1992
Executive Research Project
DIS9

A Look At The Space Industry

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY N/A	3. DISTRIBUTION/AVAILABILITY OF REPORT Distribution Statement A: Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NDU-ICAF-92-D159	5. MONITORING ORGANIZATION REPORT NUMBER(S) Same
6a. NAME OF PERFORMING ORGANIZATION Industrial College of the Armed Forces 6b. OFFICE SYMBOL (If applicable) ICAF-FAP	7a. NAME OF MONITORING ORGANIZATION National Defense University
6c. ADDRESS (City, State, and ZIP Code) Fort Lesley J. McNair Washington, D.C. 20319-6000	7b. ADDRESS (City, State, and ZIP Code) Fort Lesley J. McNair Washington, D.C. 20319-6000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) A Look at the Space Industry	
12. PERSONAL AUTHOR(S) James W. Kulbacki	
13a. TYPE OF REPORT Research	13b. TIME COVERED FROM Aug 91 TO Apr 92
14. DATE OF REPORT (Year, Month, Day) April 92	15. PAGE COUNT 38
16. SUPPLEMENTARY NOTATION	

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

SEE ATTACHED

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Judy Clark	22b. TELEPHONE (Include Area Code) (202) 475-1889 22c. OFFICE SYMBOL ICAF-FAP

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

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Kulbacki

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This paper is designed to provide the foundation from which the reader can become versed in what the key elements of the space industry are, who the principal commercial and governmental players are, and what functions, products and services these players provide. Also, the paper describes the recent space industry performance in terms of its size, structure, growth and its workforce. Finally, the U.S. space policy and strategy is discussed and its future ramifications are briefly examined.

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This research report represents the views of the author and does not necessarily reflect the official opinion of the Industrial College of the Armed Forces, the National Defense University, or the Department of Defense.

ABSTRACT

Space systems have grown to assume a critical role in our national security posture. The changing geopolitical world and associated military balance, coupled with the continued reduction in the DOD budget, dictates the need for us to be intimately aware of the space industry and its impact on the industrial base and national security.

This paper is designed to provide the foundation from which the reader can become versed in what the key elements of the space industry are, who the principal commercial and governmental players are, and what functions, products and services these players provide. Also, the paper describes the recent space industry performance in terms of its size, structure, growth and its workforce. Finally, the U.S. space policy and strategy is discussed and its future ramifications are briefly examined.

INTRODUCTION:

This report is designed to familiarize readers with the specifics of the space industry and provide a basis and a firm foundation that one can expand and build upon. A definition of the U.S. space industry will be presented and described in terms of key parameters, to include structure, size, players (to include international), performance, and locations. Additionally, the nation's space policy and strategy and the role of the space industry with respect to both civilian and military use will be presented.

Much discussion has already taken place in the literature concerning the importance and role of space. Even with all the advances and progress that has been made, space industry is still in the embryonic stages of its development and the courses of action pursued by the world community during this next decade will decide space's future role. As quoted in the International Space Year publication

> "International Space Year falls in a decade that will probably set the stage for long-term development of space. Since space programs no longer help keep politicians in power, they are likely to treat these programs harshly. But in order to make international programs work, a great deal of trust is required. Some nations will need to alter their attitude to partnerships if the large projects are to be pursued. Long-term commitments are needed. In many nations, particularly in the USA, this does not fit well with the annual budgetary process.
>
> Thus, the USA could well lose its leadership in space. Meanwhile, other nations, under the aegis of the ESA - which in the near future could include China, Japan and Australia - may take its place. With deficits in the United States and political change in the Soviet Union, this could happen very soon."
>
> Ian Parker
> Editor of British magazine - Space

INDUSTRY STRUCTURE:

Although there are a variety of ways to categorize the space industry the most common and popular one is functionally and is

depicted by using the government's Standard Industrial Classification (SIC) code which is managed by the Office of Management and Budget (OMB).[1] This code was developed by the government in concert with industry as a way to categorize economic activity. Normally, each type of business/industry is assigned a four letter SIC code; the first two digits describe the nature of the industry in broad terms; and the other two digits hone in on the specific area.

The problem that is encountered when one examines the space industry is that a consensus of what really constitutes the space industry elements is not readily agreed upon and as such a clearly defined individual or set of SIC codes does not exist. As a consequence, much of the space industry is by default lumped into the aerospace industry. Although a consensus may not exist, upon closer examinations of those codes that could be applicable, it appears that a variety of businesses that provide services associated with space activities can be found in the following SIC codes:[2]

SIC 3761, Guided Missiles and Space Vehicles. This SIC includes businesses primarily engaged in manufacturing complete guided missiles and space vehicles excluding propulsion units (which are included in SIC 3764). Also included in this SIC are research and development - including simulation and evaluation - on complete guided missiles and space launch vehicles, as well as

other services requiring a thorough knowledge of complete guided missiles and space vehicles.

SIC 3764, Guided missiles and Space Vehicle Propulsion Units and Parts. This SIC includes businesses primarily engaged in producing guided missile and space vehicle propulsion units and parts, as well as research and development associated with such parts, and other services requiring a thorough knowledge of guided missile and space vehicle propulsion systems.

SIC 3769, Guide Missile and Space Vehicle Parts, Not Elsewhere Classified. This SIC includes businesses primarily engaged in manufacturing guided missile and space vehicle parts and auxiliary equipment, not elsewhere classified. Also included in this SIC code is research and development on guided missile and space vehicle parts and components.

Portions of **SIC 3663, Radio and Television Communication Equipment.** This SIC includes businesses that are engaged in a myriad of products that include systems and equipment associated with guided missile and space vehicles, and satellites and tracking electronic components and systems.

These SIC codes are still not all encompassing when examining the space industry. It can be legitimately argued that elements of other SIC codes contribute to the space industry and could be

integrated into the overall examination. Additionally the U.S. government conducts many classified space programs which are not captured within these SICs, but do impact the overall space industry.

INDUSTRY PLAYERS:

The space industry can be characterized as both an Oligopoly and a Monopsony. This characterization results because of the complex nature of the industry. In both characterizations the sellers are the same and are few in number - it can be seen that over 80% of the business base of the market is controlled by less than six firms.[3] (In an Oligopoly, there is a limited number of sellers - government and commercial (foreign and domestic) and in a Monopsony there is only one buyer - the federal government.) In this latter characterization, one still could argue that the federal government is really made up of multiple buyers (DOD, DOT, NASA, DOE, Commerce).

There are a variety of ways to categorize the key players, but prior to doing that, it is worthwhile to first discuss space systems and their composition. Space systems basically can be divided into three components: the spacecraft, launch system, and the ground station.[4]

The spacecraft/satellite contains the essential elements to perform the mission or specific function of the mission - the

mission payload. The spacecraft contains all the life support systems necessary to support the function of the system.

The spacecraft is currently launched into space by the two primary means: the space shuttle and the expendable launch vehicle (ELV).

The space shuttle is a re-usable manned multiple launch and reentry vehicle designed to carry a variety of diverse payloads into near earth orbit; specifically, capable of delivering up to 25t of cargo into a 28.5 degree low earth orbit. The four primary elements of the shuttle are the Orbiter, two solid rocket boosters, external tank, and three Rocketdyne space shuttle main engines (SSME).[5] In operation, the shuttle is launched vertically with all engines firing. At an altitude of approximately 43,000 meters the boosters separate, the Orbiter continues under SSME power and, after approximately 8.5 minutes after launch, jettisons the external tank. The Orbiter is then maneuvered into its operational orbit by firing its orbital maneuvering system. The Orbiter is designed to deploy and retrieve payloads utilizing its cargo bay, permitting in site servicing or earth return. An array of standard payload platforms is available for short duration research missions. For payload deployment, the payload is released from the cargo bay in close proximity of the shuttle and maneuvered into final orbit by the mission control ground station. Upon mission completion, the space shuttle then returns to earth, landing similar to conventual aircraft.

ELVs vary in size and configuration but they basically are designed to boost payloads into either a final or parking orbit. Generally, ELVs are multi-staged; the first is liquid fueled (sometimes supplemented by solid propellant strap-on boosters, based upon payload requirements) and of high thrust, the second stage, which is normally liquid fueled and the last high thrust system, is designed to place the spacecraft into a direct ascent to final orbit or into a parking orbit. If the spacecraft is placed into a parking orbit, an upper or third stage is used to boost it into higher orbit or to adjust its orbit parameters.

The mission control ground stations achieve control of the spacecraft electronically by accessing the command module of the spacecraft after it has reached its parking orbit and/or initial orbit. The spacecraft is then manipulated into its final orbit by commands from the ground station. The ground station normally is responsible for maintaining the spacecraft in its designated orbit and configuration. It also may be responsible for all or some of the mission data collection functions which may be necessary. In some cases, the data collection responsibilities may also be distributed to multiple ground stations or to other downlinks. Ground stations normally control multiple spacecraft and are responsible for multiple missions.

With these categories as the basic framework, the major industry players are identified as follows:[6]

SPACECRFT	SHUTTLE	ELVs	GRND STAS
Martin-Marietta	Rockwell	Martin-Marietta	Martin-Marietta
Rockwell	Martin-Marietta	McDonnell Douglas	Cincinnati Electr
Lockheed	McDonnell Douglas	General Dynamics	Bendix Field Engr
TRW	Thiokol Inc	Thiokol Inc	Computer Science
Hughes	United Technology	United Technology	Ford Aerospace
General Electric	Aerojet	Boeing Aerospace	TRW
RCA		General Dynamics	
Ford Aerospace		Orbital Sciences	
		Hercules Aerospace	

This is not an exhaustive list, but highlights how the industry is concentrated amongst a few. The following is a short summary of the roles of some of the major companies:

Rockwell International: This corporation has a variety of its divisions involved with space activities. They develop and build both manned and unmanned space vehicles. They are the prime contractor for the space shuttle orbiters and are responsible for shuttle mission planning, flight design, mission data production, ground facility engineering and operations support, and direct mission support. In the spacecraft area, they are the prime contractor for the NAVSTAR GPS program.

Martin-Marietta: This corporation has elements involved in spacecraft, shuttle and ground station areas. In the spacecraft area, they produce planetary space craft such as NASA's Magellan Venus orbiter, and the Tethered Satellite program. In the shuttle and ELV area, they design and build the Titan launch systems which are used to launch the shuttle and other military and commercial payloads. In the ground station area, they operate for the USAF

the Titan launch facilities at Cape Canaveral.

McDonnell Douglas: This corporation is heavily involved in the launch area, shuttle and ELVs. They produce space shuttle hardware, to include the aft propulsion system consisting of an orbital maneuver and a reaction control system. They also build the Delta launch vehicle which is considered to be the USAF's medium launch vehicle. They also developed and produced the Payload Assist Module (PAM) which launches unmanned satellites from the cargo bay of the shuttle and also is used on the upper stage of the Delta to place commercial payloads into final orbit.

Ford Aerospace: This corporation is also involved in multiple space areas. In the spacecraft area, they have developed and produced communication satellites for the US, Japan, India, NATO, and Intelsat. They are presently providing the next generation of the geostationary operational environmental satellites (GOES) satellites. In the ground station area, they are responsible for modernizing the existing shuttle facility and building NASA's new Mission Control Center in Houston. Ford Aerospace has provided more than 200 large satellite ground terminals in the world.

More detailed description of these and other major corporations are readily available in numerous documents to include Interavia Space Directory, and Standard and Poor's Registry of Corporations.

Federal government agencies play a significant role in space

activities as follows:

USSPACECOMMAND - Activated in 1984, USSPACECOMMAND is headquartered at Peterson AFB Colorado. Its mission is to assure access to space for US forces and be capable of denying it to potential adversaries if and when required. Also, it is responsible for providing integrated warning and assessment of attacks on the continental United States by ballistic missiles, bombers, cruise missiles and space related threats. Its command and control centers are in the Cheyenne Mountain Complex and in the Consolidated Space Operations Center (CSOC) both in Colorado Springs.

AIRFORCE SPACECOMMMAND - The Air Force component of the Unified Space Command, was established September 1982 in Colorado Springs, Colorado. Its mission is to manage and operate assigned space assets in support of the North American Aerospace Defense Command (NORAD) and USSPACECOMMAND, to centralize planning, to consolidate and advocate operational requirements, and to insure close interface between research and development activities and operational users of Air Force space systems. The command is also the Air Force command responsible for strategic defense and acts as the focal point for space policy and doctrine development. Air Force Space Command operates an extensive network of space/missile warning and surveillance systems. It also operates the Cheyenne Mountain Complex and the CSOC.

ARMY SPACECOMMAND - The Army component of the Unified Space Command is also headquartered at Colorado Springs, Colorado. Its mission is to influence the development and the applications of space-based systems to satisfy Army requirements such as tactical communications and the NAVSTAR GPS system. It is responsible for the ground control of the DSCS satellite communications network, planning the command and control aspects of the exoatmospheric re-entry interceptor system (ERIS) and the ground-based surveillance and tracking system (GSTS) for Space Defense Initiative (SDI) system.

NAVY SPACECOMMAND - The Navy component of the Unified Space Command and is headquartered at Dahlgren, Virginia. Its mission is to insure that the fleet operational commander has available the space assets required.

NASA - Was formally established in 1958 to plan and execute the US national civil space program. It consists of five principle offices and approximately twelve major centers and facilities.

The Office of Aeronautics and Exploration Technology is responsible for the research and development programs and manages the Ames, Langley and Lewis research centers. These centers are involved in a myriad of areas to include space propulsion, space power, hypersonic aircraft, and infrared astronomy. Major projects that they have been involved in are Pioneer-Venus Orbiter and Galileo's Jupiter missions, Vikings-Mars orbiters, and Atlas and

Centaur launchings.

The Office of Space Flight develops and manages space systems, such as the Space Shuttle and Spacelab, through the major Kennedy, Marshall, Johnson and Stennis centers.

The Office of Space Science and Applications manages the unmanned space activities directed at planetary, earth observation and astronomical investigation, life sciences, sounding rockets and the science elements of manned missions through the Jet Propulsion Laboratory (JPL) and the Goddard Space Flight centers. JPL is responsible for most of the deep space missions, to include the Voyager, Magellan, Galileo, and Mars Observer. Goddard Space Flight center is responsible for most of NASA's earth-orbiting science and applications satellites, directs NASA's Delta launch activities, and operates NASA's tracking networks for all space missions. In addition, Goddard is responsible for the free-flying earth observing and microgravity platforms associated with the Space Station.

NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION - Operates the NOAA polar and GOES geostationary meteorological satellite systems, and is the federal overseer of the commercial Landsat remote sensing satellite system. As part of the Dept of Commerce, NOAA is the US signatory to the international Cospas-Sarsat agreement which uses an international satellite-based search and rescue system (COSPAS/SARSAT) to locate ships and aircraft in distress. This system was established in 1979 by Canada, France, USA, and USSR,

and is based on the detection of distress beacons by four polar-orbiting satellites.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY - is the Dept of Defense's central research and development organization for maintaining technical development and proof of concept demonstrations. It conducts research and development in space related technologies. Examples include Lightsat and Pegasus programs.

DEFENSE NUCLEAR AGENCY - conducts research and studies associated with the survivability of space programs.

STRATEGIC DEFENSE INITIATIVE ORGANIZATION - is the focal point for the Strategic Defense Initiative (SDI). It is responsible for the overall management and integration of the SDI efforts performed by the armed services and other DOD agencies and appropriate contractors. SDI underwent a fundamental re-orientation in late 1990. Instead of developing a system capable of defending the contiguous US against a strategic strike by thousands of Soviet missiles, a Global Protection Against Limited Strikes (GPALS) is envisioned that would protect against smaller attacks on all US territories, allies, and theater forces.

PHYSICAL CHARACTERISTICS:

As noted previously, the space industry displays the

attributes of both an oligopoly and a monopsony and, as such, only a limited number of very large corporations are involved at the prime level in the development and production of all segments of space systems. There are smaller companies which support these large companies in producing assemblies, sub-assemblies, components and sub systems, but their influence on any part of the industry, if any, is small. This concentration within a very small segment of industry has significant impact on the work force's characteristics and composition.

The actual work force is one that is comparatively small in numbers, with respect to other industries, but is highly skilled and specialized. It consists of engineers, scientists, technicians, and production workers. The total number of those involved in the space industry are approximated (because of the disparate SICs involved) to be about 200,000 strong.[7] A significant portion of the workforce is non-production oriented and is devoted to R&D. This being the case, the overall labor cost is more expensive than in other industries - the average cost a company incurs per aerospace R&D scientist and engineer is approximately $184,000 versus $139,000 in the other defense related industries. Although this work force is very stable and to a degree recession proof because of its unique relationships and nature of business, indications are that a 10-20% reduction over the next five years can be expected; particularly, with the present and projected reduction in the military and civilian space budget.[8]

PERFORMANCE:

As previously indicated, because of the disparate SIC codes that impact the space industry, the total performance in terms of industry sales can only be approximated. Over the last ten years, the federal government's involvement and role in space has kept the U.S. space industry on a growth curve. U.S. federal space expenditure of about $31 billion annually was approached only by the former Soviet Union. The Department of Defense and NASA together account for about 98% of the expenditures, with the military accounting for approximately 60%. Space sales accounted for about $29.2 billion of the aerospace industries' $131.4 billion FY90 revenue and is only expected to rise to $30.5 billion in FY91.[9] This represented a growth rate increase of only 5% in constant dollars. Previously from 1985 to 1989, the space industry had exhibited a constant 8.4% real growth rate, but since 1989 has exhibited a steadily decreasing growth rate. The reduction in sales backlog at the major corporations reinforces the projection that the downward trend (which supports the downward projection for employment) is expected to continue.

R&D spending is expected to continue to grow at a steady but moderate level. The revised SDI budget still allocates approximately $2 billion to the research and development.

FOREIGN COUNTRIES/ORGANIZATIONS:

This projected slow and/or flat growth has been complicated by the number of foreign players involved. Earlier the United States

and the former Soviet Union clearly dominated space activities, but this is no longer true with the emergence of at least four additional countries/organizations: China, the European Space Agency, India, and Japan. These countries/organizations are pursuing very aggressive policies that are intended to capture and dominate the largest market share of the space industry as possible. Four other countries - Australia, France, Italy, and the United Kingdom - are sometimes considered launch countries. The former Soviet Union and the four emerging countries/organizations involvement in space is as follows:[10]

The **Soviet Union**, even with its dissolution and replacement by the Confederation of Independent States, has a formidable space program. Prior to the Soviet's dissolution, they had been aggressively pursuing a myriad of space activities . They continue to work on heavier lift capability (Energiya) and continue to conduct a wide range of experiments in their space stations on remote sensing, materials processing, and biology as well as astronomical and atmospheric studies. It appears that their Shuttle (Buran) which is very similar to ours and was initially thought to have air breathing engines which would have allowed multi-landing approaches does not and must also land on the first attempt. Until recently the Soviets were also developing a small spaceplane which would accommodate a crew of two and be able to function as ferry aircraft to take crews back and forth from earth to the space station. Recently, in efforts to derive economic

returns from their space industry, discussions amongst the republics have centered upon expanding the capacity of the space station Mir and renting space aboard it for commercial use.[11] Future U.S. - Russian efforts are directly dependent upon the success of the emerging democratic governments coupled with the knowledge that these cooperative efforts will take time and patience to bring to fruition.

China launched its first satellite in 1970; and by 1990 had 28 successful launches resulting in 31 satellites placed in orbit. China did not identify the missions of these satellites, but most western observers believed they ranged from communications to reconnaissance missions. The Chinese now are actively marketing their launch services abroad using the Long March 2 and 3. Initially, they concentrated their efforts on commercial launches of material processing experiments, but they are now concentrated their efforts on the commercial communications satellites market which is much larger. Additionally, several American companies have initiated discussions with the Chinese to launch communication satellites. Most recently, China has been negotiating with Intelsat to launch one of their communications satellites by the late 1990s.[12] China's future role in the space industry is not totally clear, but the Chinese have indicated that they will use this industry to further their economic reforms and also to help springboard them to superpower status.

Japan has indicated it is embarking upon a very ambitious space industry plan. It has made 41 successful launches since 1970, placing 40 satellites successfully in orbit. It has concentrated on development of space launch vehicles and communications, weather, and scientific satellites. Japan uses a combination of U.S. and Japanese technology. There are two major governmental organizations involved in launching satellites in Japan: the National Space Development Agency (NASDA), which is designed to oversee the government's role in developing applications satellites; and the Institute of Space and Astronomical Science (ISAS), which concentrates its activities on space science and application. NASDA's most critical program is the H-2 launch vehicle, the first rocket that will consist of entirely of Japanese components. The H-2 launch vehicle will be capable of launching more than 2 tons into a geostationary orbit. A major obstacle for the vehicle has been cost which is projected at $117 million per launch (vice $50-80 million average with other space vehicle launching countries). Japan hopes to reduce the overall cost of the H-2 by mass production, but even with this exorbitant cost customers are lining up - Engineering Test Satellite 6 (Japan - will demonstrate technology for future data relay system for orbiting spacecraft), Geostationary Meteorological Satellite (GMS) 5 (Japan - part of GMS system that provides coverage of the Pacific region) and the Space Flyer Unit (Japan - free flying orbital platform to conduct a variety of experiments and then be retrieved by the space shuttle) are all scheduled for

launch in 1994.[13] ISAS is responsible for the space science program and has launched a number of earth orbiting satellites for astronomy and other research. In January 1990, Japan became the third nation to send an spacecraft to the Moon.[14] They are gradually setting their technological pieces in place. Japan is on its way of becoming a significant competitor in the area of space technology, particularly with communication satellites and the associated ground stations.

European Space Agency (ESA) was formed in 1975 by the merger of the European Scientific research Organization and the European Launcher Development Organization. It has thirteen members. The Ariane is their prime launch vehicle and France played the major role in its development. Arianespace, a private company which markets the Ariane and manages the launches is incorporated in France. ESA is presently developing the Ariane 5 which will have a maximum lift capability of 15,000 kilograms placed into a low earth orbit (LEO) and will be reusable. ESA and the U.S. have cooperated on numerous endeavors and ESA has agreed to participate in the space station program. The Spacelab is Europe's initial manned space flight capability. It will be a cargo bay module that will rely on the U.S. orbiter for life support during 9-10 day missions. In addition, they are developing a European Retrievable Carrier (Eureca) a free-flying platform that will be a follow-on to the Spacelab pallet. The platform is intended to be deployed from and retrieved by the U.S. shuttle. ESA will continue to pursue

gaining a larger segment of the commercial launch market.

India has been developing satellites and launch vehicles for several years. The Indian Space Research Organization (ISRO) is the primary government space agency. They have launched several platforms, but have had limited success in the payloads' overall performance and duration. Their prime aims involve operational space-based remote sensing and communications systems. They are actively soliciting assistance from the West to achieve launch autonomy, but to date have been unsuccessful. Most recently, they have negotiated on a commercial versus a cooperative basis with the former Soviet Union to launch three satellites (2-remote sensing; 1-communications) for them by 1994.[15]

NATIONAL SPACE STRATEGY AND POLICY:

The United States space policy and strategy is reflected first in the National Security Decision Directives (NSDD) signed by the President which are then translated into specific policy and guidance. Three significant space NSDDs have been developed:

National Space Policy,

National Space Strategy and,

National Security Launch Strategy.

The 1982 National Space Policy provided a series of goals for our nation's space program: strengthen the security of the United States, maintain U.S. leadership in space, expand private sector investment in space, promote international cooperation, and

cooperate with other nations in maintaining the freedom of space for activities which enhance the security and welfare of mankind. Several specific principles governing this policy were stated, the most important of which expresses that the United States is committed to peaceful exploration of space and rejects claims by all of sovereignty over celestial bodies or space itself. Also, the policy specified that two separate and distinct, but cooperative segments of the U.S. space program will exist - the civil segment and the national security segment.

The National Space Strategy delivered by President Reagan in his 1984 State of the Union message reflected the position that in the:

space transportation system - the Shuttle will be the primary launch vehicle;

civil space program - NASA was charged to build a permanently manned space station, and foster international joint efforts involving the space station;

commercial space program - commercial launch of ELVs would be encouraged and;

national security space programs - limited number of ELVs would be procured to complement the shuttle, and efforts would continue to assure access to space and survivability.

Finally, the National Security Launch Strategy issued in 1985 directed DOD to procure additional ELVs which they had not done to date. Additionally, it reiterated that the shuttle would continue to be the primary launch vehicle and directed that a long range

study of future launch systems would be conducted.

In a February 1988 policy announcement, President Reagan declared that one of US space goals was to expand human presence and activity beyond Earth orbit into the solar system. This policy announcement was in response to the Paine Commission and Ride reports, which had stated that the United States should lead the way in opening the inner solar system for science, exploration and development, to include bases on the Moon and Mars.

In 1989 President Bush, in support of these space goals, made a major policy address announcing the aim of returning humans to the Moon and then going to Mars in the 21st century (Space Exploration Initiative (SEI)).[16] The President strongly believed that SEI would help maintain US preeminence in space and insure that new technologies could be developed that would contribute to United States' international competitiveness. In addition, in December 1990 the Advisory Committee on the Future of the US Space Program recommended that the Government shift payloads from the shuttle to a new expendable launch vehicle. This was a result of the committee's conclusion that the civil sector was overly dependent upon the space shuttle for access to space and the development of a new launch system was required.

In July 1991, President Bush released a new National Space Launch Strategy which details a long range plan to meet US space launch needs. The National Launch System (NLS) strategy endorses using a combination of shuttle and ELVs (mixed fleet) approach, maintaining current launch facilities and systems well into the

21st century, while developing a family of vehicles that are able to access space for less cost and are more reliable and responsive to mission needs.[17]

The ambitious SEI program has Congress' support conceptually, whereas the NLS has mixed reviews, and many in Congress feel that there is no firm military or civil requirement for a new launch system. In both cases, Congress is reluctant to approve these programs because of their expected cost of at least $400 billion over 30 years. Proponents of other alternative approaches feel that these same goals can be achieved at much less cost and risk of human life. With the importance of maintaining our edge in space, it is likely that limited funding will be allocated, but the programs will be reduced in scope and stretched out in duration.

Overall, our space policy and strategy has not changed, but it is clear that with the evolving world and the players involved, compounded by our present economic situation, we must carefully select those space areas that will give us our greatest return on investment in terms of our elements of power in order to continue to maintain our superpower status.

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List of Symbols and Abbreviations

DSCS	Defense Satellite Communications System
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
ELV	expendable launch vehicle
GEO	geostationary (geosynchronous) earth orbit
GPS	global positioning system
LEO	low earth orbit
NASA	National Aeronautics and Space Administration
Navstar	navigation system using timing and ranging