to consist of revenues from any fees assessed by the Department of Transportation for the licensing of commercial launch activities and to be used for projects that directly benefit the U.S. space transportation industry. It requires that projects be selected by an Industry Selection Committee representing fee payers. The act requires an inventory to identify federally-owned launch support facilities: (1) not needed for public use; or (2) which could be made available for non-Federal use on a reimbursable basis without interfering with Federal activities. Requires the

Administrator to submit a program report to the Congress. (Omnibus Space Commercialization Act of 1996)

1997 Commercialization

The only difficulty with reusable commercial vehicles was the technicalities they faced in the law. The law before 1997 stated that the moment a space vehicle left US airspace it immediately became an export and was subject to international commerce laws. The 1997 Commercial Space Act remedied this definition:

Current law governing commercial space launch activities (49 USC 70101 et seq.) includes a provision designating that a launch vehicle or payload is not to be considered an export simply due to the launch itself. H.R. 1702 amends this provision to include reentries which should not be considered an import simply because of the reentry. Prior to enactment of the original Commercial Space Launch Act in 1984, the launch of a launch vehicle was considered an export. The intent of the original provision, launch not an export, was to obviate the need for an export license for a commercial launch since such a launch is not considered an export, in the traditional sense. There was never any intent that, launch not an export, would affect foreign trade zone procedures. (HR 1702, Sec 701)

Recently Congress passed the Commercial Space Act of 1997, (CSA), HR 1702, an update to the Launch Services Purchase Act of 1989 and of other space-related legislation. The Commercial Space Act of 1997 provides that:

Except as otherwise provided in this section, the Federal Government shall acquire space transportation services from United States commercial providers whenever such services are required in the course of its activities. To the maximum extent practicable, the Federal Government shall plan missions accommodate the space transportation services capabilities of United States commercial providers. Acquisitions of space transportation services by the Federal Government shall be carried out in accordance with applicable acquisition laws and regulations. Space transportation services shall be considered to be a commercial item for purposes of such laws and regulations. (HR 1702, Sec 701)

Congressman Sensenbrenner and four other members introduced H.R. 1702, the Commercial Space Act of 1997, which directs the Transportation Department to establish regulatory procedures for re-entering vehicles from space. This regulation ensures reentry will not be considered an import. It also directs the federal government to purchase commercial launch services (Sensenbrenner: 1). The policy literature here indicates an evolving trend of commercialization of space transportation technology. Indeed Major General Robert S. Dickman has stated, "For the first time, the commercial interest [in 1998] in space is perhaps the biggest driver of national policy" (Ruzika: 30).

Legislation of the 105th Congress 1997 reflects most of the changes brought on by the first and second "March Storms":

(Sec. 303) Makes conforming amendments to the Launch Services Purchase Act of 1990. Maintains the prohibition for the launching of commercial payloads as primary payloads on the space shuttle.

(Sec. 304) Provides for a study and report on space shuttle privatization.

(Sec. 305) Prohibits the Federal Government from: (1) converting certain excess intercontinental ballistic missiles to a space transportation vehicle configuration or otherwise using such missiles to place a payload in space; or (2) transferring ownership of such missiles to another person, except as provided in this Act.

Authorizes such conversions if the agency seeking to use the missile reports to specified congressional committees that the use of the missile: (1) would result in Government cost savings compared to the cost of acquiring space transportation services from commercial providers; (2) meets all agency mission requirements; (3) is consistent with U.S. international obligations; and (4) is approved by the Secretary of Defense.

(Sec. 306) Requires the Secretary of Defense to report to specified congressional committees on the total potential national mission model (a model to assess the total potential space missions to be conducted by the United States during a specified time period that includes all U.S. launches), with specific information on resources necessary to carry out the model. (HR 1702, Sec 300)

It is important to note Section 304 of the Commercial Space Act of 1997 calls for a study of the impact of the consolidation of the organic functions of NASA which occurred in 1996.

Michael Kelly's testimony before the Science Committee on the Commercial Space Act of 1997 brings out many cogent points regarding the mixed success of commercialization up to the present. Congressman Rohrbacher invited Kelly to testify on June 4, 1997 regarding the licensing of reusable launch vehicles and the commercialization of USG stakeholders launch vehicles. Kelly testified that the difference between expendable launch vehicles and reusable launch vehicles is very significant. Expendable launch vehicles do not require the long series of flight testing which reusable launch vehicles do (105th Congress:16, Kelly). RLV continued flight testing requires continued licensing from the FAA, because of the current provisions on spaceflight that require a new license every time a space vehicle re-enters earth's atmosphere. The solution which Kelly proposes and which actually becomes section 701 of the Commercial Space Act of 1997 issues a RLV license which involves substantially the same RLV operating within a well-defined flight regime. According to Kelly, smaller companies will not conduct RLV programs if a licensing arrangement is not created that avoids the burdensome and costly licensing of each re-entry from testing or operating an RLV.

The second element of Kelly's testimony is that the current provision of the 1989 Launch Service Purchase Act and its follow on in the 1992 Space Commercialization Act and the 1994 National Space Transportation Policy is flawed when it directs continued purchase of commercial launch services. Kelly states that the only commercial launch

vehicles in service today are expendable (105th Congress:16, Kelly). Because, each vehicle only flies once, almost every copy has at least one design change manufacturing differences occur (105th Congress:16, Kelly). The provisions of the launch service purchase legislation did more to delay the progress of commercial space transportation than any other single event (105th Congress:16, Kelly). Kelly contends that the fleet of Atlas, Delta and Titan cost the government billions of dollars to develop and the transfer of ownership to the private companies gave them a possession of assets worth billions of dollars.

The customers of these spacelift vehicles were the government and the mega rich telecommunications satellite makers, who could afford to pay the enormous cost of using launch services, so the long anticipated boom of space business in areas other than communications never materialized (105th Congress:16, Kelly). Kelly's assertion holds true for the heavy lift segment of the market, but is flawed when small and medium lift are considered. His own testimony even contradicts a blanket statement against commercial ELV service purchase. Commercial launch services are the only flights that work cost effectively, and Kelly believed it is because of the lack of oversight imposed on Orbital Science Corporation (105th Congress:16, Kelly).

1998 Commercialization

The Congressional Committee for Science 1998 Report states that the "crisis" of space launch expense is being solved. According to Congressman Sensenbrenner, "We're fixing this problem. NASA is investing \$1 billion in reusable launch technology in the X-33 and X-34 programs. Congress also provided modest funding for the Air Force's

military spaceplane program to leverage NASA's investments for national security, but the President line-item vetoed that and two other important space technology programs last year" (Sensenbrenner, p.1) The X-33 has slipped two of its milestones to date. However, Lockheed Martin Skunk Works has promised to finance the scheduled events until the program gets back on schedule.

Congress may not be taking the space transportation industries' perspective on inefficient, exorbitantly expensive launch corporations in 1998. Congress is not removing loan guarantees and forcing more full and open competition. These actions would support the guaranteed funds for government space transportation vehicle acquisition. On May 22, 1998 the Senate bill S.2121 was read twice and referred to the Committee on Commerce.

S. 2121 prohibits the program [FY99 DoD space acquisition authorization] from: (1) providing for loan guarantees pertaining to the construction, reconstruction, or reconditioning of space launch sites; or (2) removing, restricting, or replacing funding provided by the Department of Defense (DOD) to companies participating in the Evolved Expendable Launch Vehicle Program. Makes companies receiving DOD funding for the development of such vehicles ineligible for loan guarantees for the same vehicles. (Sec. 103) Creates a Space Launch Vehicle Loan Guarantee Fund (Fund) to be used by the Administrator as a revolving fund to carry out this Act. Allocates a specified amount to the Fund. (Senate bill S.2121)

China Gate 1998

The China Gate controversy of 1998 centers on the legality of Hughes providing post-crash details in an accident report to Long March rocket scientists (Kim, 1998). The report allegedly violates the moratorium on intellectual property transfer on spacecraft and space transportation vehicle which was mandated in the Launch Services Purchase

Act of 1990. Hughes scientists may have included technological improvements for the Long March rockets, which may have been illegal technology transfer. This situation continues to evolve.

Some industry experts assert that the "ChinaGate" scandal exemplifies the space transportation cost crisis: "Without a doubt, the 'ChinaGate' controversy is a direct consequence of our country's failure to replace a government dominated segment of our space program with a true commercial space transportation industry" (Miller: 31).

Summary

The 1994 NSTP shaped the USG stakeholders' and commercial industry firms' outlook on reducing the cost to access space. The years 1995-1998 saw strides toward the goal of reducing the cost to access space. Our current spacelift launch costs indicate that the US industry still has a long way to go to be directly cost competitive with foreign competition.

V. Analysis

Introduction

The investigative questions from the research objective explore the point of origin and attributes of commercialization policy from 1988-1998. The first three questions have some conceptual overlap and can be answered, chronologically together.

1. What were the historical characteristics of the space transportation policy, as it evolved from 1988?
2. What people, forces or events caused space transportation policy to move towards commercialization?
3. How has commercialization policy changed from 1988 to the 1994 National Space Transportation Policy and to the current day, 1998?

The February 16, 1988 hearings for the FY89 Launch Service Purchase Act exemplified the early forces which shaped space transportation policy. The Presidents of McDonnell Douglass and Martin Marietta, Yardley and Brackeen respectively, testified that their space transportation business was in jeopardy, because of heavy foreign insurance subsidies in their competitors. Congressman Nelson responded by incorporating provisions for liability coverage over \$500M for the commercial firms by the USG. The subsidies were a counter current in an act which was attempting to invigorate American commercial launch business by commercializing USG stakeholders' launch vehicle usage.

The Launch Service Purchase Act of 1989 set the stage for commercialization of the space transportation. On June 15, 1989 Congressman Packard extended his remarks regarding the critical role of commercialization for reducing the cost to access space. Packard asserted that commercial firms must be encouraged through legislation to avoid USG procurement methods and specifications. Packard thought that the USG methods represented the burdensome and unnecessarily costly accounting procedures for the industry. Martin Marietta, McDonnell Douglas, and General Dynamics were still using refitted USG ICBM's for commercial launch. Packard hoped to persuade the industry giants to commercially develop their own spacelift vehicle in the years following 1989.

1989 was also typified by the intense internal struggle between Vice-President Quayle, Dick Trully and Congress for control over the next generation very heavy lift, reusable launch vehicle to replace the shuttle. The contention was the backdrop for the later arguments for a joint USG and industry arrangement for building a heavy and very heavy lift space vehicle.

Orbital Sciences Corporation executed Packard's vision for commercially owned and developed spacelift vehicles in the fall of 1990. OSC launched a USG payload aboard an air-launched Pegasus and made the first privately developed space launch vehicle and launch to be sold to the government on a commercial basis. OSC sent the signal to legislators and the executive branch that cost to access space can be reduced by allowing market forces in the commercial sector to shape aerospace prices instead of bureaucrats among the USG stakeholders. Although the Pegasus was not substantially less expensive than its USG alternatives, it set the stage for a simply designed Taurus

spacelift vehicle, which would exemplify the commercially developed, inexpensive alternative in later years.

The January 1991 congressional hearings for the Omnibus Space Commercialization Act of 1992 exemplified the commercialization current and the subsidy counter current from commercial industry. Norm Augustine de-emphasized the role of commercial space ventures because he was pessimistic that a completely commercially developed heavy lift vehicle was possible. Augustine convinced the Science Committee that the USG must play the critical role in financing the development of the heavy lift space vehicle. Augustine argued that the government could borrow money more cheaply than the private sector and could provide a more long-term commitment for flight rates than the commercial sector. This testimony influenced the creation of the anchor tenancy principle in section 401 of the 1992 Act. This creative arrangement allowed the USG to act as a private investor and partially finance a commercial effort and then gain returns after the programs success. The anchor tenancy arrangement was actually executed in 1996 with the X-33/Venture Star program.

The Omnibus Space Commercialization Act of 1992 established the legal precedent for the anchor tenancy financing of commercial spacelift programs. Congressman Rohrbacher was skeptical about NASA's Assistant Administrator James Rose's willingness to step into commercial functions and assert USG control. He recognized that NASA was unwilling to completely comply with the LSPA of 1989 and utilize commercial launch services to the fullest extent feasible. Rohrbacher hoped that NASA would not become a trap for commercialization but rather a promotee of commercialization. The result of Rose's testimony and Rohrbacher's comments was that

Section 101 reemphasized the USG commitment to procure commercially available launch services.

The events which led to the 1994 NSTP are an amalgamation of commercial and USG activities performed in self-interest. The 1988-1994 period for the USG was shaped by the NASA and DoD stakeholders assertions for expanded bureaucratic control of the nation's space transportation resources. The NASA or DoD compliance with the LSPA of 1990 and the NSPD-2 has not decreased the payload to orbit cost of heavy and very heavy spacelift as shown in Table 1. Congressman Packard's comments regarding USG type programs and input were finally to be heeded. USG Stakeholders were given a higher level commitment from the President to purchase commercial launch services. Other USG subsidies like additional liability coverage for insurance fell by the wayside in the 1994 NSTP because the President's focus was to reduce the cost to access space by commercializing not underwriting the entire industry. His logic was justified because during the period when the USG provided additional coverage for the space industries, they did not become any more competitive. Events of the years 1990-1994 did not indicate any significant downward trend in the cost to access space for larger payloads (Nielsen, 1998). Before 1994, USG stakeholders assertions for control were justified because the commercial industry was in its infancy and the public good problem was in effect for transportation services. This means that the USG was justified in continuing its GL arrangements because the public benefit of space access, telecommunications, cable television, Landsat imagery and astronomical optics relied on space transportation. The space transportation which was relied upon could not have been purely commercial enterprises, because there would not have been enough revenue from "ticket sales" to

recoup the billions of dollars invested in research and development of the current space vehicle inventory (Claybaugh, 1998).

The DoD organizational culture plays a large role in how it approaches commercialization. According to Kiger, the US Navy launched the UFO (Ultra High Frequency Follow-On Satellite) using commercial launch services, because “the Navy does not care what technology is procured, they just want their ships to get the signals and they are strapped for cash for the next class of carriers” (Kiger, 1998). The Air Force used GL arrangements for the Delta, Titan and Atlas families. Why should its organizational culture change to CL arrangements for the EELV acquisition? (Kiger, 1998). The political forces which have shaped our space transportation industry may run counter to or tangentially to executive or congressional direction.

The DC-XA military space plane did not receive immediate support on Capitol Hill, so that Pentagon officials severed pieces of other program acquisition and R&D budgets to continue the ground work for the program. Compliance with an executive order is not a given. Compliance is not a binary issue either. USG agencies or industry may decide to conditionally comply with provisions of the executive order that enhances their position, while ignoring other provisions of the executive order that does not enhance their economic position or ability to influence. The CLL category between full commercialization in CL and no commercialization in GL attempts to capture this phenomenon.

Augustine’s vision for an anchor tenancy arrangement was brought to fruition when Lockheed Martin Skunk Works won the opportunity to build the X-33/Venture Star in 1996. This reusable heavy spacelift vehicle is developed with taxpayer and Wall

Street investor financing and is expected to be operational by 2002. The year 1996, was also a critical time for NASA shuttle operations. The privatization of the space shuttle was a result of the citizen's March Storm and continued pressure from Congress and the President to move toward commercialization. The X-Prize represented the commercial industry's attempt to mimic OSC and go one step further in reusable spacecraft technology. Michael Kelly persuaded Congress at the markup hearings for the Commercial Space Act of 1997 to remove the costly licensing barriers for reusable spacelift vehicle development.

The Commercial Space Act of 1997 enacted Kelly's recommendations regarding the barriers to development, which small spacelift firms face regarding FAA licensing requirements and government oversight. The Congress also prohibited ICBM conversion to spacelift vehicles, a practice which General Dynamics, McDonnell Douglas and Martin Marietta began over seven years ago. This prohibition was Congress' attempt to encourage commercially developed spacelift vehicles in the tradition of OSC.

The China Gate incident polarized the spacelift community in June of 1998. Hughes Space Corporation methodically launched its communication satellites on Chinese Long March rockets because of their comparative cost advantage with US spacelift vehicle services. The debate looms over whether Hughes is enabling a potentially hostile power to improve its long range launch capability or simply promoting global commerce.

4. What impact has the 1994 National Space Transportation Policy had on current space transportation (USG and commercial) industry?

The tide of commercialization which has caught on in the space transportation industry is not all consuming. The USG stakeholders continue to maintain the decision-making authority regarding which commercial firms shape space transportation technology and which firms are left by the wayside. The Pro Space and Space Frontier Foundation representatives for small entrepreneurs continue to request more "commercialization." However, it appears that their real concern may be they are not receiving the contracts which Orbital Sciences Corporation and the giants are receiving. Although there is some discontent regarding NASA's sole sourcing and prequalifying from Pro Space and Space Frontier and other entrepreneurs like Michael Kelly, they do not appear to be able to perform as successfully as their larger counterparts (Lockheed Martin, Boeing). Their focus may be better spent on mimicking OSC, instead of fault-finding NASA. OSC began with Pegasus, small LEO spacelift, utilizing 1970s liquid propellant technology. The technology was unremarkable but reliable. The propellant was stable and inexpensive to operate. According to Tim Kiger, many entrepreneurs that are seeking capitalization use more exotic material and designs than necessary (Kiger, 1998).

Is the commercial market ready? There are corporations which can operate safe, reliable space transportation at USG safety standards. Boeing and Lockheed Martin can be used for medium, heavy and very heavy spacelift and OSC or small or microspace lift. When Miller asserted the "competition was not allowed in the market because investors were frightened away by government overregulation," one must consider the level of

preparation the competition had to deal with government oversight (Miller, 1998). The USG stakeholders had established relationships with the giants of aerospace. These “cozy” arrangements, as Miller characterized them, were long term supplier relationships which were based on a history of successful performance. The missions for STS, Delta, Titan and other major spacelift vehicles have enjoyed reasonably high reliability rates (94.3%).

However, mission success is not the only consideration in today’s space transportation industry. As a matter of fact, most experts agree that mission and cost are critical in determining the future of spacelift (Kim, 1998). The USG is attempting to achieve “Cheap Access to Space” by using creative arrangements directed in the 1994 NSTP. These creative CL arrangements include commercialization by using anchor tenancy arrangements. The X-33 and X-34 programs exemplify the NASA doctrine of reducing the cost of accessing space by paying \$1 billion to Lockheed Martin Skunk Works or Orbital Sciences Corporation to experiment on exotic aerospace solutions. DoD is attempting to reduce the cost of space access by using GL and acquiring yet another expendable spacelift vehicle. Commercial industry is attempting reduce the cost of space access by competing for the X-prize and improving commercial practices with the USG by CLL-type privatization, such as USA privatization of the space shuttle, for example. Table 9 summarizes the trends of commercialization between 1988 and 1998.

Table 10. Thesis Summary Table

Years to/from 1994 NSTP	Critical Public Policy	Critical Industry Event	Impact
1988	Lobbying for Space Transportation Services Purchase Act of 1989	Space Services of Texas and OSC are offering spacelift to small payload customers	Set groundwork for 1989 STSP. Small telecommunications firm is first payload customer for commercial spacelift
1989	Space Transportation Services Purchase Act of 1989	1 st Commercial Space Launch (CL) by Space Services of Texas aboard sounding rocket.	Launch validated the public policy attempting to foster more commercial launch services.
1990	Commercial Launch Services Purchase Act of 1990	Atlas I/Titan II/Titan III/Titan IV and Delta II are given to Lockheed Martin/Boeing for commercial operation	This LSPA '90 is still the legislative standard for space transportation commercialization. This codified the requirements for USG stakeholders to seek CL.
1991		Atlas II successfully launched from Cape Canaveral	USG continued use of GL acquisition programs is justified by medium lift requirements (6,580 pounds to LEO) that has no CL substitute
1992	Omnibus Space Commercialization Act of 1992	Atlas IIA successfully launched from Cape Canaveral	The SCA initiates the anchor tenancy idea for space. USAF gains GL programs because the expendable IIA can lift (7,280 pounds to LEO) without CL substitute.
1993			
1994	National Space Transportation Policy	OSC launches Taurus (1,400 pounds to LEO)	Reoriented USG stakeholders priority toward more CL and less GL to accomplish commercialization of space transportation.
1995		LLV 1 launched	LLV represents a small Lockheed Martin microspace lift vehicle competing with OSC. Microspace lift costs decrease slightly.

Table 10. Thesis Summary Table (Continued)

1996	Pre-Commercial Space Act of 1997 is lobbied by March Stormers. CSA of 1996 is passed. X-33/Venture Star cooperative agreement is signed. USA is established for mission/ground for STS	X-prize competition for "Cheap Access to Space" for space tourism begins [\$10M is prize]	RLVs gain protection from foreign encroachment in the CSA of 1996. The X-prize indicates industry is willing to reward daring entrepreneurs. The capital accumulation is still incomplete.
1997	Commercial Space Act of 1997		Legislates that commercial payloads cannot be primary payload of STS. Prohibits ICBMs conversion to space transportation or sale to any user.
1998			

It is worthwhile to note the space efforts mounted by other countries and to compare American efforts with them. For the past five years Russia and Europe have led the world in orbital launch and commercial launch, respectively. Russia has conducted the most orbital launches during the period of 1993-1997, with 186 launches, while Europe has conducted the largest number of commercial launches for this period, with 42 internationally competed launch events, for a 44% market share of the commercial market (Cate: 8). France's Arianespace commercial launches outnumbered non-commercial launches within Europe. Table 10 indicates the competitive advantage that Europe and may have in the launch sector due to subsidization, internal politics and other government policies.

Table 11. Worldwide Launch Totals over 5 years,1993-1997

	<i>Non-commercial launches</i>	<i>Commercial Launches</i>	<i>Total Launches</i>
<i>United States</i>	<i>117</i>	<i>36</i>	<i>153</i>
<i>Russia</i>	<i>177</i>	<i>9</i>	<i>186</i>
<i>Europe</i>	<i>7</i>	<i>42</i>	<i>49</i>
<i>China</i>	<i>9</i>	<i>10</i>	<i>19</i>
<i>Japan</i>	<i>8</i>	<i>0</i>	<i>8</i>
<i>India</i>	<i>5</i>	<i>0</i>	<i>5</i>
<i>Brazil</i>	<i>1</i>	<i>0</i>	<i>1</i>
<i>Israel</i>	<i>1</i>	<i>0</i>	<i>1</i>
<i>Total</i>	<i>325</i>	<i>97</i>	<i>422</i>

From 1993 to 1997, worldwide commercial launches increased at a rate of approximately 41 percent per year. Combined worldwide commercial revenues were \$2.4 billion, a 57% increase from 1996 revenues (Cate: 7). Russia nearly tripled its commercial revenues last year at \$351 million from \$120 million in 1996. The US showed a 76% growth in revenues from 1996 internationally competed launches. These numbers do not tell the entire story. However, it is interesting to note America's place among international competition.

Table 12. Commercial Space Transportation: 1997 Year in Review

	<i>NonCommercial Launches</i>	<i>Commercial Launches</i>	<i>Total Launches</i>
<i>United States</i>	<i>24</i>	<i>14</i>	<i>38</i>
<i>Russia</i>	<i>22</i>	<i>7</i>	<i>29</i>
<i>Europe</i>	<i>1</i>	<i>11</i>	<i>12</i>
<i>China</i>	<i>3</i>	<i>3</i>	<i>6</i>
<i>Japan</i>	<i>2</i>	<i>0</i>	<i>2</i>
<i>India</i>	<i>1</i>	<i>0</i>	<i>1</i>
<i>Brazil</i>	<i>1</i>	<i>0</i>	<i>1</i>
<i>Total</i>	<i>54</i>	<i>35</i>	<i>89</i>

The forces which shaped the commercialization theory within the NSTP continue to shape the marketplace for space transportation today. The industry is at a "jumping off point," according to Kiger, who suggests that most new spacelift manufacturers can be still be considered nascent participants in a wide open race for "cheap access to space." It is yet to be seen if the purely commercial X-prize will display the correct incentive for driving down the costs of space access or the \$1 billion dollar technological experimental arrangement between Lockheed and NASA.

Appendix A: The National Space Transportation Policy Commercialization Provision

The Provision of the 1994 NSTP indicate President Clinton's emphasis on innovative arrangements to reduce the cost to access space through commercialization:

National Space Transportation Policy August 5, 1994

IV. Commercial Space Transportation Guidelines

(1) The United States Government is committed to encouraging a viable commercial U.S. space transportation industry.

(a) The Departments of Transportation and Commerce will be responsible for identifying and promoting innovative types of arrangements between the U.S. Government and the private sector, as well as State and local governments, that may be used to implement applicable portions of this policy.

(b) The Department of Transportation will license, facilitate, and promote commercial launch operations as set forth in the Commercial Space Launch Act, as amended, and Executive Order 12465. The Department of Transportation will coordinate with the Department of Commerce where appropriate.

(c) U.S. Government agencies shall purchase commercially available U.S. space transportation products and services to the fullest extent feasible that meet mission requirements and shall not conduct activities with commercial applications that preclude or deter commercial space activities, except for national security or public safety reasons.

(d) The U.S. Government will provide for the timely transfer to the private sector of unclassified Government-developed space transportation technologies in such a manner as to protect their commercial value.

(e) The U.S. Government will make all reasonable efforts to provide stable and predictable access to appropriate space transportation-related hardware, facilities, and services; these will be on a reimbursable basis. The U.S. Government reserves the right to use such facilities and services on a priority basis to meet national security and critical civil sector mission requirements.

(f) U.S. Government agencies shall work with the U.S. commercial space sector to promote the establishment of technical standards for commercial space products and services.

(2) U.S. Government agencies, in acquiring space launch-related capabilities, will to the extent feasible and consistent with mission requirements:

(a) Involve the private sector in the design and development of space transportation capabilities and encourage private sector financing, as appropriate.

(b) Emphasize procurement strategies that are based on the use of commercial U.S. space transportation products and services.

(c) Provide for private sector retention of technical data rights, limited only to the extent necessary to meet government needs.

(d) Encourage private sector and State and local government investment and participation in the development and improvement of U.S. launch systems and infrastructure.

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