Summary

As the year 2001 approaches, visions of annular space stations and tourist flights to the Moon remain science fiction. With fewer than six years until the new millennium, the U.S. space transportation technology and industrial base is faced with a number of challenges, and some opportunities.[1]

The federal government has been the primary customer for space transportation services since the early days of rocketry. Recent efforts to reduce the federal budget deficit, cut the national debt, and shift development responsibilities to the private sector, however, have limited government funding for new space transportation technologies and missions. Similarly, the end of the Cold War has led to a reexamination of defense and national security spending on space missions and long-range ballistic missiles.

Meanwhile, European, Russian, and Chinese launch providers have captured more than 60 percent of the global commercial launch market for medium launch vehicles (MLVs). At the same time, entrepreneurs in the telecommunication, navigational, and remote sensing satellite industries predict an increasing need for launch services to establish and maintain large constellations of new satellites.

[1] Space transportation in this report refers to vehicles able to carry payloads or passengers to orbit. Space transportation systems may be expendable launch vehicles (ELVs), partially or fully reusable launch vehicles (RLVs), and long-range ballistic missiles. Currently, the U.S. Space Shuttle is the world's only operational RLV. This report does not address suborbital launch systems or transportation systems designed primarily to move payload or passengers between or beyond Earth orbits.

To address these challenges and opportunities, on August 5, 1994, the White House announced the National Space Transportation Policy (NSTP), developed by the National Science and Technology Council and approved by President Clinton.[2] The Clinton Administration's four fundamental objectives for the NSTP were to establish new national policy regarding:

1. federal space transportation spending, consistent with current budget constraints and the opportunities presented by emerging technologies;
2. federal agencies' use of foreign launch systems and components;
3. federal agencies' use of excess ballistic missile assets for space launch, to prevent adverse impacts on the U.S. commercial space launch industry; and
4. an expanded private sector role in the federal space transportation research and development (R&D) decisionmaking process.[3]

This report examines the new policy and the implementation plans of the Department of Defense (DOD), the National Aeronautics and Space Administration (NASA), and the Departments of Transportation (DOT) and Commerce (DOC) in the context of these four fundamental objectives. The report raises issues for Congress to consider as it debates the funding, oversight, and legislative requirements of the new space transportation policy. General findings, issues for Congress, and critical decision points identified in the report are summarized below. The main body of the report provides background on the fundamental objectives and examines each issue for Congress in detail.

GENERAL FINDINGS

Lack of Consensus on U.S. Space Policy Goals

The U.S. space transportation technology and industrial base is in a period of tumult and uncertainty brought about by the end of the Cold War, a constrained fiscal environment, and a pending shift in responsibilities from the public to the private sector. Even more than ordinary times, such a period demands clear intermediate and long-term goals, strong Presidential leadership, and the formation of a national consensus among the executive branch, Congress, industry, and the public.

The NSTP states that "assuring reliable and affordable access to space through U.S. space transportation capabilities is a fundamental goal of the U.S. space program."[4] Most observers agree that reducing costs and improving reliability are important objectives for the U.S. space program. Reliable, affordable access to space is a necessary part of the nation's infrastructure for achieving broader space goals.

The policy implies that lowering the cost of access to space will allow the United States to do whatever it wants in space. It may be difficult to achieve lower launch costs, however, without a clearly articulated, long-term plan supported by adequate funding, especially when the government is asking industry to make significant investments in ambitious new space transportation development programs. Indeed, the Office of Technology Assessment (OTA) previously noted that "until the nation chooses *what* it wants to accomplish in space, and what the U.S. taxpayer is

[2] Presidential Decision Directive NSTC-4. Most, if not all, the text of this internal policy was released publicly in The White House, Office of Science and Technology Policy, "National Space Transportation Policy," Fact Sheet, Washington, DC, Aug. 5, 1994. See appendix for complete text.

[3] The White House, Office of Science and Technology Policy, "Statement on National Space Transportation Policy," Washington, DC, Aug. 5, 1994. See appendix for complete text.

[4] The White House Office, Office of Science and Technology Policy, op. cit., footnote 2, Intro.

willing to pay for, neither the *type* nor number of necessary launchers and facilities can be estimated with accuracy."[5]

Establishing a national consensus first requires a clear delineation of specific national space goals by the Administration and its implementing departments and agencies. Then the Administration must cultivate congressional and public support for these goals, and convince industry that pursuing and achieving these goals would serve its interests.

The Administration has outlined some broad national space goals, such as achieving the International Space Station. It has not made clear, however, how specific goals relate to each other. It has not issued, for example, an overall space policy to replace the 1989 space policy of the Bush Administration. Without a clear articulation of space policy and how it relates to the broader national agenda, it may be difficult for both industry and government to pursue space transportation goals with vigor.

As the experience of the last decade has shown, even if the Administration were to delineate clear and specific national space goals, industry officials might still be reluctant to commit corporate resources to new space transportation ventures without strong congressional support. This support, in turn, depends on the ability of Members of Congress to bridge jurisdictional divisions and reach a consensus on how to buttress national space goals.

Living Within Severe Budget Constraints

Fiscal constraints imposed by the budget deficit, the federal debt, competition from other programs, and a desire to reduce government spending have forced DOD and NASA to cut back on space transportation programs, and to attempt to fund more creatively those programs that remain (e.g., through public-private partnerships). Both DOD and NASA state that they can meet their current space goals, but many government and industry officials are skeptical. These officials point out the previous commitments to new space transportation systems that failed to produce operational vehicles despite less severe budget constraints (e.g., the National Launch System, the Advanced Launch System, the Air Force Space Lifter, the Shuttle C, the Shuttle II, and the National Aerospace Plane). The U.S. government could afford to fund fully new space transportation systems, but it has currently placed its spending priorities elsewhere. In the absence of more government spending, the government and industry will have to sustain a commitment to new ways of doing business if the challenges and opportunities confronting U.S. space transportation are to be met.

Government Demand Dominates the Space Transportation Market

Since the advent of the space age, the U.S. government has played a large and critical role in shaping the domestic space transportation technology and industrial base. The U.S. government created the base to build long-range ballistic missiles and place men on the Moon. The U.S. government and industry remain tightly entwined through R&D and procurement contracts, federal regulations, and the need for licenses, despite the rise of commercial space launch markets.

For at least the next decade, U.S. national security and civil demands for space transportation will continue to dominate the domestic industry. Even the most optimistic growth projections for the global commercial market do not forecast a significant shift away from the government without major changes in the marketplace (e.g., the development of a dramatically less-expensive space transportation system or the discovery of a commercially lucrative space activity). Moreover, some launch providers are reluctant to take the steps necessary to make their launch operations

[5] U.S. Congress, Office of Technology Assessment, *Access to Space: The Future of U.S. Space Transportation Systems*, OTA-ISC-415 (Washington, DC: U.S. Government Printing Office, April 1990), p. 21.

more commercially price-competitive, because the changes might conflict with government requirements or the government might demand similar savings.

Current Capabilities Can Meet National Security Requirements

The national security community currently requires a domestic capability to launch payloads into orbit. The existing fleet of launch vehicles can continue to meet this requirement for the foreseeable future. DOD's major new development program, the Evolved Expendable Launch Vehicle (EELV), is intended to reduce DOD space transportation costs, rather than ensure continued access to space. The EELV program attempts to maximize cost savings by replacing DOD's current stable of MLVs and heavy launch vehicles (HLVs), procured from several vendors, with a unified family of vehicles that share many common components and launch infrastructure and are built by a single launch provider. One consequence of this consolidation, however, is that a systemic failure in one vehicle might ground the entire family of vehicles along with its national security payloads.

Competing Interests Make Common Strategy Difficult

While all members of the space transportation technology and industrial base see a critical need to reduce the cost of space transportation, their differing interests make it difficult to agree on a common space transportation development strategy. National security space transportation decisions are largely driven by the need to reduce expensive HLV launch costs through the EELV program. NASA hopes to replace its aging Space Shuttle fleet with a new, low-cost reusable launch vehicle (RLV) in the high MLV class that would carry crews and cargo to and from the International Space Station. Most industry representatives want to focus development dollars on a smaller, reusable MLV, designed to recapture lost commercial market share worldwide, while small launch vehicle (SLV) producers and selected space scientists want to maintain U.S. leadership in SLVs.

Recognizing and balancing these competing interests is critical to the success of a truly national space policy. The NSTP and its implementation plans are careful to ensure that DOD and NASA needs are met, but are less diligent about meeting the needs of the private sector.

ISSUES FOR CONGRESS

The following section summarizes OTA's discussion of issues that may be of interest to Congress as it debates the future of U.S. space transportation. These issues are divided among the Clinton Administration's four fundamental objectives for the NSTP and correspond directly to the main body of the report.

Fundamental Objective #1: Space Transportation Funding and the Division of Responsibilities

The NSTP attempts to set government spending priorities for current and future space transportation systems by assigning specific roles and functions to designated departments and agencies. By placing DOD in charge of expendable launch vehicle (ELV) development and NASA in charge of continued Space Shuttle operation and RLV development, the Administration has taken a step toward reducing conflicts and redundancies within government space transportation development programs.

DOD currently spends roughly $1.6 billion (about 84 percent) of its $1.9-billion space transportation budget on its HLV program, the Titan IV, while NASA spends just over $4 billion per year on Space Shuttle modifications and operations. Each organization has individually initiated a set of programs to address the budgetary difficulties posed by these high costs (see table S-1).

An added dimension to the current effort to develop new space transportation systems is the role of the private sector—both in decisionmaking and

TABLE S-1: DOD and NASA Development Programs and Procurements

	Program	Description	Objective
DOD	Existing ELV upgrades	Upgrades to the current fleet of launch systems and supporting infrastructure,	Keep the existing ELV fleet flying safely and reliably. Achieve significant, short-term payoffs where possible,
	Evolved Expendable Launch Vehicle (EELV)	A new, single family of MLVs and HLVs based on an evolutionary redesign of one or more existing ELVs.	Lower overall cost of access to space for DOD, especially for heavy payloads, by using common subsystems, components, and Infrastructure,
NASA	Space Shuttle upgrades	System Improvements and replacement of aging subsystems and components.	Keep the Space Shuttle flying safely and reliably,
	Med-Lite	A launch system with capacity falling between existing SLVs and MLVs.	Acquire a less expensive vehicle to serve future planetary exploration mission requirements.
	DC-XA	Upgrades to the DC-X (a vertical-takeoff/vertical-landing, sub-scale, fully reusable, single-stage-to-orbit technology demonstrator) with more advanced components	Demonstrate system operability by testing new components and the Integrated system in a realistic flight environment
	x-33	A sub-scale advanced technology demonstrator that will be, at a minimum, an autonomous, suborbital, experimental, single-stage-to-orbit RLV.	By 2000, prove the concept of a fully reusable single-stage-to-orbit space transportation system in the high MLV class by demonstrating key technology, operations, and reliability in an integrated flight vehicle, Encourage private Investment in a commercial follow-on RLV by reducing the technical risks of SSTO.
	x-34	A partially reusable demonstration vehicle for small payloads.	Investigate technologies that may be incorporated into future RLVs, Demonstrate streamlined management of joint Industry-government development effort. Address commercial and U.S. government need for an inexpensive SLV.
	Supporting RLV technology demonstration	Development and validation of propulsion, structural, and operations technologies	Progressively Integrate and flight-demonstrate these technologies on three experimental test vehicles (DC-XA, X-33, and X-34) in order to 1) mature technologies required for a next-generation launch system, 2) demonstrate the capability to achieve low development and operational costs, and rapid launch turnarounds, and 3) reduce technical risk to encourage private Investment in the commercial development and operation of next-generation systems.

SOURCE Off Ice of Technology Assessment, 1995 financing. This has important implications on the nature of space transportation development programs and raises an entirely new set of considerations that must be taken into account when evaluating development programs proposed by both DOD and NASA.

ISSUE 1a: *Divided responsibility and interagency coordination*

The NSTP divides the government's primary responsibilities for space transportation between DOD and NASA. If existing space transportation assets and those under development are to be managed in a manner conducive to all interests, this division of responsibility will increase the need for both organizations to coordinate with one another, as well as with the private sector.

That DOD and NASA will adequately account for the interests of all parties is not a certainty, especially as funds available for space transportation diminish. Conflicts over how to approach the development of new space transportation systems will undoubtedly arise. At present, it appears that resolution of these conflicts will be achieved via negotiations between DOD and NASA on a case-by-case basis, possibly with some mediation by a third party within the executive branch. Such negotiations may succeed in satisfying both DOD and NASA, but could fail to account for the interests of all relevant parties, especially those in the private sector.

Such negotiations could also lead to programmatic redundancies. In the absence of central authority or leadership, DOD and NASA may discount potential redundancies and simply continue to promote those projects that best address their own organizational requirements. As a result, hard space transportation policy choices may go unmade.

Many analysts and policymakers have proposed a central authority as a way to better account for all interests and avoid programmatic redundancies. In the Bush Administration, for example, Vice President Quayle was given considerable authority over space transportation policy. It is not clear, however, that the imposition of a central authority has remedied these problems in the past, or that it will necessarily do so in the future. Given the considerable bureaucratic and political weight of DOD and NASA, competing organizational interests could potentially override the wishes of a central authority. Furthermore, existing legal and organizational obstacles may prevent the level of interagency and private sector coordination sought by a central authority.

The recent controversy between DOD and NASA over NASA's Med-Lite procurement may be emblematic of this latter problem. This controversy illustrates how interagency coordination can be precluded by current law, divergent interpretations of that law, and competing organizational interests. Therefore, although the NSTP calls on DOD and NASA to "combine their [ELV] requirements into single procurements when such procurements would result in cost savings or are otherwise advantageous to the government," achieving this level of interagency coordination may prove extremely difficult.

ISSUE 1b: *Potential conflicts and redundancies*

DOD and NASA have collectively proposed a sizable portfolio of new space transportation technology development programs. While this multitrack approach may reduce the overall risk of pursuing new space transportation systems, it may also lead to potential conflicts and redundancies and higher overall costs. For example, development of a commercially competitive EELV by DOD could undercut NASA's effort to commercialize a follow-on to the X-33 by reducing the incentive for private investors to fund a technically risky RLV.

If a low-cost RLV is developed, nonetheless, it may be difficult for the EELV program to achieve the long-term cost reduction targets set by DOD. At a minimum, the RLV will compete with the EELV for payloads, possibly attracting payloads away from the EELV. Were this to occur, it would reduce savings generated by the EELV program by offsetting or potentially outweighing any gains in production volume created by commonality within the EELV family.

As for NASA's dual-track RLV development strategy, the Agency believes that early X-34 test flights could positively affect X-33 development by steering it toward or away from certain technologies. Moreover, proponents note that the X-34 could generate significant benefits for the government, industry, and consumers of space-based services if its target of threefold cost reductions for launching small payloads are achieved.

Critics, however, have suggested canceling the X-34 program, arguing that it is geared toward developing an operational vehicle, not an experimental vehicle, and that its cancellation would not affect the technological success of the X-33 program.

There are other potential conflicts and redundancies. In particular, DOD officials are concerned that the Med-Lite vehicle might eventually compete with the EELV for medium payloads, thereby threatening the ability of the EELV program to achieve maximum launch cost reductions for DOD. In addition, NASA has proposed to phase in any newly developed RLV follow-on to the X-33 between 2005 and 2012 while continuing to fly the Space Shuttle in support of the International Space Station.

ISSUE 1c: *HLVs drive the EELV program*

DOD currently spends $1.6 billion of its $1.9-billion space transportation budget on its HLV program. Therefore, DOD has geared the EELV program toward achieving significant HLV cost reductions. DOD's focus on HLV cost reductions, however, ignores the need of U.S. launch providers to develop a commercially competitive launch vehicle in the hotly contested MLV market. While the EELV program may reduce MLV costs by as much as 10 percent, such a cost reduction would probably not help the EELV manufacturer recapture a significant portion of the global market for launch services. And without an increased share of the available market, DOD will receive little, if any, additional price reductions generated by larger production volumes.

On the other hand, the European Space Agency's (ESA's) development of the heavy-lift Ariane 5 suggests that significant HLV cost reductions may be commercially attractive. It is unlikely, however, that the heavy-lift EELV will be inexpensive enough to compete with the Ariane 5, even if it achieves a 40 percent cost reduction over the Titan IV.

ISSUE 1d: *RLV development*

NASA has pointed to its RLV development strategy as one example of its "new way of doing business." Outside of NASA, however, some have expressed concern over NASA's proposed RLV development strategy. In particular, industry officials are concerned that property and data rights issues, as well as the uncertainty surrounding the distribution of core RLV technology development funds, may slow or prevent RLV commercialization.

Other analysts and policymakers believe the X-33 program should be structured differently. Some critics have argued that the X-33 is being designed in the shadow cast by future requirements for the International Space Station, and that it would be better if NASA opted to fund fully an X-33 program that focuses solely on demonstrating single-stage-to-orbit (SSTO) technology. NASA officials believe the X-33 does focus on demonstrating SSTO technology, but contend that industry investment is appropriate because the successful development of a low-cost, commercial RLV will significantly improve the competitiveness of the U.S. space transportation industry, and because government space budgets are declining.

Others critics of the X-33 program structure have suggested a competitive fly-off among competing X-33 concepts, a strategy in which NASA has expressed some interest. Proponents of a fly-off believe that it would decrease the possibility of choosing the "wrong" technology and increase the likelihood of retaining competition in the domestic launch vehicle industry. Critics note, however, that a fly-off strategy would require larger near-term budgets than currently planned.

Another concern surrounding RLV development has been the role of DOD payloads and whether or not they will be used during the early testing of a commercial RLV. NASA and its commercial partners will need a sufficient number of payloads to both prove the reliability of RLV technology and attract potential investors. DOD officials, however, do not wish to repeat their negative experiences with the Space Shuttle and are, therefore, hesitant to contribute DOD payloads to the RLV until it is proven. Unless NASA and its industry partners can entice other payloads to fly aboard an RLV, DOD's reluctance could potentially drive up the price of launching payloads on the RLV.

ISSUE 1e: *SSTO?*

SSTO development entails significant technical risks. NASA has proposed a phased SSTO technology maturation program that periodically pauses along the way to determine the prudence of continuing. In the event the pursuit of SSTO is terminated at any point, NASA suggests that other RLV concepts (e.g., two-stages-to-orbit or TSTO systems) can then be considered and that new RLV efforts could possibly draw on past SSTO technology development efforts.

Some analysts and policymakers have taken issue with this approach, arguing that it grants too much upfront attention to the SSTO concept. They note that pursuing another RLV concept such as TSTO after investing significant resources in SSTO risks a suboptimal result that does not achieve the desired level of cost reductions.

Also, there has been some concern that NASA has not adequately defined its criteria for judging the success of the X-33 program. NASA, in conjunction with the Office of Science and Technology Policy and the Office of Management and Budget, has established criteria to support decisions in 1996 and 2000. Nevertheless, some analysts and policymakers are concerned that these criteria are insufficient and suggest that NASA provide Congress with a set of specific intermediate criteria for evaluating the success of the X-33 program on an annual basis. Such a requirement may, however, slow the development process.

Finally, although NASA has claimed that it must pursue block upgrades to the Space Shuttle if the government or industry decides in 2000 to forgo development of a commercial RLV follow-on to the X-33, there are other alternatives. For example, NASA could decide to extend SSTO development efforts, initiate TSTO development efforts, support development of a commercial TSTO, pursue block upgrades to the Space Shuttle, commission a new space transportation study, or reconsider alternative options already examined in past studies. Which alternative NASA chooses in coordination with its industry partners will depend on the progress made during the X-33 program, as well as the commercial prospects of an RLV.

ISSUE 1f: *Space Shuttle—beyond 2000*

As noted, NASA may decide in 2000 to pursue block upgrades to the Space Shuttle in order to ensure safe operations until 2020. Discussions with both NASA and industry officials reveal, however, that little planning for this possibility and little investigation into whether or not the industrial base will be able to support these upgrades are currently being done by NASA.

In its implementation plan, NASA has proposed replacing the existing solid rocket boosters (SRBs) with Liquid Fly Back Boosters (LFBBs) between 2007 and 2010. NASA claims that LFBBs would increase Shuttle safety, payload performance, and launch probability, and would also reduce annual Shuttle operating costs compared with SRBs. The implementation plan does not, however, outline any contingencies to address the significant impact that replacing SRBs with LFBBs might have on the solid rocket motor industry and the nation's continued ability to produce long-range ballistic missiles.

Finally, there remains the prospect of another Space Shuttle accident that results in the loss of an

Orbiter. Such a loss would have major repercussions for both the Space Shuttle and X-33 programs.

Fundamental Objective #2: U.S. Use of Foreign Launch Systems and Components

The NSTP encourages federal agencies to take advantage of foreign technologies in U.S. space transportation systems. It also limits the flight of U.S. government payloads to U.S. space transportation systems, in effect removing U.S. government payloads from the available international marketplace for launch services. In this, it follows past policy. In addition, the policy allows the launch of government payloads on foreign launch vehicles if they are made available on a no-exchange-of-funds basis and if they support cooperative scientific programs.

ISSUE 2a: *The use of foreign launch technology*

The use of foreign technologies in U.S. space transportation systems may improve the efficiencies of U.S. launch systems, assist U.S. access to space, and improve U.S. competitiveness in the international space transportation market. With the important exception of the Space Shuttle and its main engines, the United States has done relatively little launch system R&D since the 1960s. The use of foreign technologies in U.S. space transportation systems could reduce the amount of R&D now required of U.S. firms in efforts to improve the performance and reduce the costs of U.S. systems. Russian launch vehicles and related systems (particularly propulsion) have significant potential for commercial use. Russian hardware and space transportation skills can fill important gaps in U.S. capabilities. The United States might benefit from European space transportation technologies as well.

On the other hand, U.S. national security interests demand that the United States maintain a viable national launch capability and technology base. The use of foreign technologies might reduce the incentives for maintaining the domestic R&D that underlies that technology base.

The simple purchase of either vehicles or launch services appears to be less attractive than joint ventures, co-production of vehicles and/or systems, and analogous business arrangements, as ways of harmonizing these differing interests. For example, Aerojet and Pratt and Whitney, both U.S. manufacturers of liquid-fueled engines, are exploring ways in which to capitalize on the use of Russian liquid-fueled engines in U.S. vehicles.[6] U.S. launch operations experts have expressed interest in Russian and European methods to reduce operations costs. In its implementation plan, DOD has expressed openness to the use of foreign technologies in U.S. launch vehicles, but only under conditions that would protect the supply of critical components should foreign sources become unavailable. Each proposed technology insertion would be judged on a case-by-case basis.

Methods to protect component supply, such as stockpiling critical components or duplicating production lines in the United States would likely result in higher costs to the government, but might ensure that the United States will be able to fulfill its space-related national security needs in times of crisis. Officials of Arianespace have offered to sell the Ariane 5, or license rights to build it, to service U.S. HLV needs. Such an arrangement could substantially reduce the costs of building and operating a U.S. HLV.[7] However, building a vehicle under license might inhibit the development of new U.S. technology that could be used to improve the U.S. MLV fleet.

Experts disagree over the extent to which cooperation with the Russian government and industry on space projects would affect U.S. competitive-

[6] Michael A. Dornheim, "Aerojet Imports Trud NK-33 Rocket Engine," *Aviation Week and Space Technology*, Oct. 25, 1993, p. 29; and Jeffrey M. Lenorovitz, "Pratt Signs Accord with NPO Energomash," *Aviation Week and Space Technology*, Nov. 2, 1992, pp. 25-26.

[7] Ben Ionatta and Cheri Privor, "Arianespace's EELV Proposal Finds Little Favor," *Space News*, Apr. 10, 1995, p. 3.

ness and the retention of U.S. jobs. Some industry officials, for example, express concern that the United States could lose employment in the launch services industry if Russian technology were used extensively in U.S. launch systems. Others have argued that skillful incorporation of Russian technologies in U.S. systems could save taxpayer dollars in publicly funded programs like the International Space Station and boost U.S. international competitiveness in commercial programs. Greater competitiveness might generate new jobs in space transportation and space-related fields, partially or fully offsetting job losses due to the use of foreign technology.

Second-, third-, and fourth-tier launch system equipment suppliers appear to be most vulnerable to the extensive use of Russian technology in U.S. launch systems, especially those that now supply subsystems and parts for U.S. propulsion systems. Loss of critical skills in the lower tiers of the space transportation industrial base may, in some instances, adversely affect the nation's ability to maintain assured domestic access to space and reconstitute production of long-range ballistic missiles. Nevertheless, reducing the cost of access to space may well lead to more aerospace jobs as a whole.

Some observers worry that given the precarious state of the Russian economy and government, Russian equipment suppliers may not be able to sustain their ability to produce space goods and services.[8] Russian firms, recently privatized and undergoing massive restructuring, have experienced difficulties in moving to a demand-driven, market-oriented economy. Concern over the future ability of Russian firms to perform could be eased, in part, if Russian firms successfully demonstrate that they can produce goods and services on time and within the terms of cooperative contracts with the U.S. government and industry. The existing cooperative activities between NASA and the Russian Space Agency, especially with regard to construction and operation of the International Space Station, will provide considerable insight into the long-term viability of the Russian space transportation industry.[9]

The NSTP also allows the use of foreign launch systems to carry U.S. instruments and spacecraft on a no-exchange-of-funds basis when supporting cooperative programs with other countries. Examples of such cooperative use of non-U.S. launchers include the shipment of U.S. equipment to the Russian Mir space station aboard a Russian Spektr spacecraft launched on a Russian Proton launch vehicle in May 1995, and the earlier launch of the TOPEX/Poseidon spacecraft on an Ariane 4 in 1992. Such use can sharply reduce U.S. costs for science programs and may facilitate some projects that might otherwise not be flown, but could deprive U.S. launch providers of a few launch opportunities. The launching country gains by receiving access to data generated by the U.S.-built, or jointly built, instrument or spacecraft.

ISSUE 2b: *International trade in launch services*

In keeping with broader U.S. international trade principles, the NSTP seeks to achieve free and fair trade in launch services. However, as a result of the close connections between defense and launch system technologies, and the desire to achieve or retain autonomy in launch services, all spacefaring nations subsidize their launch services industry to some extent. Because the economic structure of each country is different, it is difficult to determine the true extent of the subsidy each extends to its launch industry. In addition, each spacefaring country generally reserves government payloads for its own launch systems. For example, in keeping with past U.S. policies, the NSTP requires that U.S. government payloads fly

[8] Judyth L. Twigg, "The Russian Space Program: What Lies Ahead?" *Space Policy* 10(1):19-31, 1994.

[9] U.S. Congress, Office of Technology Assessment, *U.S.-Russian Cooperation in Space*, OTA-ISS-618 (Washington, DC: U.S. Government Printing Office, April 1995).

on U.S. space transportation systems, except for well-defined cooperative programs.

Trade agreements with China and Russia, which are intended to manage the international market for launch services and reduce the impact of low Chinese and Russian prices on U.S. launch service companies, may also reduce international competition and raise the overall price of launch services. The United States first faced competition from non-U.S. launch service entities after ESA developed the Ariane launch system in the late 1970s. Specifically designed to carry payloads to geosynchronous Earth orbit (GEO), and marketed by the European corporation Arianespace, the Ariane system was designed and built on the premise that it would capture a significant share of the available world market in commercial payload launch services. Since the loss of the Space Shuttle *Challenger* in January 1986, Arianespace has garnered a dominant share of the international commercial payload market.[10]

During the late 1980s, China and Russia (then the Soviet Union) began to offer launch services on the international market, increasing the competitive pressure on the U.S. commercial launch services industry. Faced with growing competition in launch services, increasing concern that launch systems built in non-market economies would unfairly compete with U.S. launch systems, and pressure from U.S. satellite manufacturers to allow the launch of U.S.-built satellites on Chinese and Russian launch systems, the United States sought and obtained launch service agreements with China and Russia.

In addition to setting limits on the total number of Chinese and Russian launches within a specified period, the agreements attempt to establish rules by which the market will operate. The United States is able to exert influence over trade in launch services because it sells more satellites on the international market than any other country. Russia and China have signed trade agreements because the United States could severely restrict the international sale of U.S.-manufactured satellites launched on other countries' vehicles. The Office of the U.S. Trade Representative (USTR) is the U.S. agent in negotiating these agreements.

U.S. satellite manufacturers have begun to pressure the USTR to relax or do away with the existing restrictions on the number of Russian commercial launches allowed between now and the end of the century. They have been joined by U.S. partners of Russian launch companies, which would profit from relaxed restrictions. Existing and planned partnerships between U.S. and Russian companies are likely to complicate U.S. considerations of these agreements, making it much more difficult to assess overall benefits and drawbacks of changes in the agreements.[11] Relaxation of the U.S.-Russia agreement would make the launch services market more competitive. It might also undercut the ability of U.S. launch service providers to compete and indirectly raise the costs of space transportation services to the federal government.

Arianespace, which now commands the largest share of the commercial launch services market, may be more affected by a relaxation of the U.S.-Russia launch services agreement than U.S. firms. Although a relaxation of the agreement would increase the competitive pressures on U.S. launch companies not now associated with Russian companies (such as McDonnell Douglas, which markets the Delta MLV, and Orbital Sciences, which markets the Pegasus and Taurus SLVs), those companies launch payloads for the U.S. government and therefore would retain a strong core market for launch services. Lockheed Martin, which markets the Atlas ELV, also markets the Russian Proton

[10] Prior to the loss of *Challenger*, NASA actively marketed commercial launch services on the government-owned and -operated Space Shuttle. In August 1986, President Reagan issued a policy directive limiting the use of the Shuttle to payloads that required the unique capabilities of the Shuttle.

[11] Craig Covault, "Russian Proton Challenges Ariane," *Aviation Week and Space Technology,* Apr. 24, 1995, pp. 40-43.

through LKE International. Lockheed Martin intends to use the two vehicles to back each other up, should one be temporarily removed from service to correct a system failure.

ISSUE 2c: *Technology transfer and foreign policy objectives*

Cooperative ventures risk transferring domestic technologies that could be used to strengthen a competitor's position in the international aerospace market and to assist belligerent countries in developing the means of delivering weapons of mass destruction (nuclear, chemical, and biological weapons). Experts disagree over how effective means to prevent such transfer can really be, but present policy clearly moves toward loosening trade restrictions. For example, many items having to do with satellites and satellite technology have been moved from the U.S. Munitions List onto the Commerce Control List, effectively making it easier to trade in those items. Further loosening of restrictions could result in improved U.S. trade in space transportation technologies. On the other hand, the United States must also remain sensitive to the potential proliferation of missile-related technologies.[12]

U.S. cooperative agreements with other countries must conform with related U.S. obligations and treaties, such as technology transfer policies and the Missile Technology Control Regime (MTCR), which was developed in 1987 to limit proliferation of long-range delivery systems capable of delivering weapons of mass destruction.

Admittance to the U.S. satellite market has become a tool in encouraging adherence by China, Russia, and Ukraine to the MTCR. Russia and Ukraine have agreed to join the MTCR. The Clinton Administration believes that helping the Russian civilian space program stay as healthy as possible and capable of retaining its experts will reduce global proliferation of missile technology. China has declined to join the MTCR, but has agreed to abide by its restrictions. However, the United States has raised several issues of noncompliance with Chinese officials. On October 4, 1994, the United States and China agreed to "work together to promote missile nonproliferation through a step-by-step approach to resolve differences over missile exports."[13] The United States could levy sanctions against the Chinese launch company, including prohibition of satellite launches, if the United States found that the entity was selling missile-related technology to a country that did not previously possess such technology.

Fundamental Objective #3: The Use of Excess Ballistic Missiles

The NSTP reserves use of excess ballistic missiles for government payloads only, and only when their use results in cost savings to the government over the use of commercial launch services. Excess ballistic missiles can be used by the government for engineering tests and suborbital flights, but orbital flights that might compete with private launch services must satisfy tough conditions before they are allowed.

Some 650 long-range ballistic missiles will be made available by U.S. adherence to the first Strategic Arms Reduction Talks treaty alone. These missiles, and others to be retired under other treaties, could be used to launch government and commercial satellites into orbit. Even if the missiles themselves are not used, parts of the missiles and the tooling for building those parts could be useful to industry.

[12] U.S. Congress, Office of Technology Assessment, *Export Controls and Nonproliferation Policy*, OTA-ISS-596 (Washington, DC: U.S. Government Printing Office, May 1994).

[13] U.S. Department of State, Office of the Spokesman, "Joint United States-People's Republic of China Statement on Missile Proliferation," Fact Sheet, Oct. 4, 1994.

ISSUE 3a: *Unfair competition or market creation?*

The Clinton Administration's policy continues the Bush Administration's policy of tightly restricting the use of excess long-range ballistic missiles. Some analysts argue that making these missiles more widely available for use as space launch systems would not only save much needed government resources, but could also demonstrate the viability of new markets for SLVs. Others argue, however, that although such a scheme might save the taxpayers money in the short term, it might also drive commercial SLV vendors from the market, leaving the U.S. industry with no SLV producers in the long term.

There is a lack of data on how much it would cost to convert surplus ballistic missiles for new payloads, how useful these missiles might be for more delicate payloads, and how SLV providers might maintain their ability to develop new systems should converted ballistic missiles be priced below current SLVs. Those questions must be answered before the debate on how to use excess ballistic missiles can be resolved.

ISSUE 3b: *Russian excess ballistic missiles*

In contrast to American policy regarding surplus missiles assets, former Soviet Union firms are promoting a number of converted intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles for an assortment of commercial duties. Two already on the market are the Start-1 and the Rokot, derived from the SS-25 and SS-19 ICBMs, respectively.

Russia's use of its excess ballistic missiles as SLVs has not yet proven to be a viable commercial strategy. If Russia is successful in marketing its surplus ballistic missiles, however, U.S. SLV launch service providers will face international competition from Russian excess ballistic missiles, while the U.S. government will receive none of the benefits of selling its stockpiles.

Fundamental Objective #4: The Private Sector Role in Space Transportation Decisionmaking

The private sector is expected to play a crucial role in accomplishing many of the space transportation goals set forth in the NSTP and the supporting implementation plans. It is, for example, designated to be a source of: 1) significant funding in a fiscally constrained budget environment; 2) expertise to manage space launch activities more efficiently; and 3) innovative ideas and products in the design and development of future space transportation systems. Placing greater reliance on the private sector is in keeping with general trends that emphasize reducing government's responsibilities in areas in which the private sector might reasonably be expected to provide the desired goods and services.

But the private sector is not a monolithic entity with a single coherent view of space transportation needs or the goals outlined in the NSTP. While the principal prime contractors for space transportation are in general agreement on many aspects of the Clinton Administration's space transportation policy, they have different views about the implications of particular elements of policy. Additionally, some subtier firms are skeptical about the potential for the government to achieve the goals of the NSTP.

The willingness and, indeed, the ability of private sector firms to fulfill the roles suggested in the national space transportation planning documents depend in many instances on factors that possess a great deal of uncertainty and are difficult to estimate accurately (e.g., the size and character of the future commercial space transportation market) and that are highly dependent on actions by the government (e.g., the nature of any government-industry partnership). These facts raise several issues that Congress might wish to consider in evaluating the role that the private sector plays in implementing the Administration's policy.

ISSUE 4a: *Will the estimated market support policy goals?*

In the absence of a major increase in the government's space transportation budget, private sector investment is viewed as essential for the development and production of an RLV follow-on to the X-33 possessing the characteristics desired by NASA. But any private sector investment depends on the potential for sufficient return on that investment to make it attractive. The assessment of the size, character, availability, and relationship (potential overlap) of future space transportation markets is therefore critical to industry's attitude toward new launch vehicle development programs and government cost-sharing arrangements.

The current industry assessment of the space transportation market appears to be that the potential market for commercial payloads in the MLV class is by itself insufficient to entice enough private sector investment to build a future RLV capable of meeting NASA's needs.

Current analysis indicates that the government is likely to continue to be the largest single market for U.S. space transportation for at least the next 10 to 15 years. Expansion of the commercial market in areas such as communications and earth observation is probable, but the size and rapidity of such expansion is uncertain. A number of potential new markets, such as space manufacturing and tourism, are on the horizon, but the size and speed of development of these markets are uncertain. This uncertainty about future markets inhibits private sector investment.

Industry analysis indicates that the potential commercial market for small payloads may be sufficient to attract enough private sector investment to develop vehicles to meet both commercial and government needs for small payloads. The willingness of firms to invest in the X-34 program supports this conclusion.

U.S. industry sees little commercial need for heavy lift and views this as principally a government market. The private sector is unlikely to put much of its own funds in this area without strong government support. Some observers note, however, that Arianespace plans to replace its medium-lift Ariane 4 with the heavy-lift Ariane 5.

Such assessments imply that if the government desires an RLV replacement for the Space Shuttle, it will have to provide a significant amount of the funding—either through a direct development and procurement process or through some form of guaranteed business.

ISSUE 4b: *The nature of the government-industry space transportation partnership*

The NSTP and implementation plans stress the need for closer government-industry cooperation—what NASA terms a partnership. Government planners believe that a more important role for industry in decisionmaking is essential if industry is going to be asked to help finance much of the production of a future medium-to-heavy-lift RLV. There are, however, a number of questions about the nature of any new government-industry relationship and the possible implications of closer ties between the government and any particular firm.

There appear to be a number of advantages to closer cooperation between government and industry. One is a potentially more efficient and less costly management structure. Another benefit is more effective use of the nation's public and private sector space transportation industry's technical expertise and facilities. But closer cooperation raises serious questions about who decides what research topics to pursue, which efforts will be funded, who will own the technical data rights resulting from this partnership, and how these rights might be transferred if such transfer appears to benefit the government. These questions and many others will have to be addressed if a partnership is to be successful.

Each government organization appears to have different expectations for the government-industry relationship. The designated advocates of increased commercial participation are the DOT and DOC, but with little money and small staffs, these two Departments are likely to play a limited role. NASA needs private sector investment to build a new RLV. It is, therefore, interested in policies that will provide support for industry, as well as incentives for industry to invest. It has streamlined its program management, changed funding rules, and made its research staff available to industry.

DOD, in contrast to NASA, does not have the same perceived need for a new space launch vehicle to perform its missions. Its current capabilities are more costly and less flexible than desired, but they perform well enough to meet the Department's fundamental mission requirements. DOD therefore appears less concerned about developing a close partnership with industry than is NASA.

ISSUE 4c: *Risk management—striking the proper balance*

Uncertainties about the future space transportation markets increase the need for private sector firms to protect any investment against losses. With estimates on the cost of development and production of a future medium-to-heavy-lift RLV ranging from $6 billion to $20 billion, many in industry are supporting the concept of anchor tenancy (e.g., committing the federal government to purchase an agreed upon amount of launch services from commercial firms) as a means of encouraging industry to invest in RLV development and production. By providing a guaranteed market for a specific period, anchor tenancy would reduce investment risk for the private sector during the formation of a more robust commercial market. A recent example of a commercial anchor tenancy is McDonnell Douglas' agreement to develop a Delta III ELV in exchange for a commitment by Hughes Telecommunications and Space Co. to purchase 10 future launches.

There are a number of issues that must be addressed. One is that a program based on anchor tenancy might be considered a "lease-purchase" arrangement. This could make the arrangement problematic because current government accounting rules require that such an arrangement be recorded in the budget as if the government purchases the assets outright. The discounted value of the expected costs of space launch services would be recorded as budget authority when the contract was signed. Outlays would be recorded (scored) in proportion to the construction activity on the launchers, as if the government were building the system.

Other observers argue that there is a need for new thinking in anchor tenancy, particularly when the government is slated to be less involved in the development of goods and services that might come from the private sector. They argue that anchor tenancy might be successfully used if the situation is one in which there is little technological risk, the contractor is taking the risk of performance, the contractor is financing the project, and the contractor has design control. Competitive bidding to help establish the market assessment of risk is also important.

Several industry representatives have argued that the basis for an anchor tenancy arrangement needs to be established by April 1996, when industry must begin to commit significant funds toward the development of the X-33 technology demonstrator. Without this commitment, industry may still participate in the X-33 program, but will probably reduce its share of the investment.

Industry also argues that termination liability (e.g., requiring the government to compensate industry should the government cancel a launch contract for its own convenience) is essential for reducing the risk to the private sector of entering into a long-term launch service agreement with the government. Skeptics have argued that such arrangements amount to providing a "risk-free" environment for U.S. business. Still, termination liability usually does not provide for loss of future revenue, only for money already spent. Thus firms continue to risk the loss of future returns on the money invested and bear the opportunity cost of not having invested the money elsewhere, even if compensation for funds already spent is guaranteed.

ISSUE 4d: *Infrastructure*

Many analysts argue that significant launch cost savings might be realized through changes in launch operations and infrastructure. Some have suggested building new, more generic launch facilities. Many analysts indicate that important launch cost reductions are unlikely unless launch operations engineers and facility managers have a greater role in the design of future launch systems.[14] Efficient launch operations are key competitive advantages for both Arianespace and Russia. A future RLV may have a completely different launch infrastructure than that of ELVs.

Because of the importance of the impact of launch services and infrastructure to long-term government costs and commercial competitiveness, Congress may wish to pay particular attention to activities in these often overlooked areas. Questions of how future space transportation systems will operate and how such operations will save money in comparison with current operations might be key oversight issues.

ISSUE 4e: *Accommodating commercial needs*

Many in industry express concern over the extent to which development of new space transportation systems will be influenced by rigid government space launch and payload requirements rather than by accommodation of commercial space transportation competitiveness considerations. For example, although NASA has restructured its program management and made a number of procedural changes that can aid development, its program may still be best structured to produce an RLV that will serve the U.S. government's space transportation needs first—rather than producing a commercially viable vehicle that will also meet government needs.

Part of the problem is the NASA requirement to carry crews to and from the International Space Station. Another part of the problem is the inability to define what might be commercially viable. Some industry representatives have noted, for example, the need to design commercial vehicles to serve the GEO market. This might result in very different designs from those optimized for NASA's International Space Station mission. These issues will need to be resolved if the programs are to meet their objectives.

Additional Issues for Congress

Two important issues were not addressed by either the NSTP or its implementation plans, but warrant consideration by Congress. These are the preservation of long-range ballistic missile capabilities and the status of the lower tiers of the space transportation technology and industrial base.

ISSUE 5: *Preservation of long-range ballistic missile capabilities*

The U.S. Navy plans to procure the last long-range ballistic missile in the strategic nuclear arsenal in 2005. No plans currently exist to produce any additional missiles after that time. Without producing missiles, however, the United States' ability and capacity to design and produce long-range ballistic missiles will deteriorate unless significant efforts are made to preserve them.

Both the U.S. Air Force and the Navy have preservation programs underway, but they are limited to a small set of critical components. Solid rocket motor technology may be particularly threatened. At present, all U.S. long-range ballistic missiles use solid rocket motors. If both the EELV and RLV designs use only liquid-fueled engines, and if liquid-fueled boosters replace the Space Shuttle's solid rocket motors, the market for large solid rocket motors in the United States may all but disappear.

ISSUE 6: *The invisible lower industrial tiers*

Current policy focuses on the large prime contractors, but there is more to the U.S. space transportation industry than just those firms. Hundreds of smaller firms provide subsystems and components, to the extent that about 50 cents of every procurement dollar flows down to these lower tiers of the industry.

[14] See U.S. Congress, Office of Technology Assessment, *Reducing Launch Operations Costs: New Technologies and Practices*, OTA-TM-ISC-28 (Washington, DC: U.S. Government Printing Office, September 1988).

OTA found that many of the lower-tier firms are pessimistic about their chances of survival. They believe that the government is not committed to the actual completion of new launch vehicles, and that research and development money will not find its way past the prime contractors.

Congress may wish to consider what the chances are that some of these lower-tier firms might be forced out of business, and what effect that is likely to have on the United States' ability to compete in the international market. If all the companies that produce a particular component or material critical to the space transportation industry go out of business because of lack of funds from the upper-tier firms, it could be very difficult and expensive to regain the capability to produce that component again.

CRITICAL DECISION POINTS

Each of the space transportation policy implementation plans was accompanied by an idealized timeline. While each department and agency was careful to say that the timelines were not set in stone, they do provide policymakers with some sense of the important decisions that await them and some of the hidden problems they may face in a few short years. Table S-2 lists some of the more critical decision points and their potential implications. Changes in political leadership, new space program goals, stretched out or terminated programs, unforeseen technical difficulties, and launch failures are just a few events that could dramatically alter the timing of these important decisions.

TABLE S-2: Critical Decision Points and Their Possible Implications

Date	Decision or event	Possible implications
1995	Corporate investment strategies for X-33 and X-34 development programs must be formulated	Corporate evaluation that government programs are unlikely to transpire as advertised could result in inadequate corporate Investment, creating a self-fulfilling prophesy.
1996	Down-selection for Phase II of X-33 single-stage-to-orbit demonstration vehicle	Industry participation in Phase II may require early government commitment to and legislative action on cost and risk sharing on the follow-on operational RLV. This is four years before NASA's specified 2000 decision on Space Shuttle upgrades (see below). Contract winner has an advantage for production of follow-on RLV unless other companies invest in their own competitive vehicles or the contract winner fails to meet program performance and cost objectives
1998	Down-selection to one EELV producer	Contract winner will develop family of medium-to-heavy vehicles for DOD, perhaps consolidating U.S. ELV business to one firm Med-Lite winner, however, may compete at lower payload range
1999	X-34 RLV demonstration vehicle fight tests are completed	A successful X-34 producer could potentially dominate the SLV market if significant per flight price reductions are achieved, U.S. government costs for SLVs drops New markets may develop for LEO light satellites if X-34 producer drastically lowers per flight prices
2000	Government decision required to pursue either a manned RLV variant or major block upgrades to the Space Shuttle	A premature decision to develop a manned RLV could result in a less-than-revolutionary vehicle Spending on major upgrades to the Shuttle could indefinitely postpone RLV development to the detriment of government launch expenditures and U.S. competitiveness in the commercial launch market
2000+	Corporate decision to build a commercial RLV	Size of government market and government commitment to RLV producer may lead producer to focus exclusively on government needs, at the expense of capturing and creating commercial markets Alternately, RLV producer may choose to construct two vehicles or a single vehicle with optional strap-on boosters to accommodate heavy government payloads and medium commercial payloads.
2001	Medium EELV becomes operational	A maximum 10-percent cost savings from new MLV improves U.S. position in the commercial market, but not enough to hold off Russian and Chinese competition, To ensure success of its EELV program, DOD may avoid early participation on RLV flights, limiting the customer base for potential RLV investors
2001/2	Trade agreements with Russia/ China expire	Unless new agreements are negotiated, U S launch providers find themselves at a severe pricing disadvantage. Without an RLV or greater than expected savings from a medium EELV, launch providers may find themselves unable to compete in the commercial market
2005	Heavy EELV becomes operational	A maximum 40-percent savings on new HLV results in substantial cost savings to the government Potential for the development of a multipayload version, like the Ariane 5, for limited, expensive commercial use
2005	Limited RLV fights commence	RLV begins direct competition for flights with the Space Shuttle, the EELV family, and other ELVs.
2005	Last of the current generation of long-range ballistic missiles IS produced	Lack of development or production programs may result in loss of ability to make new ballistic missiles without significant startup costs and delays Move of industry to all liquid-fueled boosters on the Space Shuttle, EELV, and future RLVs would all but eliminate domestic production of large solid rocket motors
2012	International Space Station IS scheduled to cease operation just as a manned RLV replaces the Space Shuttle or block upgrades of the Shuttle commence	One of the few planning goals identified for the RLV IS its ability to deliver passengers and cargo to the space station orbit. Life extension of the International Space Station seems likely, especially if operations are passed to a commercial venture

SOURCE Off Ice of Technology Assessment, 1995