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2001

SPACE LAUNCH INITIATIVE:
A PROGRAM REVIEW

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES

ONE HUNDRED SEVENTH CONGRESS

FIRST SESSION

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June 20, 2001

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SPACE LAUNCH INITIATIVE: A PROGRAM REVIEW

WEDNESDAY, JUNE 20, 2001

House of Representatives,

Subcommittee on Space and Aeronautics,

Committee on Science,

Washington, DC.

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The Subcommittee met, pursuant to call, at 2:10 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Dana Rohrabacher [Chairman of the Subcommittee] presiding.

Chairman **ROHRABACHER.** I call the Subcommittee to order and without objection, the Chair will be granted the authority to recess this Committee. And hearing no objection, so ordered. Today, we will examine the Space Launch Initiative at a program level. The significant programmatic changes that have occurred since NASA introduced the SLI program earlier last year, warrant a more detailed review by this Subcommittee. And that is why we have asked the program manager to testify. Nobody is likely to be more versed in the SLI program than the individual we have asked to answer to NASA headquarters.

And since its introduction, the SLI program has experienced a variety of contortions and constantly changing performance goals. After years of failed efforts, I believe we must begin to peel back the layers of the space launch initiative to ensure that it will help us realize the promise of affordable and reliable space transportation, which is, of course, the purpose of the Space Launch Initiative.

This Subcommittee has long-supported high-risk technology ventures with the hope of achieving cheap and better access and more reliable access to space. Significantly reduced launch costs will remove a major barrier for conducting scientific and commercial space missions. Even in the face of significant setbacks and the pursuit of second generation reasonable launch vehicle development, this Subcommittee recognizes the vast value or, say, the important value of the continuing investments in the space transportation area.

If the Space Launch Initiative is to become a cornerstone in America's foundation for low-earth orbit development, then NASA must make the goal of reducing the cost of getting into space the highest priority for the Space Launch Initiative and provide constant oversight of the major program's phases.

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Currently, NASA has configured the Space Launch Initiative to develop generic and pre-competitive technology, a critical first step in developing a next generation launch vehicle. The Agency has resisted settling on a final vehicle concept at this early stage. This bottoms-up approach is a new way of doing business in the space launch arena and it involves several risks. We can expect to see the program continue evolving as NASA learns from the technologies and learns which technologies work and which ones don't. Nevertheless, the Space Launch Initiative still gives me cause for concern.

There are—and, you know, are there going to be enough flight demonstrators funded by the Space Launch Initiative? Is the SLI predicated on the assumption that we are going to fully privatize the government's earth-to-orbit space transportation needs? And is the Space Launch Initiative a shuttle replacement or an upgrade program disguised as a generic technology program?

I support the Space Launch Initiative so long as we are able to answer these and other questions of import to the launch community. We have a distinguished group of individuals who have made space launch a vital area of their own careers. And with their help, we hope to address the many issues that are before us today.

And before we recognize our Ranking Member, I would like to—three votes. I would suggest—agreement, that you have your opening statement and then we report to break and come back immediately after for the testimony of the witnesses. And then I would now yield to our ranking—distinguished Ranking Member, Bart Gordon of Tennessee, for his opening statement. We will then have a recess until immediately after the final vote.

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[The prepared statement of Mr. Rohrabacher follows:]

OPENING STATEMENT OF CHAIRMAN DANA ROHRABACHER

SUBCOMMITTEE ON SPACE AND AERONAUTICS

Today we will examine the Space Launch Initiative at the program level. The significant programmatic changes that have occurred since NASA introduced the SLI Program early last year warrant a more detailed review by this Subcommittee. This is why we've asked the program manager to testify. Nobody is likely to be more versed in the SLI Program than the individual who has to answer to NASA headquarters. Since its introduction, the SLI Program has experienced a variety of contortions and constantly changing performance goals. After years of failed efforts, I believe we must begin to peel back the layers of SLI to ensure that it will help us realize the promise of affordable and reliable space transportation.

This Subcommittee has long supported high-risk technology ventures with the hope of achieving cheap and better access to space. Significantly reduce launch cost will remove a major barrier for conducting scientific and commercial space missions. Even in the face of significant setbacks in the pursuit of second generation RLV development, this Subcommittee recognizes the value of continuing investments in the space transportation area. If SLI is to become the cornerstone in America's foundation for low-Earth orbit development, then NASA must make the goal of reducing the cost of getting to space the highest priority for SLI and provide constant oversight of major program phases.

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Currently, NASA has configured the Space Launch Initiative to develop generic, precompetitive technology a critical first step in developing a next-generation launch vehicle. The agency is resisting settling on a final vehicle concept at this early stage. This "bottoms-up" approach is a new way of doing business in the space launch arena and it involves several risks. We can expect to see the program to continue evolving as NASA learns which technologies work, and which ones don't. Nevertheless, SLI still gives me cause for concern. Are there enough flight demonstrators funded in SLI? Is SLI predicated on the assumption that we are going to fully privatize the government's Earth-to-orbit space transportation needs? Is SLI a Shuttle-replacement or upgrades program disguised as a generic technology program? I support SLI so long as we're able to answer these and other questions of import to the launch community.

We have a distinguish group of individuals who have made space launch a vital area in their careers. With their help we hope to address the many issues before us today.

Mr. **GORDON.** Thank you, Mr. Chairman. And good afternoon. I want to welcome our witnesses today and I look forward to your testimony. I think that most people would agree that space transportation is central to our Nation's ability to achieve its goals in space, whether those goals be scientific, commercial, defense-related, or focused on exploration.

We Americans are going to realize the potential of space. We need highly reliable and affordable transportation for both humans and cargo and however liability and affordability would be critical to keeping the Americans—keeping America's commercial launch industry competitive worldwide for the coming decades.

Last year, NASA unveiled its Space Launch Initiative, which is aimed at developing the technologies critical for such advanced space transportation systems. And just last month, NASA announced the first series of Space Launch Initiative contract awards. That is an encouraging development, but we should not underestimate the challenges that lie ahead.

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The Space Launch Initiative has set itself some very challenging goals, but just being—but just setting challenging goals doesn't guarantee the success of the initiative. The National Aerospace plane, the Advanced Launch System, the National Launch System, are all past examples of DoD and NASA space transportation programs that, for a variety of reasons, did not succeed.

Even the space shuttle fell far short of its original goals for cost and flight rate, although, it remains a technological marvel in the mainstay of the U.S. Human Space Flight Program.

More recently, NASA decided to cancel X–33 and X–34 reusable launch vehicle projects prior to their first flights. Nevertheless, I don't want my remarks to leave the impression that I don't think that NASA should undertake a space launch initiative. Far from it. This is an important undertaking for the Nation and I am encouraged by NASA's approach. However, I want to ensure that NASA and the Administration take the steps necessary for SLI to succeed.

Today's testimony by the GAO witness identifies some of the areas that NASA will have to pay attention to if it is to maximize the Space Launch Initiative's challenges for success. I would like to get NASA's reactions to the GAO findings. And, finally, it is clear that the outlook for a commercial launch market is much less rosy than it was projected even a few years ago.

I would like to know how sensitive NASA's SLI plans are to the commercial launch market projections and what NASA plans to do to minimize the impact of commercial launch market uncertainties on the government's ability to meet its own future space transportation needs. But we have a lot of material to cover and a vote coming up, so I will close and look forward to coming back and hearing our witnesses' testimony.

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Chairman **ROHRABACHER.** Thank you very much. Without objection, the opening statement of other members will be put in the written record so we can get right to the testimony after we return. And hearing no objection, so ordered. I also ask unanimous consent to insert at the appropriate place in the record, the background memorandum prepared by the majority staff for this hearing. Hearing no objection, so ordered.

HEARING CHARTER

COMMITTEE ON SCIENCE

SUBCOMMITTEE ON SPACE AND AERONAUTICS

U.S. HOUSE OF REPRESENTATIVES

Space Launch Initiative:

A Program Review

WEDNESDAY, JUNE 20, 2001

2:00 P.M.–4:00 P.M.

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I. Purpose

The hearing will examine NASA's Space Launch Initiative. Witnesses have been asked to address the agency's procurement practices and investments in key technology areas and processes for the development of new launch vehicle architectures that will increase the national launch capability.

The panel will include:

Mr. Dennis Smith is currently NASA's Program Manager of the SLI/2nd Generation RLV Program Office, where he has responsibility for developing program objectives and performance goals, implementing program requirements, determining resources, schedules and controls for program execution.

Mr. Allen Li is director, Acquisition and Sourcing Management at the U.S. General Accounting Office, and is responsible for leading GAO's NASA-related work and reviewing other areas such as tactical aircraft and battlefield communications.

Mr. Steve HoAE4eser is a space launch analyst who was involved in the early stages of the Defense Department's highly successful Single-Stage-To-Orbit (SSTO) Program, also known as the Delta Clipper Experimental (DC–X).

Mr. Tom Rogers is Chief Scientist of the Space Transportation Association (STA), and holds degrees in physics.

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2. Background

Access to Space

Since the beginning of the space age, people have traditionally sent payloads to orbit with an expendable launch vehicle (ELV). The process of launching an ELV involves discarding stages during the rocket's ascent into space. The last stage carries either a crew or payload/cargo capsule. These stages eventually fall back to Earth and usually burn up in the Earth's atmosphere. (Crew capsules contain heat shields and other re-entry systems that enable them and their occupants to safely return to Earth.) Thus, an expendable rocket is used only once. Because each rocket launch requires the creation of a new launch vehicle, ELVs are an expensive means of delivering payloads to space.

Engineers have long thought they could reduce the cost of access to space by developing a reusable launch vehicle (RLV), which would operate more like an airplane. After delivering its payload to orbit, an RLV would return to Earth, where it could be refueled and launched again. Thus, one would not incur the cost of building a new launch vehicle every time it was necessary to launch a payload into space.

In the 1970s, NASA began developing the Space Shuttle, the first reusable space launch vehicle. Unlike ELVs, which generally launched crew *or* cargo in a capsule separable from the main propulsion contained in the lower stages, the Space Shuttle combines crew, cargo, and main propulsion in a single vehicle. (The Shuttle's main fuel tank and two solid rocket boosters that help it achieve orbit are separable from the main vehicle.) Moreover, in addition to merely getting to orbit, the Shuttle must be capable of rendezvousing with other spacecraft and supporting human operations in space for several days. This makes the Space Shuttle a very complex and flexible spacecraft. Unfortunately, the added cost of that complexity and flexibility exceeded the savings engineers sought in making their launch vehicle reusable. Currently, it costs about $10,000/lb to launch a payload to space aboard the Space Shuttle, which is more expensive than the ELVs it was meant to replace. Where engineers seeking to develop RLVs had wanted the space-equivalent of an efficient cargo-hauling semi, the Space Shuttle might be thought of as the space equivalent of a recreational vehicle, which can haul a lot of mass but not efficiently transport a lot of cargo.

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By the late 1980s, the Department of Defense's Strategic Defense Initiative Office, which later became the Ballistic Missile Defense Office (BMDO), determined that neither the Shuttle or existing fleet of ELVs would meet its needs. BMDO renewed efforts to develop a low-cost, reusable launch vehicle. There were several ways BMDO theorized it could attack the problem of achieving cheap access to space. First, it could simplify the design of the launch vehicle, principally by separating the crew and cargo. (The need to keep people alive in space and the unwillingness to take many risks during the launch and reentry portion of a mission require a variety of multiply redundant and complex spacecraft systems that are costly, and unnecessary for unmanned vehicles.) Second, it could introduce new technologies that would make the launch vehicle more efficient. Third, it could develop new procedures and technologies for use in the ground-based portion of preparing a space launch vehicle and its payload for flight. In the early 1990s, BMDO developed an experimental rocket known as the Delta Clipper-Experimental (DC–X), which conducted a successful series of flight tests demonstrating that a small number of people, using the latest off-the-shelf technology could prepare and launch rockets faster and cheaper. (It was notable that the DC–X did NOT seek to demonstrate many new technologies for use in the launch vehicle itself.)

In 1994, the Clinton Administration released its National Space Transportation policy, giving NASA the leading responsibility for developing RLVs. BMDO transferred the DC–X to NASA, and DOD focused its space launch activities on marginally improving expendable launch vehicles, upon which it relied to place its uncrewed payloads into space.

Where DOD was focused on reducing the cost of getting payloads to orbit and had concentrated on simple vehicle designs and improved ground activities, NASA sought to develop new technologies for use in the launch vehicle itself. NASA re-designed the DC–X (replacing metal tanks with composite tanks, for example), dubbed it the DC–XA and successfully flew several missions before destroying the vehicle during a landing accident. Additionally, NASA started the X–33 and X–34 programs to develop even more advanced technology for use in the launch vehicle itself. These included thermal protection systems, rocket engines, and structures, such as oddly-shaped fuel tanks made out of lightweight composite materials instead of metal.(see footnote 1) Unfortunately, both programs fell behind schedule, experienced significant cost growth, and failed to reach major performance milestones, including a first flight. NASA subsequently canceled them after spending roughly $1.3 billion.

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Space Launch Initiative

In 2000, NASA went back to the drawing board and created the Space Launch Initiative (SLI). NASA intended to spend $4.5 billion between FY 2001 and FY 2005 to develop a "2nd Generation Reusable Launch Vehicle" that would meet NASA's 21st century space launch needs. (At this point, NASA decided that the Space Shuttle was the "1st Generation Reusable Launch Vehicle.") Unfortunately, NASA's 21st century space launch needs seemed to change continually. For example, NASA presented SLI as a generic technology development program with a range of applications for non-NASA missions, such as simply placing unmanned payloads in orbit at the lowest-possible cost. NASA expects such a vehicle to be privately-owned and operated and to meet the bulk of U.S. commercial, civil, and military needs for access to space. Conversely, NASA also discussed SLI as a shuttle-replacement program intended to meet NASA's human-space flight needs. The private sector, however, has no need for such complex—and costly—launch vehicles. Thus, NASA's desire to develop a Shuttle replacement conflicts with its desires to develop a low-cost RLV and depend on the private sector for its human spaceflight needs.

Reorganizing SLI into a Technology-Focused Program

In developing the Shuttle and X–33, NASA started with a particular design and then sought to develop the technologies necessary to realize that particular design. This past spring, NASA reconfigured the SLI Program by employing a new strategy that emphasizes development of launch vehicle component technologies, as opposed to starting with a launch vehicle concept. NASA's new focus is to raise the technology readiness levels (TRL) of "high-risk" technologies to determine what kind of vehicle might be built. In short, SLI's "bottoms up" approach is the opposite of the "top-down" approach taken in the X–33.

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This does not mean that NASA is simply developing component technologies in isolation from one another, however. Simultaneous with its technology activities, NASA is studying various "launch architectures" built around a specific vehicle concept. It hopes to conduct these architecture studies in parallel with its technology development activities so that the two processes will benefit one another. The agency also expects to narrow the range of possible launch architectures to two or three by 2003 so that it can begin designing specific launch vehicles.

This technology "bottoms-up" approach identifies ten major technology areas (TA) that, when integrated, will enable NASA to decide whether to initiate full-scale development of a new launch vehicle beginning in 2006. The ten technology categories range from system engineering and risk reduction to flight demonstrations of experimental systems. NASA believes that some technology demonstration proposals from industry have strong synergy with other technologies that support non-SLI programs such as launch vehicle /International Space Station rendezvous and docking operations. In March, NASA awarded contracts to 22 companies for work in each of these ten technology areas. (Summarized in the appendix.)

NASA also has reworked its set of launch vehicle technology design requirements in accordance with the new strategy. These requirements are intended to guide the systems analysis and engineering phases of SLI and are divided into primary and secondary categories. The primary set of requirements captures existing NASA-unique mission needs concerning International Space Station re-supply, crew safety, and cost reduction in launch services. Secondary requirements includes theoretical NASA-unique missions—such as rendezvousing with a Mars orbiting vehicle—and "evolutionary growth paths" for enabling future commercial development of space and supporting future military launch needs. NASA intends to study the tradeoffs between primary and secondary requirements with an eye towards establishing an optimal mix of primary requirements. However, the criteria by which these tradeoffs will be assessed remain unclear.

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Current Structure

The SLI budget request for FY 2002 totals $475.0 million, which is divided into five major investment areas: (1) Systems Engineering and Requirements Definition, (2) RLV Competition and Risk Reduction, (3) NASA Unique Systems (4) Alternative Access to Station and (5) Future X/Pathfinder.

1) Systems Engineering and Requirements Definition establishes the program direction and determines plans and budgets for new launch vehicle systems.

2) RLV Competition and Risk Reduction is designed to raise the technology readiness levels of RLV technologies under review.

3) NASA Unique Systems concentrates on developing and demonstrating the designs, technologies and systems level integration issues associated with government unique space transportation needs.

4) Alternative Access to Space (which was not included in the initial SLI procurement awards) seeks to take advantage of all U.S. launch systems and utilize then for ISS re-supply.

5) The Future X/Pathfinder program objective is to flight demonstrate advanced space transportation technologies by flight-testing.

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3. Issues

NASA has often been criticized for focusing on developing new technologies for optimal vehicle performance. By designing for maximum vehicle performance, NASA may lose sight of more mundane issues such as reliability and operability. Operability and reliability, however, may play a greater role in determining the final cost of an RLV than performance. Engineers sometimes describe the high-performance space shuttle as a formula 1 racer. They worry that by focusing on building a better formula 1 racer, NASA's past RLV efforts have ignored the need for more reliable, albeit less high-tech, transportation to space. SLI's "bottoms-up" approach to technology and its decision to avoid prematurely selecting a final design may allow NASA to pursue operability and reliability objectives in a 2nd Generation RLV. NASA's space programs traditionally do not adopt this model of generic technology development, but its successful aeronautics programs historically have.

NASA must also reconcile the contradictory goals of meeting its human space flight needs, reducing the cost of getting payloads to orbit, and depending on the private sector to develop, finance, and operate its spacecraft. If NASA is the only customer for privately-owned and operated spacecraft carrying people into space, there may be no advantages in a privately-owned and operated spacecraft. Conversely, if NASA excessively focuses on meeting its human spaceflight needs without regard to commercial realities, any RLV that results from the SLI may not be commercially viable. In that event, SLI's benefit to the country would be limited to any impact the program had on NASA.

Additionally, there are no guarantees the recent SLI procurement awards will produce hardware that ever flies in space. NASA must not permit the study phases captured within the 2nd Generation RLV Program to overshadow the need for delivering tested, demonstrated, and validated hardware. Too often, generic technology development programs never leave the laboratory and are never practically applied in space. The consequences of failure in this case will only extend U.S. dependence on the costly Space Shuttle for human spaceflight and less-than-ideal ELVs for non-crewed payloads. Constant oversight of major program phases will be the key in ensuring program success.

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4. Questions

1) What is the process for determining the top level requirements and program goals for the Space Launch Initiative?

2) How does NASA balance its unique needs in the area of Human Spaceflight with the commercial and

military need for low-cost, reliable access to space?

3) Which has greater weight in determining SLI's direction: replacing the shuttle or reducing the cost of placing payloads in orbit?

4) What was the rationale behind NASA's decision not to select the X–33 and X–34 experimental vehicles for flight demonstrations in the 2nd Generation Reusable Launch Vehicle Program?

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Chairman **ROHRABACHER.** And, lastly, I request unanimous consent that the written testimony of Sam Venneri be placed in the record for this hearing. Hearing no objection, so ordered.

[The prepared statement of Mr. Venneri follows:]

PREPARED STATEMENT OF SAM VENNERI

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Mr. Chairman and Members of the Subcommittee:

Thank you for this opportunity to provide you with an overview of the revitalized commitment to innovation and technology development within Aerospace Technology Enterprise.

The Goals and Objectives of this enterprise reflect the national needs and sustain the Agency's dedication to the advancement of technologies that contribute to national security, the public good and the quality of life. Our four Strategic Goals: Revolutionize Aviation, Advance Space Transportation, Pioneer Technology Innovation, and Commercialize Technology provide an integrated blue print to prioritize our investments and achieve what is not possible today. Today, I will focus on the Advance Space Transportation Goal and the Integrated Space Transportation Plan. I am very excited about the Agency's vision to revolutionize the Nation's space transportation systems. This vision is being realized through an evolutionary, phased approach embodied within the Integrated Space Transportation Plan and the Space Launch Initiative. We recognize that privately owned and operated domestic launch vehicles lofting NASA payloads on a regular basis is the right strategy to free up the agency's resources for scientific pursuit on the new frontier. Currently, NASA relies on U.S. commercial expendable launch vehicle services to meet the Agency freeflyer primary payload requirements. As NASA continues to expand the limits of human exploration and establish new standards for the full time presence of humans in space, the need for a safer and lower cost access to space must be developed. The assurance of reliable and affordable access to space is a fundamental goal of this Agency, and is directed by the United States' space policies. In August 1994, the National Space Transportation Policy called on NASA to pursue technology development and demonstration efforts to support future Government and private sector decisions on the development of an operational, 2nd Generation architecture reusable launch vehicle by the end of the 1990s. In addition, NASA was instructed under the Civil Space Transportation guidelines, to maintain the current Space Shuttle system until a replacement becomes operational. This guidance was reinforced in 1996 in the National Space Policy. As the lead Agency for research and development in civil space activities, NASA has passionately accepted the challenge or improving the nation's civil access to space. Building upon the successes and the failures of our recent partnerships and technology demonstrator programs, NASA and its industry and academia partners have developed the Integrated Space Transportation Plan (ISTP). This plan is the result of the dedication of numerous individuals within NASA, industry, Department of Defense and academia. It was not developed easily or quickly. To enable innovative and revolutionary changes in how NASA meets its launch needs, we were forced to make extremely difficult decisions. We determined that some programs, though successful within their respective technical areas, did not support this new plan and were terminated.

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The comprehensive approach outlined in the Integrated Space Transportation Plan provides the Agency with a single integrated investment strategy for all its diverse space transportation efforts. Investments in a sustained progression of research and technology development initiatives will enable us to realize our vision for the next generations of reusable launch vehicles. The ISTP describes the technical roadmaps and funding for the following: near-term Space Shuttle safety investments, Space Launch Initiative (also referred to as the 2nd Generation RLV) in the mid-term, far-term technology investments for the 3rd Generation RLV and beyond.

America's Space Shuttle is the 1st Generation RLV and it continues to provide our Nation with an unequaled capability. However, the Space Shuttle requires a significant portion of the Agency's resources to operate and maintain. The focus of ISTP will be to enable NASA to meet its launch needs on commercially competitive, privately operated vehicles near the beginning of the next decade. Until that occurs, the Space Shuttle is NASA's primary launch vehicle for access to the Space Station and missions that require human interaction. It is essential that we continue to ensure its safe operation. Therefore, Space Shuttle safety investments are the first element in the ISTP.

The second element and main focus of the ISTP is the Space Launch Initiative (SLI). SLI is the highest priority new initiative within the Agency. Also known as the 2nd Generation RLV Program, SLI provides the catalyst for NASA and its partners, including the Department of Defense, to explore new space transportation architectures. NASA's strategic goals for a next generation RLV are to reduce the risk of crew loss to approximately 1 in 10,000 missions while lowering the cost of delivering payloads to low-Earth orbit to less than $1000 per pound. The long-term vision is to have a commercially competitive vehicle operational around the beginning of the next decade. In the interim, SLI's Alternate Access to Space Station initiative seeks to enable demonstration of alternative U.S. launch systems to the orbiting laboratory.

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The third and final component within ISTP is the technology and research that will enable America to maintain its leadership into the foreseeable future. The 3rd Generation RLV technologies and beyond have the potential to enable routine access to space and provide airline-like operations along a vastly enlarged highway to space.

The Space Launch Initiative plans to invest approximately $4.85 billion from FY 2001 to FY 2006. This recent increase in funding outlined in the President's FY 02 Budget Blueprint reinforces the Administration's commitment to maintaining our position as the world leader in the exploration of space. The Space Launch Initiative is a technology development program designed to reduce the technical and programmatic risks and cost uncertainties associated with the development of a next generation RLV. The program employs rigorous systems engineering and integration methodologies to ensure that every investment contributes significantly to the overall strategic goals and can be efficiently applied to competing industry concepts. By mid-decade an informed decision to go forward into full-scale development, with at least two competing full-scale RLV architectures will be made. It is fitting that the "Blueprint for New Beginnings" coincides with the dawn of a new millennium. That plan clearly acknowledges that transitioning launch services and vehicles to the private sector is key to opening new trade routes and advancing human knowledge in the 21st century.

SLI is an agency-wide effort, with significant involvement from all NASA Centers. As Associate Administrator for the Aerospace Technology Enterprise, I will ensure unique capability and expertise within the Agency will be brought to bear on this initiative to successfully achieve the ambitious goals established for our future space transportation systems.

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Chairman **ROHRABACHER.** And we will now recess until—and if what could do is vote on that last—the third one and then come back here immediately, we will start as soon as we get done with that vote. So this Committee is now in recess. It will probably be about 15, 20 minutes.

[Recess]

Chairman **ROHRABACHER.** The Subcommittee will come to order. We have a distinguished Panel of aerospace experts with us today and to help us review NASA's Space Launch Initiative. And I would ask you all to try to summarize your testimony into 5 minutes. If you give us 5 minutes of condensed testimony and put the rest in the record, that is going to help this hearing out a lot and we will get to a dialog which I think is a much more valuable use of our time than just listening to a lecture. So we would hope that you could condense your testimony to 5 minutes for us.

And our first witness is Dennis Smith, NASA's Program Manager for the Space Launch Initiative and Second Generation Reusable Launch Vehicle Program. He is responsible for developing program objectives and performance goals and implementing the program requirements, determining resources, schedules, and control for the program's execution. Mr. Smith, you may proceed.

STATEMENT OF DENNIS SMITH, PROGRAM MANAGER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. **SMITH.** Thank you. I have submitted written comments and I am going to summarize those in my oral statement. It is a real pleasure to be here today to talk about the Space Launch Initiative, which we think is going to revolutionize space transportation. I like to always share with everybody, when I talk about the program, that this is an agency-wide program. We manage it centrally out of Marshall Space Flight Center, but every NASA center in the Agency has a key role and several of them have major leadership roles throughout the Agency. So it is a real honor to represent the program for not only the Agency, but for all the

NASA centers.

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We believe the Space Launch Initiative is a program about national leadership. In fact, the President's blueprint said, and I quote, "The NASA Space Launch Initiative provides commercial industry with the opportunity to meet NASA's future launch needs, including human access to space with new launch vehicles that promise to dramatically reduce cost and improve safety and reliability." You are going to hear a lot about safety and reliability throughout my comments.

The bottom line is, there is a lot of visions for NASA and for commercial industry, the scientific work and the commercial economic development. We look at SLI as the fundamental hard work behind those visions. We believe it will craft a new aerospace industry and it is more than just technology. We like to use the term risk reduction, because it is the development of those technologies, but it is also the development of the analysis tools, the design capability, bringing all the best talent together so that that technology can be applied to the best concept.

We think the bottom line behind this program is that it is supporting economic development of this country. Throughout our history, space transportation and technologies have always been enabling to our economic growth. We think for the next 25 to 50 years, space transportation will be that enabling transportation element. In fact, a DOT report showed that in—or, yeah, in 1999, commercial space business was about $61 billion, of which only a small fraction of that was the space launch piece. Five-hundred thousand jobs in this country enabled by the space transportation element, but the real jobs, the real money is in what you do in space.

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And we think that is really what we are about, is to give the ultimate customers the safety and reliability and affordability that they need. Those same customers have come back and they actually today spend more money on insurance than they do on launch costs to protect themselves unreliability. This program is focused on safety and reliability.

That is an infant marketplace. If we do our job, you are going to see an economic development of space that far exceeds that $60 billion. But it comes down to safety, reliability, and affordability.

That is why what we are doing is we are looking at a convert set of commercial and government requirements. We are not picking a solution until we have done our homework, until we have looked at all the trade studies, we have looked at all the elements. And we are integrating everything through a very rigorous process, taking into account all the lessons learned that we can find. We are defining the architectures over the next few years to really understand how we can develop a system that supports commercial needs, private ownership, and operation of launch vehicles, but can also perform the NASA mission.

We are trying to develop the knowledge base for informed decisions and we are trying to maintain competition, because that is where the innovation comes from. Today, we don't have a specific design point, and we did that on purpose. This is a bottoms-up program. We are doing all the trade studies. We are doing all the homework we need to define not only the architectures, but all of the risk reduction, all of the technology that feeds into that.

We also look at this program—it is a program of accountability and discipline. We have looked at every lessons learned you could find and we have built into this program inchstones. We have base periods. All the contracts we have awarded recently, the $800 million contracts we awarded to 22 companies, have a base period of less than 1 year so that we can see the parts of the program that are doing well and continue to fund them. The areas that do not do well, we can stop. This program's on-ramps and off-ramps to make sure that it stays linked and that we remain accountable.

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For instance, this fall, we are going to have a second cycle of procurements to fill in the gaps to find even more innovative ideas that we have already uncovered. This program is also a very hardware-rich program. We have looked at the numbers and it appears that about 85 percent of the funding is going for design and build and test of hardware. So it is very much a hardware-related program. We believe it is the fundamental work, that it is going to really make a difference. It is going to make this vision come true. We are really focused on safety. We are looking at what it takes to get inherent reliability and to develop a system that gets the rate up so that the cost can come down. Again, that we can do commercial missions and NASA's mission with the same architecture.

We are excited about the program. We invite, obviously, any comment and question that you might have for us today. I look forward to my colleagues' comments and your questions. Thank you.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF DENNIS E. SMITH

Mr. Chairman and Members of the Subcommittee:

Thank you for this opportunity to provide you with detailed information on NASA's vision for the future of this Nation's reusable launch vehicles—the Space Launch Initiative (SLI).

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Before describing the Space Launch Initiative in depth, I would like to take a minute and review the recent history of space transportation development that led us to structure SLI the way we have.

NASA's primary mission is to advance goals in science research, technology development and space exploration. The National Space Policy called on NASA to pursue technology development and demonstration efforts to support future Government and private sector decisions on the development of an operational, next generation, reusable launch system by the end of the 1990's. The primary technology demonstrator in this effort was the X–33, an attempt to demonstrate key technologies for a highly efficient, single-stage-to-orbit (SSTO) vehicle. As this Subcommittee knows, the X–33 program encountered a major set back when one of its two composite liquid hydrogen tanks failed while undergoing cryogenic-structural testing. Continued NASA investment in the X–33 was not determined to be the best use of SLI funds and the cooperative agreement expired on March 31, 2001. However, a number of valuable technologies applicable to future vehicles and important lessons were learned under the X–33 program and have been accommodated in the SLI plan. For example, the Space Launch Initiative employs a bottoms-up, rigorous systems engineering approach to define multiple competing architectures and links all technology investments to those systems. This approach will ensure that the program is resilient to technical and programmatic obstacles and is open to different and innovative technical approaches.

Concurrent with the technology demonstrator projects, NASA sponsored a series of U.S. aerospace industry led future launch studies to identify private sector options for reducing NASA's launch costs. These studies incorporated the X–33 and other space transportation development efforts being undertaken by NASA, the Department of Defense (DoD), and the aerospace industry. Within the framework of these studies, NASA pursued a set of evaluative efforts referred to as the Space Transportation Architecture Studies (STAS). NASA contracted with five industry teams to develop commercial space transportation architectures to meet the Agency's specific mission requirements. The Agency's safety, reliability, and cost goals as well as its unique mission needs were provided as guidelines to each team. In response to NASA's guidelines, the industry teams generated a diverse set of preliminary architecture options that met commercial needs as well as the NASA unique missions. The strategic integration of the commercial, and NASA unique and Department of Defense missions served as the basis for identifying the key risk reduction efforts that would need to be undertaken to reduce technical risks and cost uncertainty prior to full-scale development decisions. This process served as the basis for understanding Space Launch Initiative investment levels.

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Building upon the knowledge and experience gained through the STAS process and the technology demonstrators initiated in the 1990's, NASA, and its academic and industry partners developed the Integrated Space Transportation Plan (ISTP). The ISTP is a comprehensive investment strategy for achieving the Agency's strategic goals and objectives for a safer, more reliable RLV that is less expensive to maintain and operate than today's current Space Shuttle. This investment strategy encompasses all of the space transportation efforts including: near-term Space Shuttle safety investments: the Space Launch Initiative; and far-term investments the 3rd Generation of RLVs and beyond.

Today, I would like to focus on the Space Launch Initiative and the recent contracts awarded under NASA Research Announcement (NRA8–30). The Space Launch Initiative, also referred to as the 2nd Generation RLV program, is the center-piece of NASA's Integrate Space Transportation Plan. NASA recently announced the award of nearly $800 million of initial contracts with 22 companies. These efforts put us on the path to transition to a commercially competitive 2nd Generation RLV architecture around the beginning of the next decade. We believe this is a critical step to opening the space frontier and for the United States to lead the economic development and exploration of space. The Agency's strategic goals for the next generation of RLVs are to reduce the risk of crew loss to approximately 1 in 10,000 missions, while reducing the cost of payload to low Earth orbit to $1000.00 per pound.

The Space Launch Initiative is a program for NASA and our partners to investigate new space transportation architectures and invest approximately $4.85 billion between FY 2001 and FY 2006 for risk reduction and technology development efforts supporting at least two competing industry solutions. Through this initiative, NASA will reduce the technical and programmatic risks and cost uncertainties to enable informed decisions prior to proceeding to full-scale development of a 2nd Generation RLV around the middle of this decade. SLI is based upon four primary principles: Commercial Convergence, Competition, Assured Access, and the ability to evolve. Building upon this foundation, we have structured the Space Launch Initiative to be managed in three programmatic elements: 2nd Generation RLV Program, which includes a Systems Engineering and Requirements Definition Phase and a Risk Reduction Phase, NASA Unique Systems, and Alternative Access to Space Station.

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2nd Generation RLV Program

Within the Systems Engineering and Requirements Definition phase, we are developing the detailed technical and programmatic requirements necessary to link technology and business risk reduction efforts to competing architectures. We are working closely with external stakeholders to continually refine and redefine our requirements. This iterative process identifies where changes in civil requirements can enable NASA to make use of commercial capabilities and maximize the use of innovative, flexible and evolvable solutions. It is vital that we completely understand the full impact of requirements on the system to ensure that the overall architecture remains commercially competitive and affordable. This rigorous systems engineering process also serves as the basis for critical decisions regarding architecture options and system characteristics to assure the proper integration of the overall program. Detailed safety, reliability, performance and cost models of space transportation flight and ground systems are under development. These models will be used to perform the trade studies necessary to determine how proposed systems relate to long-term ISTP goals.

As part of the requirements validation process, we established an External Requirements Assessment Team (ERAT) in the fall of 2000. The team is led by Kenneth Szalai, former Director of the Dryden Flight Research Center, and will remain active through the life of the 2nd Generation RLV program. The ERAT team brings an on-going and independent review of SLI program and technical details and provides recommendations to senior NASA management regarding the program. Initial reviews, to be completed this fall, are focused on the program plans, technical priorities and engineering processes.

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The Agency has placed a high priority on reducing the technical and programmatic risks and cost uncertainties associated with the development of a privately owned and operated domestic 2nd Generation RLV. Specific risk-reduction activities include business development and planning, requirement trades, and technology investments and advanced development, including ground testing and flight experiments. Focused investment activities are driven by need of both Government and industry. Development of these capabilities will be consistent with the results of the Systems Engineering and Requirements Definition process.

The recently announced NASA Research Announcement NRA 8–30 resulted in the award of multiple contracts for specific risk-reduction activities and technology demonstrations including: highly reliable rocket propulsion systems; robust, reusable airframe technologies; advanced thermal protection systems; integrated vehicle health monitoring; and streamlined launch operations, among others. The program was able to create or maintain competition in key areas to assure the best, most innovative ideas going forward. We also structured each contract with a ten month base period plus options so that the program can be adjusted to assure complete connection between the architecture definition efforts and the hardware-oriented risk reduction efforts. All selections were negotiated to achieve the proper investment balance relative to the total systems engineering effort. The data rights, as specified under NRA 8–30, are to be retained by the Government.

In parallel to these contracted activities we have already begun to identify additional key areas for investment. For instance, additional focus on crew survival and escape concepts and technologies, advanced avionics and control systems, power and other important subsystems is required to complete the needed technology portfolio. We plan to release another round of procurements this fall to solicit industry for their ideas in these and other potential areas.

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NASA's rigorous systems engineering approach, validated by the ERAT, will continue to evaluate the integrated findings and validate the connectivity between goals, architectures, and risk-reduction activities. NASA will also conduct a Non-Advocate Review (NAR), with quarterly updates, to assure continued integration of the overall effort. The initial NAR will be completed by the end of September 2001. These reviews will also contribute to the identification of technical gaps that need to be filled.

To ensure the 2nd generation vehicle is commercially viable, NASA, in collaboration with industry, continues to evaluate and support multiple architectures that can meet the program goals of safe, reliable, and affordable space transportation. The Agency is committed to ensuring that the resulting architectures will enable NASA to converge civil requirements with commercial and military capabilities, and will not pursue vehicles that cannot meet program goals.

The Space Shuttle will be utilized as a "lessons learned" reference point. Although there is a separate Space Shuttle safety investment program under NASA's ISTP, the use of the Shuttle as a reference point will provide valuable insight on how SLI technologies could improve Shuttle safety. The Shuttle integrated operations models will be used as a reference point to assess the competing SLI architectures and will assist the Agency and selected contractors in assessing potential benefits of proposed and maturing technologies.

NASA continues to refine its cost credibility plan for ensuring confidence in, and consistency between, NASA, contractor, and independent vehicle cost estimates. This activity is aimed at reducing risk for the mid-decade competition and will include links to risk-reduction activities and cost uncertainty updates. We are also performing an integrated assessment of existing NASA and industry models and tools. A plan to initiate product delivery and tool integration will be finalized by a senior manager assigned to the integrated modeling effort and reviewed by both the External Requirements Assessment Team and Non-Advocate

Review group.

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NASA-Unique Systems

Many of NASA's unique mission requirements cannot be served by commercial vehicles alone, since they often require human presence in space. This effort focuses on developing and demonstrating designs, technologies, and system-level integration issues associated with NASA-unique transportation elements such as a Crew Transport Vehicle (CTV), cargo carriers, rendezvous and docking system, crew escape system, crew situational awareness, and other architecture elements not required for commercial application. NASA-unique elements will be integrated with commercially provided Earth-to-orbit launch vehicles and other potential commercial systems to form the complete architecture for a 2nd Generation RLV system.

NASA-unique requirements will ensure the Earth-to-orbit system will remain safe, competitive, and affordable within the larger architecture context. We have contracted with two industry partners to continue the definition and design of these systems in parallel with the 2nd Generation RLV Risk Reduction process to aid in overall integration.

NASA intends to investigate innovative approaches with broad trade studies and a wide variety of systems solutions to efficiently address NASA-unique requirements. We are taking extra measures to clearly define common interfaces between NASA unique systems with the commercial booster elements to maximize the flexibility of architecture designs and to encourage competition.

Alternate Access to Space Station

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A critical element of all 2nd Generation RLV architectures includes the ability to fly cargo to and from the Space Station including missions with autonomous rendezvous and docking capability. The Alternate Access to Space Station element of SLI seeks to enable demonstration of a domestic capability for augmenting the baselined international and space shuttle supply to the station. NASA continues to work with both established and emerging launch companies to enable and demonstrate this capability.

NASA will ensure proper integration with 2nd Generation RLV activities, synthesizing common elements and evaluating systems within the context of an integrated architecture. One example of this integrated approach is the NRA 8–30 award for the Orbital DART mission—an automated rendezvous and proximity operations (ARPO) experiment. This flight experiment was chosen to demonstrate state of the art targeting sensors, automated GN&C algorithms and advanced avionics required for autonomous ISS cargo delivery and support a key element of all 2nd generation RLV architectures.

Closing

We have made significant progress in understanding future space transportation requirements and promising technologies, but much remains to be done to take these advances to the next level to achieve the goals of enabling safe, reliable, and affordable space transportation systems. Additional investment is required to reduce business and technical risks and cost uncertainties to acceptable levels. Private industry will not and cannot make adequate investments in space transportation risk reduction and technologies. The aerospace industry is dependent on NASA pursuing technological advancements to maintain or improve U. S. competitive capability in the international launch market. The Nation's long-term investment through the Integrated Space Transportation Plan, and near-term investment through the Space Launch Initiative, is the necessary key to mitigate these risks, to encourage interest in private financing of future systems, and to open the door to the space frontier. The Space Launch Initiative, though not a vehicle development program, will enable NASA and the United States to make the right decisions on the selection, design and development of the next generation RLV.

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Chairman **ROHRABACHER.** Thank you very much, Mr. Smith. Our next witness is Allen Li, Director of Acquisition and Sourcing Management at the U.S. General Accounting Office. And he has done a great deal of fine work for this Subcommittee over the years and we are very appreciative of that hard work. He leads the GAO's NASA-related work, and, as I say, he has done a good job. Mr. Li, you are welcome, and you may proceed with your testimony.

STATEMENT OF ALLEN LI, DIRECTOR, ACQUISITION AND SOURCING MANAGEMENT AT THE U.S. GENERAL ACCOUNTING OFFICE

Mr. Li. Thank you, Mr. Chairman. I am pleased to appear before you today. My team of Noel Lance and Carlos Garcia is with me this afternoon. I will discuss two issues. Issue 1, the primary factors that contributed to the difficulties experienced by the X–33 and X–34 programs. And, Issue 2, the steps needed to avoid repeating those difficulties in the Second Generation Program/Space Launch Initiative.

Issue 1, the X–33 and X–34 programs experienced difficulties achieving their goals primarily because NASA did not successfully implement and adhere to a number of critical project management tools and activities. These include realistic cost estimates and risk management plans. Without relying on those important tools up front, NASA encountered numerous difficulties.

In the case of the X–33, compounding these difficulties was a decrease in the projected commercial launch market. This, in turn, lessened the incentive of Lockheed Martin and its industry partners to continue their investments.

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Developing realistic cost estimates and risk analyses is worthy of additional explanation. Neither the X–33 nor the X–34 program fully assessed the cost associated with developing new, unproven technologies. And neither provided for the financial reserves needed to deal with technical risks and accommodate normal development and delays.

In conjunction with implementing its new way of doing business by having less government oversight and contractor reporting requirements, NASA also set ambitious schedule and cost goals. But while doing so, as in the X–33 program, the Agency did not develop realistic cost estimates in the early stages. NASA officials considered the program to be high-risk, but wanted to "push the envelope" with a success-oriented schedule that did not allow for major delays.

But NASA's cost estimate did not include a risk analysis to quantify technical and schedule uncertainties. The cost estimate assumed that needed technology would be available on schedule and as planned. A risk analysis would have highlighted the probability of higher costs.

NASA's contribution to the program was fixed—with industry partners responsible for costs exceeding the initial agreement. A contingency plan on what to do if industry was unwilling to cover additional costs was not developed. This is because NASA assumed that the projected growth in the launch market would provide the necessary incentive to sustain industry contributions.

Issue 2, which was the steps needed to avoid repeating those mistakes. NASA has initiated actions to counter some of these problems. NASA is using a different acquisition and management approach. Projects funded under the program will be NASA-led, rather than industry-led. NASA also plans to provide greater insight and decision-making. For example, it will conduct more formal reviews and require levels of project documentation from contractors that vary depending on the risk involved and the contract value. Finally, NASA discouraged the use of cooperative agreements since these agreements are not effective vehicles for R&D efforts where large investments are required.

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While it is too early to tell if these measures will be sufficient, experiences with the X–33 and X–34 show that three critical areas need to be on NASA's radar screen. These relate to (1) adequate project funding and cost provisions; (2) periodically revalidating underlying assumptions by measuring progress toward achieving a safe and affordable space transportation system, and (3) effective and efficient coordination and communication required by many individual, but related, efforts.

I cannot overemphasize the importance of effective coordination and communication. Communication and coordination were not effectively facilitated in the X–33 program. In a report following the failure of the composite fuel tank, NASA's investigation team reported that the design of the tank required high levels of communication, but such communication had not happened.

Although NASA expressed concern during the design of the tank, Lockheed Martin did not request NASA's assistance. Because the effort was industry-led, as specified in the cooperative agreement, the contractor was not required to react to such concerns.

In contrast, NASA plans to have a more active role under SLI. However, effective communication and coordination will still be critical. In managing systems engineering and various risk reduction efforts by 22 different contractors, NASA will need for its insight to be highly coordinated. In addition, contractors proposing overall architectures will need to be aware of all risk reduction development activities related to their respective designs. And they will need to do so without the structure of a prime contractor-to-subcontractor relationship. Clearly, this will be a major challenge.

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One final point. The need for improvement and coordination and communication in NASA programs has been noted in the past. We, and NASA investigative teams, have found similar programs and other NASA programs, such as the Propulsion Module for the Space Station and the two failed Mars missions. SLI would benefit from a continuous implementation of lessons learned from both past mishaps and successes.

At the request of the Subcommittee, we are undertaking a review of NASA's lessons learned process and procedures. The principal objectives of our review are to determine how NASA captures and disseminates lessons learned and if the agency is effectively applying lessons learned to current programs and projects. We will report the results of our evaluation to the Subcommittee later this year. Mr. Chairman, this concludes my statement.

[The prepared statement of Mr. Li follows:]

PREPARED STATEMENT OF ALLEN LI

SPACE TRANSPORTATION

Critical Areas NASA Needs to Address

in Managing Its Reusable Launch Vehicle Program

Mr. Chairman and Members of the Subcommittee:

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I am pleased to be here today to discuss our work, requested by this Subcommittee, on the National Aeronautics and Space Administration's (NASA) X–33 and X–34 programs. As you know, the purpose of these efforts was to significantly reduce the cost of access to space by partnering with private industry to develop and demonstrate technologies needed for future reusable launch vehicles reaching orbit in one stage (single-stage-to-orbit). In essence, these are vehicles whose components—either all or in part—can be utilized on subsequent flights. Both programs were recently terminated because of significant cost increases caused by problems developing the necessary technologies and flight demonstration vehicles. NASA is now focusing instead on its new Space Launch Initiative. This is a broader effort to develop the next generation of reusable launch vehicles, referred to as the Second Generation Reusable Launch Vehicle Program (2nd Generation Program). Today, I will discuss the primary factors that contributed to the difficulties experienced by the X–33 and X–34 programs and the steps needed to avoid repeating those problems within the 2nd Generation Program.

In brief, the X–33 and X–34 programs experienced difficulties achieving their goals primarily because NASA did not develop realistic cost estimates, timely acquisition and risk management plans, and adequate and realistic performance goals. In particular, neither program fully assessed the costs associated with developing new, unproven technologies; provided for the financial reserves needed to deal with technical risks and accommodate normal development delays; developed plans to quantify and mitigate the risks to NASA; or established performance targets showing a clear path leading to an operational reusable launch vehicle. Underlying these difficulties were problems with the agreements and contracts that established the relationship between NASA and its industry partners and eventual erosion of commercial prospects for the development of new reusable launch vehicles.

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Currently, NASA is in the process of taking steps in the 2nd Generation Program to help avoid problems like those encountered in the X–33 and X–34 programs. While it is too early to tell if these measures will be sufficient, our review of the two programs has shown that three critical areas need to be addressed. First, the technical complexity involved requires that realistic cost estimates and risk mitigation plans are developed and the projects are funded accordingly. Second, because the 2nd Generation Program will involve numerous interrelated, complex efforts to develop technology, NASA needs to ensure that all these efforts move forward in a coordinated manner and that open communication is fostered at all levels. Third, performance measures need to be implemented and periodically validated to ensure that the rationale for developing specific technology applications merits continued support.

Background

The X–33 and X–34 programs were part of an effort that began in 1994—known as the Reusable Launch Vehicle Technology/Demonstrator Program (Reusable Launch Vehicle Program)—to pave the way to full-scale, commercially-developed, reusable launch vehicles reaching orbit in one stage. In embarking on the Reusable Launch Vehicle Program, NASA sought to significantly reduce the cost of developing, producing and operating launch vehicles. NASA's goal was to reduce payload launch costs from $10,000 per pound on the space shuttle to $1,000 per pound. It planned to do so, in part, by finding "new ways of doing business" such as using innovative design methods, streamlined acquisition procedures, and creating industry-led partnerships with cost sharing to manage the development of advanced technology demonstration vehicles. The vehicles were seen as the "stepping stones" in what NASA described as an incremental flight demonstration program. The strategy was to force technologies from the laboratory into the operating environment.

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The X–34 Project started in 1995 as a cooperative agreement between NASA and Orbital Sciences Corporation(see footnote 2) (Orbital). The project was to demonstrate streamlined management and procurement, industry cost sharing and lead management, and the economics of reusability. However, the industry team, led by Orbital, withdrew from the agreement in less than 1 year, for a number of reasons including changes in the projected profitability of the venture. NASA subsequently started a new X–34 program with a smaller vehicle design. It was intended only as a flight demonstration vehicle to test some of the key features of reusable launch vehicle operations, such as quick turn-around times between launches.

Under the new program, NASA again selected Orbital as its contractor in August 1996, awarding it a fixed price, $49.5 million contract. Under the new contract, Orbital was given lead responsibility for vehicle design, fabrication, integration, and initial flight testing for powered flight of the X–34 test vehicle. The contract also provided for two options, which were later exercised, totaling about $17 million for 25 additional experimental flights and, according to a project official, other tasks, including defining how the flight tests would be undertaken. Under the new effort, NASA's Marshall Space Flight Center was to develop the engine for the X–34 as part of its Low Cost Booster Technology Project. The initial budget for this development was about $18.9 million.

In July 1996, NASA and Lockheed Martin Corporation and its industry partners(see footnote 3) entered into a cooperative agreement for the design, development, and flight-testing of the X–33.(see footnote 4) The X–33 was to be an unmanned technology demonstrator. It would take off vertically like a rocket, reaching an altitude of up to 60 miles and speeds to about Mach 13 (13 times the speed of sound), and land horizontally like an airplane. The X–33 would flight test a range of technologies needed for future launch vehicles, such as thermal protection systems, advanced engine design and lightweight fuel tanks made of composite materials. The vehicle would not actually achieve orbit, but based on the results of demonstrating the new technologies, NASA envisioned being in a better position to make a decision on the feasibility and affordability of building a full-scale system. Under the initial terms of the cooperative agreement, NASA's contribution was fixed at $912.4 million and its industry partners' initial contribution was $211.6 million. In view of the potential commercial viability of the launch vehicle and its technologies, the industry partners also agreed to finance any additional costs.(see footnote 5) During a test in November 1999, one of the fuel tanks failed due to separation of the composite surface. Following the investigation, NASA and Lockheed Martin agreed to replace the composite tanks with aluminum tanks.

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In February 2001, NASA announced it would not provide any additional funding for the X–33 or X–34 programs under its new Space Launch Initiative. The Space Launch Initiative is intended to be a more comprehensive, long-range plan to reduce high payload launch costs. NASA's goal is still to reduce payload launch cost to $1,000 per pound to low Earth orbit but it is not limited to single-stage-to-orbit concepts. Specifically, the 2nd Generation Program's objective is to substantially reduce the technical, programmatic, and business risks associated with developing reusable space transportation systems that are safe, reliable and affordable.

NASA has budgeted about $900 million for the SLI initial effort and, in May 2001, it awarded the first contracts to 22 large and small companies for space transportation system design requirements, technology risk reduction, and flight demonstration. In subsequent procurements in mid-fiscal year 2003, NASA plans to select at least two competing reusable launch system designs. The following 2.5 to 3.5 years (through fiscal years 2005 or 2006) will be spent finalizing the preliminary designs of the selected space transportation systems, and maturing the specific technologies associated with those high-risk, high-priority items needed to develop the selected launch systems.

Factors Contributing to X–33 and X–34 Program Difficulties

Undertaking ambitious, technically challenging efforts like the X–33 and X–34 programs—which involve multiple contractors and technologies that have yet to be developed and proven—requires careful oversight and management. Importantly, accurate and reliable cost estimates need to be developed, technical and program risks need to be anticipated and mitigated, sound configuration controls need to be in place, and performance needs to be closely monitored. Such undertakings also require a high level of communication and coordination. Not carefully implementing such project management tools and activities is a recipe for failure. Without realistically estimating costs and risks, and providing the reserves needed to mitigate those risks, management may not be in a position to effectively deal with the technical problems that cutting-edge projects invariably face.

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In fact, we found that NASA did not successfully implement and adhere to a number of critical project management tools and activities. Specifically:

NASA did not develop realistic cost estimates in the early stages of the X–33 program. From its inception, NASA officials considered the program to be high risk, with a success-oriented schedule that did not allow for major delays. Nevertheless, in September 1999, NASA's Office of the Inspector General (OIG) reported (see footnote 6) that NASA's cost estimate did not include a risk analysis to quantify technical and schedule uncertainties. Instead, the cost estimate assumed that needed technology would be available on schedule and as planned. According to the OIG, a risk analysis would have alerted NASA decision-makers to the probability of cost overruns in the program. Since NASA's contribution to the program was fixed—with Lockheed Martin and its industry partners responsible for costs exceeding the initial $1.1 billion—X–33 program management concluded that there was no risk of additional government financial contributions due to cost overruns. They also believed that the projected growth in the launch market and the advantages of a commercial reusable launch vehicle would provide the necessary incentive to sustain industry contributions.

NASA did not prepare risk management plans for both the X–33 and X–34 programs until several years after the projects were implemented. Risk management plans identify, assess, and document risks associated with cost, resource, schedule, and technical aspects of a project and determine the procedures that will be used to manage those risks. In doing so, they help ensure that a system will meet performance requirements and be delivered on schedule and within budget. A risk management plan for the X–34 was not developed until the program was restructured in June 2000. Although Lockheed Martin developed a plan to manage technical risks as part of its 1996 cooperative agreement for the X–33, NASA did not develop its own risk management plan for unique NASA risks until February 2000. The NASA Administrator and the NASA Advisory Council have both commented on the need for risk plans when NASA uses partnering arrangements such as a cooperative agreement. Furthermore, we found that NASA's risk mitigation plan for the X–33 program provided no mechanisms for ensuring the completion of the program if significant cost growth occurred and/or the business case motivating industry participation weakened substantially.

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Against its own policy, NASA did not prepare program commitment agreements or program plans at the onset for either program. The commitment agreement lays out the program's technical, schedule, and cost commitments, and overall acquisition strategy. The program plan addresses these issues as well but also defines the effort's management structure as well as program resources, data management, risk management, test and verification, and planned program reviews. Such plans, when done with rigor, would help NASA to define realistic time frames, identify responsibility for key tasks and deliverables and provide a yardstick by which to measure the progress of the effort.

According to the OIG, NASA did not complete a configuration management plan for the X–33 until May 1998—about 2 years after NASA awarded the cooperative agreement and Lockheed Martin began the design and development of a flight demonstration vehicle. Configuration management plans define the process to be used for defining the functional and physical characteristics of a product and systematically controlling changes in the design. As such, they enable organizations to establish and maintain the integrity of a product throughout its life cycle and prevent the production and use of inconsistent product versions. By the time the plan was implemented, hardware for the demonstration vehicle was already being fabricated.

Communication and coordination were not effectively facilitated. In a report following the failure of the X–33's composite fuel tank, the investigation team reported that the design of the tank required high levels of communication, and that such communication did not occur in this case.(see footnote 7) A NASA official told us that some NASA and Lockheed personnel, who had experience with composite materials and the phenomena identified as one of the probable causes for the tank's failure, expressed concerns about the tank design. However, because of the industry-led nature of the cooperative agreement, Lockheed Martin was not required to react to such concerns and did not request additional assistance from NASA.

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The Government Performance and Results Act of 1993 requires federal agencies to prepare annual performance plans to establish measurable objectives and performance targets for major programs. Doing so enables agencies to gauge the progress of programs like the X–33 and X–34 and in turn to take quick action when performance goals are not being met. For example, we reported in August 1999 that NASA's Fiscal Year 2000 Performance Plan did not include performance targets that established a clear path leading to a reusable launch vehicle and recommended such targets be established.

Without relying on these important project management tools up front, NASA encountered numerous problems on both the X–33 and X–34 programs. Compounding these difficulties was a decrease in the projected commercial launch market, which in turn lessened the incentive of NASA's X–33 industry partners to continue their investments.

In particular, technical problems in developing the X–33's composite fuel tanks, aerospike engines, heat shield, and avionics system resulted in significant schedule delays and cost overruns. After two program reviews in 1998 and 1999, the industry partners added a total of $145.6 million to the cooperative agreement to pay for cost overruns and establish a reserve to deal with future technical problems and schedule delays. However, NASA officials stated that they did not independently develop their own cost estimates for these program events to determine whether the additional funds provided by industry would be sufficient to complete the program. Also, these technical problems resulted in the planned first flight being delayed until October 2003, about 4.5 years after the original March 1999 first flight date.

After the composite fuel tank failed during testing in November 1999, according to NASA officials, Lockheed Martin opted not to go forward with the X–33 Program without additional NASA financial support. Lockheed Martin initially proposed adding $95 million of its own funds to develop a new aluminum tank for the hydrogen fuel, but also requested about $200 million from NASA to help complete the program. Such contributions would have increased the value of the cooperative agreement to about $1.6 billion or about 45 percent (about $500 million) more than the $1.1 billion initial cooperative agreement funding. NASA did not have the reserves available to cover such an increase. The agency did, however, allow Lockheed Martin to compete, in its 2nd Generation Program solicitation, for the additional funds Lockheed Martin believed it needed to complete the program.

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Similarly, NASA started the X–34 Project, and the related NASA engine development project, with limited government funding, an accelerated development schedule, and insufficient reserves to reduce development risks and ensure a successful test program. Based on a NASA X–34 restructure plan in June 2000, we estimate that NASA's total funding requirements for the X–34 would have increased to about $348 million—a 307-percent ($263 million) increase from the estimated $86 million budgeted for the vehicle and engine development projects in 1996. Also, since 1996, the projected first powered flight had slipped about 4 years from September 1998 to October 2002 due to the cumulative effect of added risk mitigation tasks, vehicle and engine development problems, and testing delays.

Most of the cost increase (about $213 million) was for NASA-directed risk mitigation tasks initiated after both projects started. For example, in response to several project technical reviews and internal assessments of other NASA programs,(see footnote 8) the agency developed a restructure plan for the X–34 Project in June 2000. This plan included consolidating the vehicle and engine projects under one NASA manager. The project would be managed with the NASA project manager having the final decision-making authority; Orbital would be relegated to a more traditional subordinate contractor role. Under the plan, the contract with Orbital would also be rescoped to include only unpowered flights; Orbital would have to compete for 2nd Generation Program funding for all the powered flight tests. The plan's additional risk mitigation activities would have increased the X–34 Project's funding requirements by an additional $139 million, which included about $45 million for additional engine testing and hardware; $33 million for an avionics redesign; $42 million for additional project management support and personnel; and $18 million to create a contingency reserve for future risk mitigation efforts.

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Incorporating Lessons Learned in 2nd Generation Program

NASA is revising its acquisition and management approach for the 2nd Generation Program. Projects funded under the program will be NASA-led rather than industry-led. NASA also plans to increase the level of insight into the program's projects, for example, by providing more formal reviews and varying levels of project documentation from contractors depending on the risk involved and the contract value. NASA also required that all proposals submitted in response to its research announcement be accompanied by certifiable cost and pricing data. Finally, NASA discouraged the use of cooperative agreements since these agreements did not prove to be effective contract vehicles for research and development efforts where large investments are required.

While it is too early to tell if the agency measures aimed at avoiding the problems experienced in the X–33 and X–34 programs will be sufficient, these experiences show that three critical areas need to be addressed. These relate to (1) adequate project funding and cost risk provisions, (2) the effective and efficient coordination and communication required by many individual but related efforts, and (3) periodically revalidating underlying assumptions by measuring progress toward achieving a new safe, affordable space transportation system that meets NASA's requirements.

First, the technical complexity of the 2nd Generation Program requires that NASA develop realistic cost estimates and risk mitigation plans, and accordingly set aside enough funds to cover the program's many projects. NASA plans to invest substantially more funds in the 2nd Generation Program than it did in the previous Reusable Launch Vehicle Program, and plans to provide reserves for mitigating program risk. For example, the agency plans to spend about $3.3 billion over 6 years to define system requirements for competing space transportation systems and related risk reduction activities. Most of this amount, about $3.1 billion, is for risk-reduction activities, such as the development of new lightweight composite structures, durable thermal protection systems, and new high performance engine components.

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NASA officials told us that an important way they plan to mitigate risk is by ensuring adequate management reserves in the 15- to 20-percent range, or higher if needed. They also acknowledged the need for adequate program cost estimates on which to base reserve requirements. However, we are still concerned about the timely preparation of cost estimates. The 2nd Generation deputy program manager stated that, based on the scope of the first contracts awarded, the program office planned to update their cost estimate this summer before NASA conducted a separate, independent technical review and cost estimate in September 2001. Thus, neither of these important analyses were completed prior to the first contract awards. We believe that until the program office completes it own updated cost estimate and NASA conducts an independent cost and technical review, a credible estimate of total program costs and the adequacy of planned reserves will not be available. Also, NASA is still in the process of developing the documentation required for the program, including a risk mitigation plan. NASA policy requires that key program documentation be finalized and approved prior to implementing a program.

Second, NASA will face coordination and communication challenges in managing the 2nd Generation Program. As noted earlier, NASA recently awarded initial contracts for systems engineering and various risk reduction efforts to 22 different contractors. Yet to successfully carry out the program NASA must, early on, have coordinated insight into all of the space transportation architectures(see footnote 9) being proposed by these contractors and their related risk reduction activities. Clearly, this will be a significant challenge. The contractors proposing overall architecture designs must be aware of all the related risk reduction development activities affecting their respective designs. It may also prove difficult for contractors proposing space transportation system designs to coordinate work with other contractors without a prime contractor to subcontractor relationship. NASA's own Aerospace Technology Advisory Committee, made up of outside experts, has also expressed serious concerns about the difficulty of integrating these efforts effectively.

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The need for improvement in coordination and communications in all NASA programs has been noted in the past and is not unique to the X–33 and X–34 programs. We and other NASA investigative teams have found and noted similar problems with other NASA programs such as the Propulsion Module for the International Space Station, and several other projects including the two failed Mars missions. NASA's Space Launch Initiative Program would benefit from lessons learned from past mishaps. At the request of the House Science Committee, we are undertaking a review of NASA's lessons learned process and procedures. The principal objectives of this review are to determine (1) how NASA captures and disseminates lessons learned and (2) if NASA is effectively applying lessons learned toward current programs and projects. We will report the results of our evaluation in December of this year.

The third challenge is establishing performance measures that can accurately gauge the progress being made by NASA and its contractors. NASA officials told us that they plan to periodically reassess the assumptions underlying key program objectives to ensure that the rationale for developing specific technology applications merits continued support. They also told us that they were in the process of establishing such metrics to measure performance. Ensuring that the results from the 2nd Generation Program will support a future decision to develop reusable launch vehicles also deserves attention in NASA's annual Performance Plan. The plan would be strengthened by recognizing the importance of clearly defined indicators which demonstrate that NASA is (1) on a path leading to an operational reusable launch vehicle and (2) making progress toward its objective of significantly reducing launch costs, and increasing safety and reliability compared to existing systems. Affected NASA Enterprise and Center performance plans would also be strengthened with the development of related metrics.

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Mr. Chairman, this concludes my statement. I would be happy to answer any questions you or other Members of the Subcommittee may have.

Objectives, Scope, And Methodology

We interviewed officials at NASA headquarters in Washington, D.C., NASA's Marshall Space Flight Center, Huntsville, Alabama, and at the NASA X–33 program office at Palmdale, California to (1) determine the factors that contributed to the difficulties experienced in the X–33 and X–34 programs, and (2) to identify steps that need to be taken to avoid repeating those problems within the Space Launch Initiative framework. We also talked to representatives of NASA's Independent Program Assessment Office located at the Langley Research Center, Hampton, Virginia and the OIG located at NASA headquarters and Marshall Space Flight Center. At these various locations we obtained and analyzed key program, contractual and procurement documentation for the X–33, X–34 and 2nd Generation programs. Further, we reviewed reports issued by the NASA's OIG and Independent Program Assessment Office pertaining to the management and execution of the X–33 and X–34 programs, and NASA Advisory Council minutes regarding NASA's efforts to develop reusable launch vehicles. In addition, we reviewed other NASA internal reports documenting management issues associated with program formulation and implementation of other NASA programs. We also reviewed applicable NASA policy regarding how NASA expects its programs and projects to be implemented and managed.

We conducted our review from August 2000 to June 2001 in accordance with generally accepted government auditing standards.

For information about this testimony, please contact Allen Li at (202) 512–4841. Contributors to this testimony included Jerry Herley, Noel Lance, and Carlos Garcia.

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Chairman **ROHRABACHER.** Well, thank you very much. And we are looking forward to that—findings on that report of how NASA actually deals with the lessons that it learns from these investigations. And that is very important that we not just analyze the problem, but also make sure that it is incorporated into our system.

Our next witness is Steve HoAE4eser(see footnote 10), who is a space launch analyst who was involved in the early stages of the DoD's highly successful Single-Stage-To-Orbit Program. Mr. HoAE4eser, is—I—works at Boeing, which I didn't know when he was invited and he is not representing Boeing. But he is someone who has some very unique insights as represented by some editorials commenting on NASA's space transportation programs that he wrote recently that were very intriguing. So, Mr. HoAE4eser, you may proceed.

STATEMENT OF STEVEN J. HOAE4ESER, SPACE LAUNCH ANALYST

Mr. **HOAE4ESER.** Mr. Chairman, and distinguished members of the Committee, I am honored to be called before you to discuss our country's Space Launch Initiative program. Again, let me say that I am here as a private citizen representing no company and that the testimony I present today is not intended to represent the views of either the Schafer Corporation or the Boeing Company, under who I am currently employed.

Mr. Chairman, in 1990, I was fortunate to be selected as part of a team that undertook a bold reusable launch vehicle project, the Department of Defense's Single-Stage-To-Orbit Program, under the management of the Strategic Defense Initiative Office. This project ultimately created the world's first fully reusable rocket dubbed the Delta Clipper Experimental. I apply the term bold in that the SDIO chose to employ an update of the classic rapid program approaches used so successfully in the past.

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The key rule of this classic rapid program approach demands that your primary program objective is to develop capability. This means that you use today's technology and only dip into the advanced technology bucket as needed. Our DC–X team called this using technology wisely.

To help us determine the technology needs of our SSTO rocket designs and to guide our technology investments, we ran accelerated system engineering concept studies with four contractors. These studies took only 8 months and concluded that a fully reusable single-stage-rocket system using existing and emerging 1990's technology, was possible.

Then on the 5th of August 1994, all this changed. A decision was made by former U.S. President Bill Clinton to give NASA the lead for reusable launch vehicles. This Presidential decision fundamentally changed the course of our Nation's RLV programs from demonstrations of aerospace capabilities to development projects of advanced technology.

With this direction, dutifully and with fervor, NASA started planning its RLV program efforts based on their Aeronautics and Space Act of 1959 charter, as amended. This Act states that NASA flight vehicles are for, and I quote, "demonstrating technologies necessary for reusable launch vehicles."

Unfortunately, the X–33 change—when it changed to a technology-centric program, there never appeared to be a corresponding adjustment to its cost and product expectations commensurate with those of an Advanced Technology Program. This produced a congenital defect in the resulting program that was apparently never properly diagnosed or treated. On March 1, 2001, as we all know, these programs were canceled.

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At this point, I would like to state that I believe we should not assign blame to either Lockheed Martin, Orbital Sciences, or NASA Marshall teams for the X–33 and X–34 program cancellations. Perhaps the primary reason I agreed to testify today is because I believe it is vital to our Nation's space leadership that we fix the problem and not fix the blame.

Towards that end, it appears that a flaw exists in the foundational premise driving decisions made in the current Space Launch Initiative. This flaw is that our technology is not yet ready to demonstrate fully reusable space transportation.

Although the X–33 and X–34 programs did not, "meet expectations," it must be clearly understood that they also showed no conclusive evidence that reusable launch vehicles could not be built and demonstrated today. All these programs showed was that some of advanced subsystem technologies selected and tested were not ready for use in a reusable launch vehicle.

My final point is really a question. I wonder how the SLI program can know where to make technology investments without a guiding RLV system design or designs. Without a design, you have no way to trace back to the need. More importantly, when you conduct system design engineering studies, it is critical that you disconnect them from their architectures and their architectures from the technology efforts. To not do so is to inject inherent, irresistible temptations to make management decisions that favor the technology at the expense of needed capability.

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Mr. Chairman, we should not attribute to malice that which results from bureaucracy. Specifically, blaming NASA for not meeting capability demonstrator expectations, when they were chartered to do technology development, serves no useful purpose. If the desire of SLI is to improve—or to provide capability through RLV flight demonstrations, then the contractors must be free to wisely use whatever technology will get the job done quickly, effectively, and for the least cost.

Second, we should not eliminate the idea of building a near-term RLV capacity based on a few advanced subsystem technology failures, especially when those technologies may not even be needed to make an RLV integrated flight demonstrator work.

And, finally, I believe it is both prudent and critical to conduct independently managed RLV system concept design studies for the SLI program similar to those that proved so successful in the SSTO/DC–X program.

At the very least, these studies will provide a basis to prioritize the SLI technology efforts. At the very best, we may find that our aerospace engineers will embrace the challenge and rapidly produce an RLV capability demonstrator. Thank you, and I look forward to your questions.

[The prepared statement of Mr. HoAE4eser follows:]

PREPARED STATEMENT OF STEVEN J. HOAE4ESER

Mr. Chairman and distinguished Members of the Committee, I am honored to be called before you to discuss space transportation advancement and our country's Space Launch Initiative program efforts toward that end.

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Let me first say that I am here as a private citizen and that the testimony I present today does not necessarily represent the views of either the Schafer Corporation or the Boeing Company under whom I am currently employed.

The Space Shuttle, which is the foundation of our national space transportation, is based on a design that was finalized around the close of the Vietnam War. This makes the basic design almost 30 years old. Upgrades to this system abound and several options for shuttle-derived vehicles have been designed and analyzed. Nevertheless, by the time the NASA Space Launch Initiative, or SLI for short, is schedule to produce a new vehicle, the Shuttle airframe will be 40 years old.

As we sit here today, other nations with space capability are investigating reusable launch vehicle or RLV options. Even China is closely monitoring RLV development activities. Our Global competitiveness and leadership in RLVs to date could be challenged in the not to distant future. A repeat of Europe's Air-Bus or

Ariane's entry into this global arena could have harsh economic and international political impacts to our Nation.

It is for these and other reasons I am pleased to share with the Committee my experience in the RLV field and provide three key observations related to NASA's Space Launch Initiative in my submitted testimony today.

Mr. Chairman, in 1990 I was fortunate to be selected as part of a team that undertook a bold reusable launch vehicle project; The Department of Defense's single-stage-to-orbit program under the management of the DoD's Strategic Defense Initiative Office (SDIO). This project ultimately created the world's first fully reusable rocket dubbed the Delta Clipper Experimental. I apply the term bold in that the SDIO choose to employ an update of the classic rapid program approaches used so successfully in the past in an acquisition system ill equipped to handle management styles. The heritage of the this reusable launch vehicle program approach can be traced to such aerospace successes as the Polaris and Thor ballistic missile program, the SR–71 Black Bird and U–2 high altitude reconnaissance aircraft to name a few.

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The key rule of this classic rapid program approach demands that your primary program objective is to develop a capability. This means that you use today's technology and only dip into the advanced technology bucket as needed. Our DC–X team called this "using technology wisely." This is what makes programs faster, better, cheaper.

Using technology wisely means that for most of the vehicle's design current technology that is properly engineered should be sufficient. In our case, the contractor's marching orders were to integrate state-of-the-practice aerospace technologies into a reusable rocket design that would demonstrate aircraft-like flight and ground operations.

If the current technology didn't meet the need, the contractors could look to well tested but more expensive emerging technologies. A historical example of an emerging but more expensive technology is graphite-composites. In the early 80's graphite-composites were used only in limited high payoff areas due to their expensive. Today, you see graphite-composites used in everything from umbrella handles to the most advanced military aircraft structures.

We made it clear to the SSTO contractors that high risk advanced technologies should only be used as a last resort. The SSTO contractors that choose concepts that forced them to resort to these advanced technologies were closely scrutinized by the project office and had to provide extremely convincing rational for their use.

Evidence from Experience: Perhaps my favorite example in this program of a contractor using technology wisely was when McDonnell Douglas DC–X designers chose to use stainless steel piano hinges purchased from a local hardware store for the vehicle's access panels. Better was and is the enemy of good enough for capability-demonstrator programs.

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Another example was that instead of new equipment we would find and used existing hardware whenever possible. A case in point was the cryogenic oxygen valves. Instead of designing and building these potentially very expensive parts and long lead parts, valves from old Delta rockets were salvaged and worked just great.

To determine the technology needs for our SSTO rocket designs and to guide our technology investments, we ran accelerated system engineering concept design studies with four contractors. These studies took only 8 months from August of 1990 to April of 1991. I have extracted briefings charts from the start of the program showing our rapid program objectives and from the study conclusions briefing in my submitted testimony for your reference.

These studies concluded that a fully reusable single stage rocket system using existing and emerging early 1990s technology was possible.

With these concept design studies to focus technology investments, and later the applied technology used the first phase DC–X capability demonstrator, our Nation was well on its way to opening space and gaining unchallenged space leadership for decades to come.

Then on the 5th of August 1994, all this changed. A decision was made by former U.S. President Bill Clinton to give NASA the lead for reusable launch vehicles. This decision changed the fundamental nature of the X–33 program from what I call a capability demonstrator focus to a technology centric development.

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Whether, as some speculate, this move by the Clinton Administration was a carefully crafted this move by the Clinton Administration to prevent our military from gaining unprecedented space advantage or some other motivation I cannot say for certain. Regardless, this Presidential decision fundamentally changed the course of our Nation's RLV programs from demonstrations of new aerospace capabilities to development projects for advanced technology.

President Clinton's decision was documented in the 1994 National Space Transportation Policy and I quote "gives NASA lead responsibility for technology development for a next-generation reusable space transportation system, such as the single-stage-to-orbit (SSTO) concept."

With this direction dutifully and with fervor NASA started planning its RLV program efforts. These plans were built using their Aeronautics and Space Act of 1958, Pub. L. No. 85–568 charter, as amended. This Act states that "the term 'experimental aerospace vehicle' means an object intended to be flown in, or launched into, orbital or suborbital flight for the purpose of demonstrating technologies necessary for a reusable launch vehicle, developed under an agreement between the administration and a developer." Note the key charter direction is to demonstrate technologies not demonstrate capabilities.

From this point on the X–33 and new X–34 program management decisions were made based on developing and testing advanced technology. This essentially guaranteed future NASA RLV efforts would cost more, take longer, and have higher risk than we envisioned in the DoD led DC–X follow-on program.

Evidence from Experience: As evidence of the positive cost impact of a program that manages technology demonstrations verses capability demonstrations, let me indulge in an SSTO/DC–X war story. Prior to letting the DC–X contract our program office conducted a cost estimating study. We used three models; one developed internally, one used by the U.S. Air Force, and one from NASA. The results showed our cost estimate based on the rapid program assumptions I described earlier projected a cost between $60 and $70 million. The Air Force model using standard aerospace procurement practices produced an estimate of around $365 million. The NASA model based on highly technology development based shuttle program experience projected the program would be over $600 million. The actual DC–X program cost through the first test series came in about $65 million.

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Unfortunately when the X–33 changed to a technology centric program there never appeared to be a corresponding adjustment to its cost and product expectations. This produced a congenital defect in the resulting program that was apparently never properly diagnosed or treated. On March 1, as we all know these programs were canceled, behind schedule and well over original budget estimates.

My point, Mr. Chairman, is that changing RLV programs from capability demonstrations that used technology wisely to technology development projects fundamentally changed the character of our Nation's RLV programs. It was not surprise to me that these efforts to longer, cost more, and did not meet original expectations, because they were not the same program.

At this point I would like to state that I believe we should not assigned blame to either the Lockheed Martin, Orbital Sciences or NASA Marshal (Space Flight Center) teams for the X–33 or X–34 program cancellations. NASA dutifully followed their charter to develop and test advanced technology. The contractor teams, like any good commercial business, did what their customers wanted. Perhaps the primary reason I agreed to testify today is because I believe it is vital to our Nation's space leadership that we *fix the problem, not fix the blame.*

Members of the committee, this leads me to the second of my points today regarding our Country's next generation space transportation developments under the Space Launch Initiative.

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It appears that there exists a flaw in the foundational premise driving decisions made in the Space Launch Initiative. This flaw is that the technology is not yet ready to demonstrate fully reusable space transportations.

In a 1 March 2001 press release on the X–33 and X–34 program cancellations Dr. Art Stephenson of Marshal Space Flight Center stated, "We have gained a tremendous amount of knowledge from these X-programs, but one of the things we have learned is that our technology has not yet advanced to the point that we can successfully develop a new reusable launch vehicle that substantially improves safety, reliability and affordability."

My colleague, Dr. Stephenson, correctly characterized in this same release that the technology development results of the X–33 and X–34 programs did not, in his words, "meet expectations." But it must be clearly understood that although these programs did not meet expectations, they also showed no conclusive evidence that reusable launch vehicles could not yet be built and demonstrated. All these programs showed was that the advanced subsystem technology that was tested is not ready to be used in a reusable launch vehicle.

In my continued dealings with the industry, I know of a number of companies that have developed and analyzed designs for fully reusable two stage launch vehicle that claim to provide significant cost, safety and operability improvements using today's technologies.

My final point today is really a question. I wonder how the SLI program can know where to make technology invests without an understanding of a target system design? Without this you have no way to trace back customer requirements. In my system design experience and through listening to war stories from some of the legends of America's aerospace successes is that without a system design in mind, what you often end up with is a set of very neat technology that can't be used in anything without being completely re-engineered.

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More importantly, when you conduct those system design-engineering studies, it is critical that you disconnect these studies and more importantly the architectures that drive these studies from the technology efforts. To not do so, is to inject almost irresistible temptations on managers to make decisions that favor the technology at the expense of needed capability.

In summary,

First, we should not attribute to malice that which results from existing bureaucracy. Specifically, blaming NASA for not meeting expectations that were built on a capability demonstrator foundation when they only had a technology development mandate serves no useful purpose. If the desire for SLI is to prove capability through RLV flight demonstrations, then the contractors must be free to choose and integrate whatever technologies exist to get this job done quickly, effectively, and for the least cost.

Second, we should not eliminate the idea of building a near term RLV capability based on the failure of a few advanced subsystem technologies that failed in the X–33 and X–34 programs. Especially when they may not even be needed to make a highly capable integrated RLV system work.

And finally, I believe that it is prudent and critical to conduct independent, and I stress independent, managed RLV system concept design studies for the SLI program similar to those that proved so successful to the original SSTO/DC–X program. The one change I would recommend for these independently managed studies in hindsight is that they not be limited to single stage designs. We might just find two stages areas good as one.

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At the very least such studies will provide a basis to prioritize the SLI technology efforts and cut future vehicle development cost and schedule. At the very best, we may find that our Nation's aerospace engineers will once again meet the challenge and rapidly produce an RLV capability demonstrator that can gives us solid flight test data. Which is, after-all, the best basis for an informed decision on next generation reusable launch vehicles.

Thank you and I look forward to your questions.

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Chairman **ROHRABACHER.** Thank you very much. And I found your characterization of the DC–X program very interesting indeed. And I am sure that will stimulate some discussion.

Our final witness is Tom Rogers, the Chief Scientist of the Space Transportation Association. Mr. Rogers brings a wealth of experience. And given his many years in the public and private sectors dealing with aerospace issues, he has many insights to share with us. And we are looking for your guidance today and we welcome you, and you may proceed with your testimony, Mr. Rogers.

STATEMENT OF TOM ROGERS, CHIEF SCIENTIST OF THE SPACE TRANSPORTATION ASSOCIATION

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Mr. **ROGERS.** Mr. Chairman, thank you very much for inviting me to testify before you and your Subcommittee colleagues today on an important space issue. NASA's space transportation initiative is to be completed some 45 years after Yuri Gagarin orbited the earth. Unfortunately, even if successful, our space transportation capabilities will still not then be within a factor of 100 or 1,000 times of our aviation capability 45 years after the Wright Brothers' first flights. A hundred to 1,000 times.

For improving today's space vehicle technology, while clearly important, will not—will not, by itself, improve space transportation sufficiently. Therefore, I suggest four changes to the Initiative.

First, NASA says that it wants our private sector to conduct all space activities up to and in low-earth orbit so that NASA could then concentrate upon far out things. But the great cost of such activities prevents successful commercial industrial business from being conducted there. So NASA should agree that the Initiative be devoted to seeing completely privately financed and operated space transportation services soon become available to meet all of our country's nonmilitary needs up to LEO at low cost. That should be stated as the Initiative's explicit and sole goal.

Second, no national initiative should be confined to one Federal department or agency, even though agency-wide. Therefore, the National Security Council's Space Policy Coordinating Committee should see that all of our government's appropriate experience and capabilities, not just NASA's, be enlisted to achieve this goal.

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The Department of Commerce should help to see that the course of LEO warehouses, laboratories, and hotels are sharply reduced, and it should help our travel business to expand into space. The Department of Transportation should see that vehicle operations and crew and passenger training and safety become the equivalent of commercial aviations immediately after World War II. And both should assist in the creation of commercial space lines, the absence of which is nearly paralytic to this area.

Third, the Initiative's alternate access program should be enlarged and should emphasize classical free enterprise. It should prompt our private sector to employ entrepreneurial, competitive, privately financed, profit-seeking innovation. NASA should simply describe the number of people and tons of cargo to be transported to and from the ISS annually. The DOT would certify any vehicle designed to provide such transportation, and NASA would use competitive procurement and the shuttle budget to purchase the services. Each provider would pursue additional business for its fleet diligently and negotiate downward the price paid by NASA as its revenues and profits increase.

Alternative access would, thus, become the space equivalent of the government's procurement of air mail delivery services in the 1920's, a market that was most helpful to our fledgling commercial airlines.

And, fourth, and last, NASA has always decided who should go to space and how, but it is not expected to see our private sector doing so instead. Yet, they do not foresee our astronauts striding across the solar system then because our taxpaying public will not provide the great sums required.

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In the nature of things, Mr. Chairman, this place is a grave burden upon our civil space leadership and professionals. I would repeat, a grave burden. It is clearly delaying the day when space transportation has improved enough to meet our country's needs. Therefore, I suggest a novel three-element compact should be created between our civil space leadership and our general public.

(A), The Congress should add a human Moon-Mars line item to the NASA budget.

(B) For this, NASA would pledge to work with our private sector energetically and imaginatively to create new businesses, large new businesses, involving people in space.

And, (c), the Congress would fund the line item in proportion to the revenues generated by these new businesses.

Such a compact would see new national wealth created, some of which would be used for human Moon-Mars activities. Everyone would gain. Our space transportation interests, our aerospace industry, our economy in general, and NASA. And our taxpayers would not have to use their present wealth and income for human Moon-Mars activities. All these activities would then be financed by economic growth alone here on earth. Thank you very much, Mr. Chairman.

[The prepared statement of Mr. Rogers follows:]

PREPARED STATEMENT OF T.F. ROGERS

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The New U.S. Space Transportation "Initiative"

In Brief

NASA's new space transportation "Initiative" should proceed. But, overall, its character gives further clear evidence that NASA does not yet appreciate that another long, very costly and even successful vehicle technology program simply cannot, by itself, provide us with the sufficiently improved space transportation that our Country so badly needs.

The Initiative's sole goal—seeing that all of our non-military transportation of cargo and people to/from LEO is provided by our privately financed private sector at the earliest moment and least public cost—

should be made explicitly clear. Two specific changes should be made in its conduct: other Federal offices, DOC/NIST and DOT/FAA, should become engaged in its conduct, and its "Alternative Access" portion should be markedly expanded by using some Shuttle program funds to prompt private sector vehicle acquisition and operation.

And one related fundamental change should be made in the conduct our civil space program. NASA should be prompted to work with our private sector to create and expand businesses seeing people in space, and be provided with a proportion of the new wealth so created for the conduct of human Moon-Mars activities. Doing so would modernize and clarify a fundamental goal of the program, see to its financing in a novel fashion, and advance the prospects of improving both space transportation and our Country's future in space.

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The implementation of all of these steps should see improvements to surface-space transportation coming about to a greater extent and at an earlier date than is now expected. It should see the "creative destruction" of our Shuttle fleet soon underway; and assure the Country's transition from public to private non-military transportation service provision.

Neither the suggested changes nor the addition would increase the initiative's public cost by much if anything.

A Semantic Observation

Before committing himself to be launched into space recently, in all likelihood Dennis Tito judged that he had a reasonably good chance of returning from his trip.

Mr. Chairman, when you and some/all of your Committee colleagues take your own space trips, you also will expect to return to the Earth's surface. I know that I will.

Therefore, it seems reasonable to me that the new NASA "Initiative" be renamed. That is, anticipating that round trip services as well as launch services will become available, it should become known as the Space Transportation Initiative (STI).

Introduction

We all agree that seeing sharp decreases made in the unit cost (i.e., dollars *per* person and *per* pound) of surface-LEO transportation, and sharp increases made in its safety and reliability, must remain one of the highest space activity priorities of our national civil, military and private sector space programs. And these improvements should be made soon and at the least public cost.

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For it is becoming increasingly embarrassing, indeed painful, to note that, some 40 years after the Wright brothers made their first flight, we had advanced to where we had over 40 commercial airlines using over

1,800 aircraft to carry over 50 million people and 600 million ton-miles of cargo *per* year.

For today, an analogous 40 years after Yuri Gagarin's space trip, we still have no U.S. commercial spacelines, carry no private passengers to/from space, and see only 1/1,000th of the ton-miles being transported. Passenger-carrying private sector revenues only began to be generated this year—yet by another country, not ours; indeed, we tried to keep it from happening!

Could we have done better in space?

Yes! It took less than a decade after Sputnik for the first global satellite communications system to become operational—and even that advance was preceded years earlier by the generation of private sector satellite communications business revenues.

We have just finished spending five years and over $1 billion to improve space transportation, and failed to do so. Now we are commencing another effort that does not anticipate improved vehicles becoming available for another decade—some 50 years after Gagarin—and our spending nearly another $5 billion in public funds on vehicle R&D. Even so, our national space transportation capability will still be orders of magnitude smaller than that of commercial aviation at the end of World War II. And additional public $ billions are now said to be needed to "bail out" subsequent private operational vehicle acquisition.

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Were our 20th century professional airline and communications ancestors so much smarter than we are? I'm afraid so.

For we have yet to lay out a confident course that would see to the economically creative destruction of our government-operated Shuttle fleet. This extraordinary vehicle, of which we are all proud, will be a quarter of a century old when the new "Initiative" is concluded. But it is very, very costly to operate and maintain in as safe a fashion as is possible. By then we should have a permanent International Space Station (ISS) in full operation when, therefore, we should no longer need the Shuttle's laboratory capability and can use much smaller and less costly vehicles to serve the ISS.

And we have failed to create the possibility of a new vehicle fleet being financed and operated wholly by private sector interests in the service of very large markets—steps that are mandatory if unit costs are ever to be markedly reduced through operating efficiencies so that space transportation's contribution to our economy can attain its potential.

We must appreciate that our earlier-this-century predecessors did not place the full responsibility of creating air travel and satellite communications upon a single government R&D organization, such as NASA, and its closely coupled contracting communities. The last decade has demonstrated, clearly, that NASA has very little experience in how our non-aerospace private sector really works and, unfortunately, has insufficient incentive to see it work. Our predecessors did not expect our government to reduce costs (can we really imagine that—government reducing costs?) but turned naturally to our private sector. In the private sector cutting costs is an everyday occurrence in order to keep competitors away and to increase markets and create new ones in a search for profits. Have we forgotten that the communist planned economy lost out to the free enterprise one? Lost out to the competitive marketplace?

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That is, we simply must focus all of our surface-LEO transportation improvement efforts in such a fashion as to see us replicate what we have achieved in aviation and satellite communications—in both of which areas NASA was a major player.

Certainly, the Federal government does have crucial roles to play in space transportation development. It must do related basic and applied scientific research. It must accomplish early, risky and costly, vehicle technology development, engineering and demonstration. It should provide large early space transportation markets that, in seeing public needs met, also spur initial private sector investment to promote and meet economically sound private sector needs as well. And it is absolutely mandatory that it should assist our private sector to create new space transportation markets, particularly ones of potentially large size.

But the Space Transportation Initiative (STI) is concentrating almost entirely upon vehicle technology improvement to meet what the government now perceives as our private sector needs. To repeat: *Unfortunately, even if successful 5 years hence, improved space vehicle technology by itself will not lead to sufficiently improved space transportation!*

It is most important that we not forget that only two years ago a senior executive of a major U.S. aerospace corporation, then engaged in a vehicle improvement R&D program being paid for by the Federal government, testified to the Senate that "Wall Street" had informed his company that it would not, *not,* provide the private funds to finance the program's anticipated follow-on operational vehicle-fleet!

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The X–33 program has since been canceled. But its 5X as costly successor "Initiative" is not designed to meet Wall Street's objections!

The "Initiative's" Explicit Goal

In this context, the STI goal should be clearly understood and explicitly addressed through the kind of spending that it does with the nearly $5 billion that it expects to receive in public funding.

During recent years, NASA has said on several occasions that one of its most important programmatic and institutional goals is to see those space activities conducted up to and including LEO carried out, rather, by our private sector. It wants to see this come about so that NASA could then concentrate upon the conduct of more "far out" activities. The government has continued to play the predominant national role in the conduct of such space activities since the launching of V–2s well over a half century ago, using public funds to do so. Therefore, it certainly seems that this is a fundamental and timely enough matter to be seriously considered today.

But, unfortunately, until there are much larger space activity and infrastructure markets to be served there, and much lower unit cost goods and services available to do so, our private sector has little expectation of making a profit there (unless with government contracts) and therefore will not be able to take over from NASA.

Therefore, NASA must not only "talk the talk", it must "walk the walk".

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For the good of Country, our civil space program, and NASA itself, the clear and explicit primary "Initiative" goal must be to see that our space transportation area acquires that privately financed capability required to provide essentially all non-military space transportation to/from LEO. And this public-to-private transition must take place at the earliest moment and with the least cost in public funds.

But, unfortunately, the "Initiative" 's contracts, and the reports of NASA leaders thereon, do not evidence this understanding. Here, for example, are two "for instances":

Private vehicle-fleet financing is mandatory. But it cannot be obtained given the relatively small size of the present space transportation market. Therefore, present space transportation markets should be encouraged to expand, and new markets encouraged to come into being. Yet only some 0.2% of the "Initiative" 's first-year budget is described as a market-related.

Various kinds of housing is available to travelers before and after an earthly trip, but short of the Moon it must be provided in space as part of the overall transportation "package". The acquisition of ISS Federal housing will cost us some $100 billion. Yet the "Initiative" is not spending anything at all on LEO storage, laboratories and residential volume technology efficiency improvements so that space trips/activities not confined to a vehicle can be made at a much lower price.

Therefore, to see that the attainment of the fundamental "Initiative" goal receives the imaginative and energetic attention that our Country requires, the first thing that should be done is to broaden the active Federal presence in the space transportation area. The new Rumsfeld report-related change in the National Security Council has seen the creation of an overarching Space Policy Coordinating Committee. This Committee should see that appropriate early attention is given to this Federal broadening.

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Two Other Changes That Should Be Made In The "Initiative" Soon

1. The equivalent of two small fractions (say, 0.1% each) of the STI budget should be provided to the Department of Commerce (DOC) and the Department of Transportation (DOT) to allow them to consider conducting some parallel private sector focussed studies.

The DOC has a great deal of experience in the building construction and travel business support areas and is familiar with companies and activities in these two areas.

The completed ISS will provide permanent habitable volume/housing in LEO for the first time, but at a cost of $ billions *per* person *per* year for acquisition and ongoing O&M. We now need to think out how we can see a technology improvement program for the improvement of LEO volume needed for the conduct of LEO activities to complement surface-LEO transportation. DOC's National Institute of Standards and Technology (NIST) should be encouraged to think out how laboratory, warehouse and hotel business interests could be encouraged to provide these space-related assets at unit costs orders of magnitude lower than those of the ISS.

Too, for years the DOC had a successful travel business support office. We now need to begin to think out how our enormously successful travel business (with revenues of $100s of billions *per* year) can be widened to include the surface-LEO domain, and what the Federal government could do to assist such a private sector activity.

The space office in the DOT's Federal Aviation Administration (FAA) released a report early this year that articulated the great economic value that space transportation already provides our Country—some $60 billion *per* year!

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Drawing upon its experience with our large private sector aviation business and the satellite launch business, the DOT/FAA should now study how new and markedly improved vehicles that could provide cargo- and passenger-carrying services at markedly lower prices, and much greater safety and reliability, could be used to offer the widest possible ensemble of private sector Earth-LEO transportation services. Specifically, what new vehicle, operations and financing requirements would have to be met in order to do so? And specifically, what should all of our space-interested Federal offices be doing to help see them met?

DOT/FAA should also take the lead in thinking out how to approach reducing the time now spent in training—reportedly 1–2 years—by the astronauts/cosmonauts who take space trips and/or remain on the ISS. For, if it were ever seriously suggested by civil space offices that this amount of time would be required of the general public, this would eliminate the possibility of a large general public space travel business coming into being, to our great economic loss.

They should also identify those passenger physical and social factors that can be measured objectively, easily and promptly that would disqualify a person from taking a space trip. Then these factors should be articulated in appropriate regulations. The DOT's Aerospace Medical Institute is well positioned to lead in the conduct of both passenger training and passenger/crew acceptance studies. Achieving the safety and reliability criteria in effect at, say, the end of World War II would seem to be a reasonable beginning point.

And DOC and DOT should work cooperatively in thinking out how commercial spacelines could be prompted to come into being.

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2. The "Initiative" 's "Alternative Access" element should be markedly enlarged.

We must include the presence of "classical" free enterprise and competition in the entire process by which new space transportation vehicles are financed, produced, operated and used to provide various space transportation services. Free wheeling, imaginative, entrepreneurial, let's get rich, competition is called for, with essentially all of the business decisions being made outside of NASA.

Therefore, at the outset a no-more-than two page requirement document should be prepared by NASA that describes, very simply, how many people are to be transported to/from the ISS each year, and how much cargo, consumables and otherwise, to support them and their ISS activities.

In doing so NASA would demonstrate that it appreciates one of the fundamental reasons why we decided to acquire a LEO space station: that we would then be able to construct anything we wished to in orbit—of any weight, size or sophistication—almost independent of the surface-LEO vehicle payload-carrying capability. For, except for people, having an ISS and its crew allows us to assemble things in orbit, including satellites, that can be brought up in pieces, one or several at a time.

And it would demonstrate that all of the decisions regarding the vehicles, their crews, their operation, their financing and their use, are to be made by our private sector so that their utility and economic value to their owner-operators, their users, and the Country will be maximized—just as we do with railroad trains, aircraft, cruise and cargo ships, automobiles, trucks, ...

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This document would form the substantive basis for a request for competitive procurement of space transportation services to be provided by our private sector in meeting the basic U.S. ISS activity requirements.

Any and all U.S. transportation interests would be encouraged to acquire the vehicles and develop the operations that they decide could meet these surface-ISS (and other) transportation service needs. And to secure the private financing required to acquire and operate them.

Once any new vehicle-fleet owner-operator has satisfied the DOT's FAA that it can meet the NASA articulated ISS service needs while meeting appropriate FAA regulatory requirements, the Government would place an order with them for, say, the equivalent of one (perhaps more) Shuttle trip payload capability *per* year for, say, 5–10 years. And to pay for these services at the marginal cost ($100 million *per* trip) of such Shuttle trips. N.B. These funds would *not* come from the "Initiative" 's budget, but that of the Shuttle program's.

The first contract would be made with the first owner-operator to obtain FAA approval; then the second; etc. to the extent required by the ISS needs.

The owner-operator contractor(s) would agree to employ all of its new vehicle-fleet's large operating capacity not used in meeting the contracted ISS needs to seek out, diligently, other uses for their vehicle-fleet. And, each year, to negotiate downward the price to be paid by the Government for the services that it receives, with both parties taking into appropriate consideration the vehicle-fleet's additional revenues and profits from other than ISS payload carrying.

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With the vehicle-fleet's large non-ISS unused capability in hand and a large guaranteed government payment arriving each year, the owner-operator can be expected to explore other potentially large space transportation markets such as the conduct of space sports; the use of low local-force-of-gravity laboratories by scientists to conduct studies related to the diseases and disabilities of our aging population; space tourism; the dispersal of today's 150,000,000 pounds of nuclear waste material far out into space; the orbiting of one or more large space solar power (SSP) space segments installed for R&D/demonstration purposes; the DOD's needs; . . ..

Keeping the FAA's early 2001 space launch economic study in mind, and with reference to two recent passenger-carrying market studies, it is reasonable to judge that such additional space transportation markets could build up to provide trip revenues of $ billions, or even $10s of billions, *per* year relatively soon, plus additional $ billions *per* year for the provision of related surface-based infrastructure and services.

In brief, this course would be the modern space analogue of the 1920s role played by the Federal government to advance the prospects for aviation becoming soundly commercial—it then created the Federal market of seeing the mail carried by air.

DOC, DOT, DOD and NASA, and related airline, package delivery, hotel, business school, "think tank", and other appropriate private sector interests should be brought together to see how best our Country can make the transition from today's ELV *cum* Shuttle *cum* large Federal government presence era to a next generation fully reusable vehicle primarily private sector era.

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A Fundamental Addition To Be Made To The "Initiative" And The Civil Space Program, Generally.

Now, in a broader and sensitive context. . .

A fundamental change must be made in our civil space program and its institutional setting in order for the Initiative's goal to have a truly good chance of being met reasonably soon and at low public funding cost.

For today, our whole human space flight area is approaching the crux of a deep and true dilemma. And this is reflected in a slow but seemingly inexorable "melt down" of our civil space program.

Since the outset of the human space flight era some 40 years ago our civil space program leaders have been wholly responsible for deciding who is to be allowed to travel to/from space, how people are to go and return, where they are to go, and what they are to do there. And they have expected that the taxpaying public and their representatives would supply the funds that they required to do all this.

In a decade or so, they helped to see that our national security was preserved in a great public contest with an implacable adversary. Many lives were risked and $100s of billions (in 2001 dollars) were spent. And truly extraordinary space strides have been taken in describing and opening up space to mankind.

But, of course, the world turns.

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NASA is now being expected to complete the ISS and, some time soon thereafter, see it turned over to others for its operation, maintenance and use.

It is now expected to develop the technology with which, and an operational setting in which, our private sector will do all that is required to see people travel to/from LEO and reside and work there.

And it is now asked to see that the $100 billion ISS and $30 billion Shuttle (2001 dollars) were demonstrably fine economic investments, even though it (and nobody else) now knows precisely how to do so.

At the same time NASA must deal with, to it, the painful fact that, however pleased the general public is with our present civil space program, over the past near-decade the civil space program has nonetheless seen its purchasing power decrease by nearly 30%.

While the civil space activity that NASA is best suited in the world to undertake, and that it has expected to be asked to undertake from the civil space program's birth, i.e., to see its professionals explore the solar system and universe, and begin to settle there where possible, it is prohibited from doing.

By and large our NASA professionals are among the best professionals in our Country.

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But, as do we all, they must exhibit their performance in the context of the human condition.

In effect, at the same time that they are not asked to take up the solar system exploration/settlement opportunity, they must make almost daily programmatic decisions (within the Initiative for instance) designed explicitly to hasten the day when they will no longer see their astronauts being engaged in surface-LEO activities either. So, the day is soon approaching when human space flight/astronaut activity, at least as they and we all now view it, is to be denied to them throughout all of space.

That is a most difficult burden to place on their shoulders!

Therefore, unless NASA is to be asked/expected to step back from leading the world's human space flight adventure—and such stepping back is seemingly already beginning—we must begin to take steps to modernize, fundamentally modernize our civil space program.

That is, our civil space program leaders in the White House, the Congress, NASA, DOT, and our space-related aerospace businesses and university offices now must finally set aside much of the basic manner by which our civil space program is conducted and financed in clear recognition that the Cold War is well over. The program must be modernized, fundamentally, in recognition that the unique and powerful national security concern that drove its creation and subsequent multi-decade conduct is gone, forever—a conduct that employs g–b of the NASA budget and its astronaut corps.

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Two months ago this Committee received excellent testimony from Wes Huntress about why, and how, from a scientific-programmatic-operational point of view, the United States should see NASA and our astronauts again gradually begin to explore and start to spend time in various locations across the solar system. Personally, I find his reasoning persuasive.

But the consideration of any such civil space program modernization today is "dead upon arrival" because of the great public financial costs that it implies. For we are talking not about the use of technology that is already in hand; we are talking about enormous trip distances and enormous human risks; we are talking about not years but of at least scores of years, more likely centuries. And we have had the recent sobering example of the truly great ISS program cost enlargement.

That is, if asked about our Country now seeing NASA sending astronauts back to the Moon or on to Mars, a large fraction of us would probably respond: "Fine. I agree. That is, as long as I don't have to pay for it!"

But, at other times in our history we have faced the necessity of meeting great and unprecedented national needs and interests. And we then created such great and novel programs as the Morrill land grant-universities Act, Social Security, the Marshall Plan, ...

Now we should do so for the human space flight area. *We should do so on the basis that doing so would be self-financing!*

For instance:

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The Congress could add a new line item to the NASA program-budget that is identified as being for human Moon-Mars activities;

For this long-awaited boon, our civil space leaders would pledge (a) to essentially vacate the Earth's lower space in favor of our private sector as soon as possible, and (b) to work with our private sector, and our other Federal space-related offices, imaginatively and energetically, to see new space-related businesses created that involve non-government people in space; and

The Congress would fund the line item in proportion to the revenues generated by these new people-in-space businesses.

That is, NASA and our related human space flight private sector would create new wealth, a fraction of which would be used to fund NASA Moon-Mars human activities.

This would provide NASA and its university and aerospace contractors with a clear incentive to see technologies improved, markets created and expanded, unit costs reduced, . . .in order to see new businesses advance our Country's economic prospects in the human space flight area.

Too, it would encourage them to keep their human Moon-Mars program costs down, because they would have to help earn the money to meet these costs.

Everyone would gain: space transportation—vehicles, operations and markets; our civil space program and NASA; our space-related science, technology and engineering interests; our aerospace industry; our travel business; and our economy generally.

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Thus, our national security would be strengthened.

And our taxpayers would not be called upon to fund human Moon-Mars activities with the funds that they now have and the income that they now receive. These activities would be paid for only to the extent that the creation of wholly new wealth allows. That is, the NASA human Moon-Mars program would only be as large, and would move forward only as quickly, as NASA is successful in helping to see private sector wealth created.

In brief:

Our Country would finally begin to set aside the dependence upon the kind of old fashioned Cold War thinking that still undergirds the financing of our civil space program. In doing so we would create a novel new entitlement program to underwrite our astronauts striding across the solar system for the decades and centuries ahead. But, in a creative financing fashion that replicates the creative substance of this absolutely unique national program, it would expect the recipient of the entitlement payments, NASA, to lead in the creation the national wealth from which the entitlement payments were made! Our human Moon/Mars activities would thereby become economically focussed—economically here on Earth!

Chairman **ROHRABACHER.** Well, thank you all very much. Thank you, Mr. Rogers for joining us again, and, again, you have been a valuable resource to the Committee in the past. I will proceed with my 5 minutes and then I may have to leave this hearing for about 20 or 25 minutes due to another committee obligation. And Mr. Smith, I understand, would be—would take over for me if I have to leave.

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RESOURCE ALLOCATION

Let me get right into this. Mr. Smith, was it you who stated that 85 percent, or was it Mr. Li who said that 85 percent of the money in this program is going to actually produce hardware.

Mr. **SMITH.** Yes. That was me. We—yeah, we look——

Chairman **ROHRABACHER.** You mean 85 percent of that—how does that compare to other programs?

Mr. **SMITH.** Well, if you look at the $800 million worth of contracts we have just signed with the 22 companies, about 88 million of that were for the architecture studies. Now, even that, you could say, has some hardware relation because it includes wind tunnel activity, a lot of the kind of detailed design activity. But the remaining funds, which is about 80—you know, more like 88 percent of the contracted activity, is all related to the pinpoint design, testing, analysis, and actual build of hardware in the program. So it is actually building avionic systems. It is building structures. It is building propulsion systems.

Now, there are some other activities, in terms of systems engineering, collaborative engineering——

Chairman **ROHRABACHER.** All right. Well, that will be very impressive as long as after a number of years we don't end up with simply piles of hardware instead of something that gets us somewhere. And when will that be when these piles of hardware become something that will fly?

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Mr. **SMITH.** Well, I think it has been noted by a few people that the integration job that we have is probably the most difficult part of this program. We clearly are taking it very seriously. What we have started with is we required each contractor, who wanted to work in a technology or risk-reduction area, to link themselves to an architecture that met NASA's goals and commercial goals, and they have done that. So all of the technologies we have selected support the suite of vehicle architectures we have looked at.

Chairman **ROHRABACHER.** All right. So there is four or five different potential space vehicles and every one of these pieces of hardware, the 85 percent of the money, is spent—being spent on, will fit on at least one of those vehicles.

Mr. **SMITH.** That is correct. In fact, when—as we evaluated them, the more flexible the technologies were today, the higher they rated. So if——

BOTTOMS-UP APPROACH

Chairman **ROHRABACHER.** Then, at some point, what will happen is that because we have overcome this hurdle or that hurdle, a particular system will then become more attractive than the other systems.

Mr. **SMITH.** That is correct.

Chairman **ROHRABACHER.** And that is—it is a—as you say, this is a totally different approach than what we have been taking before and we have been doing this now for a year, I guess.

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Mr. **SMITH.** Well, we have just recently signed the contracts. We started some of the in-house NASA activity that industry asked us to do earlier last fall, but we signed the contracts about a month ago and have been working on that. Now, we did have contractors on contract up until February starting the systems engineering process, the integration process, and some of the tool development activity, but we really have got started with the $800 million worth of contracts about a month ago.

X–33 PROGRAM

Chairman **ROHRABACHER.** This, certainly, as I say, is different than before, and Mr. Li's testimony went into some of the details as to what happened before, at least in the last attempt, which was the X–33. Mr. Li, you have suggested to us that we moved forward in that program and there was no risk analysis.

Mr. Li. On the X–33?

Chairman **ROHRABACHER.** Right.

Mr. Li. No. No. There was none.

Chairman **ROHRABACHER.** There was no risk analysis on the X–33.

Mr. Li. Not a formal one. The issue in that particular one, Mr. Chairman, was that Lockheed, being the lead entity in this particular sense, they were the ones responsible for doing a risk plan for themselves. But NASA did not do one themselves because, as I said, NASA was only a partner in this particular——

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Chairman **ROHRABACHER.** But did Lockheed have a risk——

Mr. Li. Yes.

Chairman **ROHRABACHER** [continuing]. Analysis?

Mr. Li. Yes.

Chairman **ROHRABACHER.** Okay. But it had a risk analysis for its own liability, but not for the government's liability.

Mr. Li. Obviously, NASA would probably have a different perspective on being the steward for the taxpayers' money.

Chairman **ROHRABACHER.** And the tank failure—you said there was a breakdown of communications ——

Mr. Li. Yes.

Chairman **ROHRABACHER** [continuing]. About the composite X–33 tank.

Mr. Li. Yes, sir.

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Chairman **ROHRABACHER.** Now, I just want to state very clearly for the record here, you know, I, again, am not an engineer. I am no expert. I have never pretended to be an expert. But all along, I knew—I personally knew—and if I could know and understand this, people who are a lot more important to this, to the success of the program than I am, must have known this as well, that the composite tank was the center core, most important part of that whole program. I mean, this is what all along we were told and people have explained to me how vital this tank was. How is it that there was a breakdown in communication as to whether or not that composite tank was functioning or not or——

Mr. Li. My understanding, Mr. Chairman, was that both NASA and even some other units within Lockheed Martin understood the phenomena and the complexities of building the inner liners, for example, of these composite tanks. That particular concern was relayed to the Skunk Works, who was leading this for Lockheed Martin, and they took that under advisement, but they did not go any further than that.

Chairman **ROHRABACHER.** Well, this is very disturbing. And, as I say, because this—everybody's eye should have been fixed on this. And it seems to me that everyone's eye—I mean, that is what I was told and it made sense to me and, boy, it is shocking to hear that that wasn't the case. And we appreciate your analysis, Mr. Li. And what would you suggest that we do to prevent this type of breakdown in the future, by the way?

AVOIDING PAST MISTAKES

Mr. Li. Well, as I said in my testimony, I think communication and coordination is a very, very critical aspect of this. I worry, Mr. Chairman, as you know before, I have talked to you about the Space Station problems.

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Chairman **ROHRABACHER.** So were we remiss in not having Lockheed in about four or five times every month and saying, hey, how is the composite tank doing?

Mr. Li. Well, I think the basic understanding and basic concept of the cooperative agreement—a vehicle by which they entered this—into endeavor, everything was industry-led. They counted on Lockheed Martin. They said, Lockheed Martin, you have responsibility; you do it. And that is, in essence, what happened.

Chairman **ROHRABACHER.** Well, we didn't do it either. I mean, you know, unless—hey, I was here and I think many of us were members of this Subcommittee during that time period. And just not to point the finger elsewhere, should this Subcommittee have had Lockheed in and when Lockheed was in and we were talking about this, did we ask things specifically——

Mr. Li. I don't think—I would not suggest that.

Chairman **ROHRABACHER** [continuing]. About the composite tank——

Mr. Li. I would not suggest that, sir. I—what I am suggesting is, and I am hopeful that this does not occur again in that, I believe the agency has now recognized that it needs to have a more hands-on role and that particular role is more hands-on now. They are more active in managing the contracts associated with SLI.

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CONGRESSIONAL OVERSIGHT

Chairman **ROHRABACHER.** Well, with this new approach that we are taking right now, what we have got is a pile of hardware that is—we are being—we have to trust the judgment of the experts here at NASA, that note that this important technology for us to invest in, and that there it is, and we have achieved something by developing this piece of hardware. And at least we have to—I mean, we have to believe that that is going to work. I mean, Mr. Li, you don't think—is there any suggestions you can have on——

Mr. Li. Yes. I do.

Chairman **ROHRABACHER** [continuing]. How we can over——

Mr. Li. Yes.

Chairman **ROHRABACHER** [continuing]. Do our oversight on this particular approach?

Mr. Li. My suggestion to the Subcommittee would be the following, that if they have an endgame right now of 2006 and they want to get to that endgame, my suggestion to you is that as part of your normal oversight on an annual basis, you have NASA come up and they tell you what was the incremental progress that they made in getting to that endgame. Luckily, in this particular case, as in the X–33, as you recall, we gave Lockheed Martin an agreed-to $900-something million. In this particular case, we are not giving away the store in the first year, going on an incremental basis.

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Chairman **ROHRABACHER.** Well, before that—and I am sorry for using too much time here—but before that, I remember that we were concerned about too much government interference and let us let these private companies go for the profit motive and give them the money and they are going to make a profit by getting the government out of their way. I mean, this was the Republican line. I mean, let us face it.

Mr. Li. I think there is a middle line. I think on one end of the spectrum there is too much oversight, where you have checkers checking the checkers, and on the other end the government is not involved at all in doing any oversight. I think it is someplace in the middle, sir.

Mr. **SMITH.** Mr. Chairman, could I——

Chairman **ROHRABACHER.** Certainly. Go ahead.

RISK MANAGEMENT ASPECTS

Mr. **SMITH** [continuing]. Comment on some of the things we are already doing? First of all, on reserve—or risk management, excuse me—I have a risk management team reporting directly to me, reports directly to the program office. We ask each project team to look at their risks every week. They look at the risks that they see. They project out 2 weeks and they try to identify problems before they occur. So we are doing risk assessments continuously on this program.

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We, the program management, monitor it every month. But we go in and we ask each of the technical areas to come in and show us risk management. And then quarterly, we have a senior board of directors, which includes the senior of NASA leadership, also to look at it.

Chairman **ROHRABACHER.** Well, Mr. Smith, to be fair about it, what is—the way the program is designed now, the factor of risk actually is minimized by the fact that you have diversified the approach by, you know, you have laid a broad foundation.

Now, Mark Twain is very famous for having said—was, you know, when people always said, don't put all your eggs in one basket, Mark Twain's answer was, no, put your eggs—put all of your eggs in one basket and then watch that basket. Well, apparently we put all of our eggs in the X–33 basket and maybe even some of us here were not watching as much as we should have. And certainly maybe we should have had the—in the future, we are going to have to do our job a little bit better too and ask for incremental approaches and analyses. But unfortunately, the broad-based approach that you are now taking makes that step even more difficult. So I am not saying it is less likely to succeed, and we all hope that you are successful, because then we will have a cheaper, more reliable system to—and more effective system of putting things into low-earth orbit. Mr. Gordon.

SLI PROGRAM GOALS

Mr. **GORDON.** Thank you, Mr. Chairman. And I don't think you did such a bad job over those years. Mr. Smith, the Space Launch Initiative, obviously, is a very ambitious, important program. I think you—to some extent you can sum up the goals by wanting to have a launch cost at a factor of less—or a factor of ten less and a reliability of a factor of 100 more.

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Now, in 2006, when this program is over with, we are not going to have a vehicle. As the Chairman said, we have a pile of hardware. How do we measure success? I mean, you know, what should Congress look for to say, yes, this has been successful or not?

Mr. **SMITH.** First of all, we are going to have the majority of a design of two competing architectures performing under this program. We are going to be actually doing design of selected architectures by the middle of the decade. There is still—there is some debate as to how far that—along that design will be, but it will be quite a bit along its path.

In each technology area, we will have built, demonstrated, and tested critical hardware that will feed directly into the knowledge base for those designs.

Mr. **GORDON.** But what will determine what should be our measure of success? Is our measure of success—if the private sector comes in and says, hot dog, we have really got something here and we are going to—we are not going to use our money and build something? Is that the measure of success?

Mr. **SMITH.** Actually, the way we are looking at it is, in each case, we have a lot of analysis tools out there that say you can take this technology to a certain place and if you implement it you can reach these goals. What we don't have is the empirical data, the actual hardware test that says how far we can actually take these systems to achieve the kind of margins and the safety and reliability that we need. So we will have matched up the empirical data and the analytical data. We will have made sure that the hardware is showing us that we can, in fact, reach the goals. An example I would like to give you is, we——

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Mr. **GORDON.** But, no—but, again, what should we look for? You know, what is—at the end of the day, what should Congress—what should the benchmark be for saying this was successful or not? If you have developed this hardware and no one uses it, as good as it might have been, was that successful?

Mr. **SMITH.** Well, we don't believe that will be the case.

Mr. **GORDON.** Okay. So the——

Mr. **SMITH.** All of the hardware that will be built and tested will be directly linked to at least two competing commercial architectures. They will——

Mr. **GORDON.** But if they don't use it, then will we be successful? In other words, does someone at the end—in 2006, does someone have to come in and say, this is so good that I am willing to risk shareholder money on this?

Mr. **SMITH.** Well, we believe that a lot of the private investment issues are market-driven. We see that NASA has a major role to do in this program in terms of potentially investing in the follow-on vehicle. What we would like it to be, however, is commercially viable. We would like the booster system——

Mr. **GORDON.** So how do you determine—again, at the end of the day—that is just what I am trying to get to——

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Mr. **SMITH.** Yes. Yes, sir.

Mr. **GORDON.** In 2006, what does Congress—what is the measure for whether this program has been successful or not?

Mr. **SMITH.** We will have the ability to make an informed decision on what the vehicle looks like that we need to go build. We will have all the tools in hand to give us the confidence that we, in fact, have the capability to go build it. And we will be able to tell you what it is going to cost to build it, what it is going to be able to—what it is going to cost to operate it, so that we can make an informed decision that says we have all the data. We have done all the work. There is general consensus in the industry that we need to move forward. The market conditions will determine who pays for the development. But we are building the capability to go make that informed decision. And it is going to take the integration of government and private industry to look at this data to develop the——

Mr. **GORDON.** So—okay—so at the end of the day, then is success—if the private sector says this is so likely to be successful and so good, that we will fund half of it—that we will fund 80 percent of it, or that we will fund 90 percent?

Mr. **SMITH.** I would say success would be that we know that when we build it, we know that we can afford it and we know that it will be safe and reliable. Now, the who pays for it, will be driven more by market forces that we don't control.

Mr. **GORDON.** All right. So would you consider it a success at the end of the day if we determined that we have taken a thorough look at this and we are satisfied that we can't afford it and that—or that the benefits aren't such that the taxpayers are willing to do it or that the shareholders are willing to do it, but at least we have taken a thorough look and we know now this is the wrong direction, the wrong thing—we can't do it? Would that be considered a success by virtue of——

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Mr. **SMITH.** Well, the way——

Mr. **GORDON** [continuing]. Reaching that conclusion?

Mr. **SMITH.** The way this program is set up is we will know that well advance in the middle of decade because it is set up so that we can reassess it on a yearly basis. A year from now, we will have a handle on the architectures. We will see how the technology is progressing.

ANALYTICAL METHODS FOR MEASURING PROPOSALS

Mr. **GORDON.** Okay. So then what would you then—what has to happen for you to come to us and say this was a good-faith effort, we are trying to do the right thing, but it is just not going to work, and we need to pull the plug and use the money somewhere else? What is the benchmark for that?

Mr. **SMITH.** We will have the analysis tools, which we already have, that says, we can, in fact, reach the goals, but we will have test data that says that the hardware just isn't coming out of it. We just don't think we are going to be able to get the kind of margin in improvements and safety and reliability. The data will be there. We have open data rights, so we will be sharing it with people. We are going to be sharing it openly so that people can come in and see the progress we are making. We——

Mr. **GORDON.** So if you don't think that you can reach a reduction of cost by a factor of ten, or a reduction of risk by a factor of 100, then you will come to us and say, again, we have made a good-faith effort, it was the right thing to do, but we have now determined that we can't do that—so don't give us any more money.

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Mr. **SMITH.** We are going to be able to tell you how far down that path—how much more reliable and safe we can be. If we don't reach 1 in 10,000, but we are able to show, without any doubt, that we could get 1 in 8,000——

Mr. **GORDON.** Okay. So each year, you are going to come back to us and say, we don't think we can get to one, reduced by a factor of ten or a factor of 100, but we can do it by a factor of nine and by a factor of 90—do you want to go on, or great news, we can do it by a factor of 11 and a factor of 110?

Mr. **SMITH.** Yes.

Mr. **GORDON.** Is that what you are going to do?

Mr. **SMITH.** And our ability to see how that all comes together will become sharper each year as we do more analysis, as we see more results from the hardwares, we are able to connect it all together, as we do the trade studies. Part of this is also just not technology. We have people looking at the market forces, looking at the ways to incentivize businesses.

Mr. **GORDON.** But are we supposed to—but are you setting the benchmark as the 10 in 100—is that what we should look at each year?

Mr. **SMITH.** Well, I look at that very much as outcome-based thinking. We have got people looking at what does it take to go do that. And by realizing that there are ways to do that, then they can begin to achieve it. And analytically, we can already show some very major breakthroughs in the way we can design and build some of these subsystems, but that is based on analysis. We have to go get the hardware in the system to prove it can be done. So we are using the hardware testing to prove that we, in fact, can reach those goals or can get very close to them.

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Mr. **GORDON.** Oh. But or that you can't. So——

Mr. **SMITH.** Or that you can't.

Mr. **GORDON** [continuing]. You are going to come in and tell us every year your evaluation of whether that can be done and whether we should go forward or not.

Mr. **SMITH.** Yes. In fact, we have the adequate——

Mr. **GORDON.** And I am——

Mr. **SMITH** [continuing]. Excuse me.

Mr. **GORDON.** Mr.——

Mr. **SMITH OF TEXAS** [presiding]. You are over time actually.

Mr. **GORDON.** Okay. Mr. Li, what is—is that a—what should be that benchmark and how do we do this each year to say, you know—again, it is not a matter of saying—you know, you got to try, you know.

Mr. Li. Uh-huh.

Mr. **GORDON.** If you don't swing the ball, you don't hit the bat.

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Mr. Li. Uh-huh.

Mr. **GORDON.** I have no criticism of making of an effort, but I want to know when you pull the plug.

Mr. Li. And that is exactly my point about incremental progress and being able to establish on an annual basis how they are achieving that goal. The thing——

Mr. **GORDON.** But what is that benchmark is what we are trying to find out?

Mr. Li. I don't know what that would be. However, I will add this, sir. I think you are right on in terms of the question—what is it in the end—at the end—in the endgame, what is it that we are expecting? I think one of the things that Mr. Smith was saying that I probably disagree a little bit with is, I think the market forces that he is talking about—here, I think we are talking about the shareholders of these major companies. The issue here is whether NASA is going to be coming up with enough technology development that is going to increase enough of the confidence in the shareholders to say, yeah, we are willing to back a $10, $15 billion RLV because we think this is technology that is going to work.

MAINTAINING SHUTTLE INVESTMENTS

The other issue I would like to raise and associate with your question is that in the amount of time that it takes to make these decisions, I believe that we still need to not forget that we have a shuttle fleet that is aging and there are some things that we need to ensure that we have—we keep up that investment. And if there are some things that need to be done, we have to keep that in mind, in conjunction with what happens on SLI.

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Mr. **SMITH OF TEXAS.** Thank you, Mr. Gordon. The gentleman from Maryland, Mr. Bartlett, is recognized for his questions.

MULTI-SPACE MISSION FOCUS

Mr. **BARTLETT.** Thank you very much. Are you looking at the development of technologies for both manned and unmanned missions?

Mr. **SMITH.** Yes. We are. In fact, we are looking at the—all the risk-reduction activities for the complete architecture, the ability to do what NASA needs to do and also what commercial industry needs to do. We are also working with the Department of Defense to make sure that they understand the technologies we are working on so that if they have an application for them too, it can be useful to them. So we have, in our budget, two line items—one called RLV risk reduction, which focuses in on the unmanned, the rocket side of it, the part that has a great deal of commercial benefit to it, and we have a NASA unique, which looks at the crude systems that we would need to go do missions to Space Station and other—the other types of things that NASA will do in the future.

Mr. **BARTLETT.** And you have quite different criteria for what will be successful in those two areas?

ARCHITECTURE REQUIREMENTS

Mr. **SMITH.** Actually, one of the reasons we continue to look at architectures in doing the trade studies is that we are trying to converge those requirements. We are trying to come up with an architecture that can, as efficiently as possible meet both goals, rather than just go down a path and say, yeah, this will do everything that NASA needs and forget about commercial industry. We don't think that is the right answer. So we are spending a lot of time working together to converge an architecture that can do both missions efficiently.

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One of the reasons for that is that rate is the biggest—one of the biggest factors in bringing the cost down. So if you had the booster element that NASA could buy services from, it was also available for commercial missions, the rate would go up, the cost would come down, and we would both benefit. So those are the kind of the sweet spots we are looking for.

NATIONAL SECURITY RISK

Mr. **BARTLETT.** Our inability in the past to meet the needs of our commercial people for launching satellites became a national security risk when we went to China for launch. Our people saw that some with —with some modest improvements in the Long March missile that they would not be losing so many satellites, that it was really quite a big missile, that they could launch two satellites. All of this, of course, was a national security risk because we helped them perfect the Long March missile, which now has 13 of these missiles, a nuclear tip pointing at our 13 biggest population centers.

How did we fail to meet the commercial launch needs of our people? Who dropped the ball? Mr. Rogers, do you have a view as to who dropped the ball, that we were not able to meet that need? Anybody else?

Mr. **ROGERS.** No. I don't. I wasn't a party to any of those activities or discussions, so I can't help.

Mr. **BARTLETT.** Anybody else on the Panel have any suggestions as to why we failed to meet that commercial need and brought ourselves to this national security risk situation? My next question then is, it is obviously either the private sector or the government or a combination of those two because they are the only ones who are playing in this game. Right?

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And since the Federal Government generally has the responsibility for making investments that are too risky or too expensive, it would seem to me that the Federal Government might need to share a major part of the responsibility for not having this technology available. What assurance do we have that this is not going to continue to be a national security risk, that we are now going to—I understand the reason for this program is that when you are using expendable launchers, that that is a pretty expensive way—you develop a very sophisticated vehicle and then you burn it up when you drop it back into the atmosphere, and so you have to start all over again and build another one. So it made common sense that if you can simply fly that thing down to a safe landing and refuel it, you could launch another satellite within and that ought to be a much cheaper way of doing it. What assurance do we have that we are—that we are not going to have a national security risk in the future because our commercial people are still going to have to go to these foreign launch capabilities?

Mr. Li. Can I just take a shot at what you are asking? I believe the genesis of some of the issues that you are talking about obviously are very broad, but a lot of them pertain to the demarcation between what the Challenger was going—after Challenger, what the shuttle was going to be able to handle and what the commercial—the expendable launch vehicles were going to handle. I think a lot of those issues also pertain to not only the cost that many of the foreign nations are subsidizing their launches, but also their launch facilities. We have a problem in this country, in terms of launch facilities, that, frankly, a lot of the commercial companies believe that they are not getting the type of service that they can get other places. And, as a result, they have gone to the Long Marches. They have gone to the Arianes of the world.

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I think that, hopefully, the RLV approach to trying to reduce costs will provide the type of incentive and the type of solution that will reduce that cost down from the $10,000 a pound to $1,000 a pound.

MANNED VS. UNMANNED LAUNCH OPERATIONS

Mr. **BARTLETT.** Just one additional question. Is the fact that it is manned, is that what makes the shuttle a more expensive way to launch satellites than the competing non-reusable vehicles? Because $10,000—is that what it is—$10,000 per pound? That costs more, I understand, to put a satellite in orbit using the shuttle than the non-reusable boosters. If it were not manned, that cost would come down considerably.

Mr. LI. Well, obviously, the shuttle—in our Space Station work, we have identified that each one of flights that the shuttle takes, is about $400 million. And obviously, sending up a Titan or a Delta is much less than that. I would not say that, while the shuttle, indeed, is expensive, because it has to be man-rated, there are certain conditions to be man-rated. However, the issue also is that some of the payloads that we are using the shuttle for, do require a—some human intervention in order to deploy, and those are the ones that we are using right now.

Mr. **BARTLETT.** Mr. Chairman, in closing, I would just like to note that I think that a high-priority national objective ought to be to have a space launch capability where we do not need to rely on others. Because to the extent that we rely on them, we help them to develop boosters which 1 day may be dropping bombs on our people or our military. The more you use a system, the more confidence you have in its success. To the extent that we are paying other people to launch our satellites, we are subsidizing their development of systems which could 1 day become weapon systems used against us. Thank you very much.

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Mr. **SMITH OF TEXAS.** Thank you, Mr. Bartlett. My colleague from Texas, Mr. Lampson, is recognized for his questions.

SLI TECHNOLOGY BENEFITTING SHUTTLE DEVELOPMENT

Mr. **LAMPSON.** Thank you, Mr. Chairman. Mr. Smith, and, Mr. Li, some 70 to 80 percent of the technology that is being developed for SLI could be used on shuttle upgrades. Can you tell us, or either of you, or both of you, tell us some of the specifics of what might be able to be transferred?

Mr. **SMITH.** Yeah. Let me talk about the primary investment area of propulsion. We have selected competing concepts there in LOX/hydrogen propulsion that is similar to shuttle. These systems were selected based on their application to multiple architectures. As we continue to mature that, if it looked like that hardware needs to be applied to shuttle in any way, we could, in fact, adjust prototype requirements, do some testing, and provide that technology to the shuttle. That is one example.

The avionics, for instance, could be a major upgrade to the shuttle. There are some structural issues. In the future you could take some of the composite work or even some of the advanced metallic and make upgrades to the tank. There is a large suite of possibilities there—integrated vehicle health management, the kind of computing technologies that give you information on how the vehicle is flying—is all applicable or could be applicable to shuttle.

What we are doing is we are focusing in on—very much on different architectures, the evolution of other architectures. But we do have a small contract with Boeing who are looking at how do these technologies apply to shuttle really to help us use it as a reference point, to understand how, in fact—how effective these technologies could be in an operational system like shuttle. It also offers us a lot of wonderful information because we know a lot about it. We know how it works. It is operational data. It helps us bring real-world lessons learned into the program. So we are doing those kings of things. But this hardware, this technology, is focused really on major improvements in reliability and safety as applicable to other architectures.

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Mr. **LAMPSON.** Are we looking at—or what are you doing to watch what other countries may be developing, what other—what technologies somebody else may have developed that we could be using so that we are not reinventing the wheel?

FOREIGN LAUNCH VEHICLE TECHNOLOGY

Mr. **SMITH.** Yeah. We are looking it—actually, what we are finding is there are some pockets of capability, primarily in Europe, where they have worked at kind of the microscopic level, down the materials level, that would be very complementary to some of the work that we are doing. There is nothing big and grand that they have been working on in terms of things that we could get a lot of benefit from. But we are looking at ways that we could, perhaps, take some of their methodology, combine it with ours, and then we would both improve our understanding in this country. We, of course, would like to see that information flow this way and are doing everything we can to make sure that we don't send it across the ocean.

COMPARATIVE DESIGN GOALS

Mr. **LAMPSON.** Can you relate the safety and reliability goals that you have set for the Second Generation Reusable Launch Vehicle to the safety and reliability performance of other aerospace systems like the shuttle, military aircraft, or even commercial airliners, and how would they compare?

Mr. **SMITH.** Yeah. The current shuttle has a loss of crew, loss of vehicle risk, of about 1 in 250 missions. Our objective is to get that to 1 in 10,000 missions. The reliability being about 1 in 1,000 to 1 in 10,000, and you might have to have a crew escape systems in order for it to approach the 1 in 10,000. A military jet going to combat is 1 in 22,000 and if you fly in an airplane anywhere, it is about 1 in 2 million. So you can see, we have a lot of room to improve our reliability and safety figures.

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We have analytically shown that you—we can take rocket engines and make them as reliable as aircraft engines in analysis, but we are a long way from showing that the hardware can do that. In fact, we don't expect this first cycle for the hardware to be able to show us we can get there. But this is the first program that we are aware of that takes the lessons learned on how they achieve that level of reliability in aircraft and we are trying to put it into rocketry.

Mr. **LAMPSON.** Then what would it take to modify the space shuttle to achieve the flight costs and reliability goals and vision for the Second Generation Reusable Launch—for the RLVs, and how practical and how affordable do you believe that such an approach would be?

SHUTTLE UPGRADES

Mr. **SMITH.** In terms of the shuttle itself?

Mr. **LAMPSON.** Yes.

Mr. **SMITH.** An upgrade to the shuttle?

Mr. **LAMPSON.** Uh-huh.

Mr. **SMITH.** We don't know what is possible with the shuttle. They have done various studies. I am not an expert on those studies. They have shown that they could get the reliability up to about 1 in 1,000 with various upgrades, and, obviously, that would be dependent up on us being successful in these technology areas.

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One of the things, however, that is has a disadvantage on, from an architectural standpoint, is that the crew is contained within the orbiter. That is one of the reasons we are looking at separating crew and cargo so that you could fly cargo missions, you would have a separate crew system that could also separate and fly away in case, you know, of some type of failure. So we are looking at those kinds of issues so that you can, again, go from the 1 in 1,000 to 1 in 10,000 in terms of getting the crew off the vehicle.

So those kinds of architectural assessments are why we are pursing alternatives. We think that if the shuttle made some investment—in fact, they are doing that now, as part of the ongoing NASA budget—they can start to approach the 1 in 1,000 figure.

Mr. **LAMPSON.** Thank you. Mr. Chairman, do we have a chance of a second time around?

Mr. **SMITH OF TEXAS.** Mr. Lampson, that is not my understanding. I think the Chairman expected just to have one round. Would you like an additional minute for an additional question?

Mr. **LAMPSON.** Yes. If you don't mind, I would.

Mr. **SMITH OF TEXAS.** Okay. Without objection.

Mr. **LAMPSON.** Thank you. For Mr. Li—actually, I have a couple of questions and I—let me ask both of you all and I will go to this other one. What criteria will NASA use? We were talking about the—us looking for the incremental progress and we were talking about the endgame. What will NASA be looking at as far as criteria is concerned for—during the SLI, to decide whether we have the technology, the design, and the cost maturity required to be able to build the reusable launch vehicle?

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CRITERIA FOR FULL-SCALE DEVELOPMENT

Mr. Li. I have asked NASA exactly that question, and the answer is that they are working on the metrics that are going to be able to—that they are going to use to assess what that progress is. Those particular metrics are not yet developed. And that is why when I was—earlier I was asked—when the Chairman asked me, what sort of benchmarks do I suggest, I don't know enough about where—what their endgame is going to be right now in terms of development——

Mr. **LAMPSON.** Do you know when those things might be developed?

Mr. **SMITH.** And I can—I could talk to that. In each of the technical areas, we are asking our industry partners and our NASA team together to define what we call TPMs, technology performance measures. That is the specific metrics that they will carry down at the technology level that we can grade them against on a periodic basis. And we are working on those now. In fact, we set up in the program, what we call the period of understanding, 45-day period of understanding, to get the NASA and industry teams together to help go define those.

Our systems engineering team, in the process, is bring those up and start to integrate those in our models and develop what we are calling figures of merit, where you are able to show how a technical improvement down here in this substance relates to safety and cost up at the system level. So we are defining those. We should have a first cut at that in the coming weeks. It was going to continue to mature as we get more knowledge of what these technical performance measures are. Some companies have already given those to us. For instance, in the propulsion area, they have shown us analytically, the kinds of things, the improvements you need to make at the microscopic level and the materials and the reusability and the temperatures—that kind of thing. We are trying to relate that back up to the system level now.

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Mr. **LAMPSON.** Now, we ought to be asking for a criteria in addition to other kinds of incremental progress that we might be seeing. Thank you very much, and thank you, Mr. Chairman.

Mr. **SMITH OF TEXAS.** Thank you, Mr. Lampson. The gentleman from Washington, Mr. Nethercutt, is recognized for his questions.

SLI PROGRAMMATIC ISSUES

Mr. **NETHERCUTT.** Thank you, Mr. Chairman. Welcome, gentlemen. Mr. Smith, let me follow on to Mr. Lampson's line of questioning. I think one thing we have learned from the overruns, cost overruns of the Space Station, is the necessity of regularly updating NASA cost estimates on major programs, as well as the conduct of independent reviews and cost reviews, as well. My understanding is, is that neither a NASA review nor an independent review were completed prior to the first contract awards on SLI. Is that correct?

Mr. **SMITH.** Actually, we started with an external—what we call an external requirements assessment team, which is a panel of experts from outside the agency, to come in and evaluate our program. Obviously, a lot of the information, in terms of the specifics, which would give them the ability to do that full assessment, was dependent upon the awards. So we have that data. In fact, the—this team has met—the ERAT team has met since then. They will meet one more time this summer.

We are also doing a non-advocate review where we bring in NASA, but independent team, to come in and do that assessment. And we are also setting up right now a independent team outside the program to look at how we cost things, how we make assessments of the program, how it is integrated. And we are setting up that now. That is going to be several months before we get that set up. But an independent team to continue to come in and look at innovative ways to do the kind of cost assessments we need.

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Mr. Li. The key to what he just said was, yes, NASA has internally made a cost estimate, but the answer that he also gave, that is important, is that the independent cost estimate has not been made.

Mr. **NETHERCUTT.** Right. And it seems like it is—just thinking—trying to think logically about this—it seems like you would do that before you make the awards, rather than after. But am I missing something here?

Mr. **SMITH.** Well, a lot of the details of the—that gives you the ability to start putting together that consistent set of data are dependent upon the technologies you are pursuing, the integrated architectures that you are pursuing. The key thing is that as you go through this thing, you want to get consensus in the industry that you have a good cost estimate.

Mr. **NETHERCUTT.** Uh-huh.

Mr. **SMITH.** That you understand what you are doing. Part of what this program is doing is maintaining some reserve, so that as we learn things and we experience problems as we go, we have the management reserves to be able to accommodate that. But one of the key things we are trying to do is get the best information within NASA, the best information in industry, but also bring in like Aerospace Corporation, that has tremendous databases, the RAND Corporation, that really knows how to do the methodology work—bring those people in here to help build consensus as we go. Because right now, we don't have the ability to do a lot of really detailed cost assessments.

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Now, we, in negotiations, all of these negotiations were competitive. We have a good handle on how we are going to maintain each individual contract costs. But at the global level, we are trying to combine that with what is the ultimate vehicle going to cost, how does all that fit together, and how do you build consensus.

Mr. **NETHERCUTT.** A couple of quick questions to follow on. What is the status of the risk mitigation plan and when do you expect the reviews that are underway and ongoing and the independent reviews to be completed?

Mr. **SMITH.** Okay. Well, one of the things that we have already done is, each of the contractors had to provide us their first risk mitigation plan and their proposals, so we have got the first cut at those.

Mr. **NETHERCUTT.** Well, will you make a judgment on that on the——

Mr. **SMITH.** Well, we are actually doing that right now. There—we have a meeting next month in Huntsville, where the contractors are coming together. It is a workshop where we are sitting down across the table from each other and saying, okay, do we really understand each other? It is again the period of understanding to get to that level of understanding. So prior to the non-advocate review, which will be completed by the end of September, is our current schedule.

Mr. **NETHERCUTT.** Uh-huh.

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Mr. **SMITH.** And then we will have a good handle of the total picture and how we stand.

Mr. **NETHERCUTT.** Is that satisfactory, Mr. Li, or any other members of the Panel—satisfied with that?

Mr. Li. Because of the approach, as they have chosen with the SLI, there is no—the endgame in not a vehicle and it is very different in terms of trying to identify risk reduction activities.

Mr. **NETHERCUTT.** Uh-huh.

Mr. Li. I think that right now we have to pretty much go with that plan.

Mr. **NETHERCUTT.** Uh-huh.

Mr. **HOAE4ESER.** All you can really—at this point in time, all you are really going to be assessing, as far as risk, is the risk of reducing the uncertainties associated with the technologies that they are developing. And to address an earlier question, if I might, there was a question of what are we going to get out of this? From what I have heard so far—I deal in real things that I can touch—it sounds to me like we are going to get a product plan which has—is backed up by a toolbox of technologies, and those technologies are going to be reduced to the point where you will understand what they are doing. But you still have to integrate them into a system.

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Mr. **NETHERCUTT.** I serve on the Appropriations Committee, as well as this—honored to serve on this Committee. But my sense is, we really need to have good assessments and make sure we know where we are headed and what the costs are and so we don't run into these overruns that we experience from time to time in the programs, various programs. So, Mr. Chairman, I see my time is up. I thank you and I thank Mr. Weldon for yielding me ahead of him at some time. Thank you.

Mr. **SMITH OF TEXAS.** Thank you, Mr. Nethercutt.

Mr. **NETHERCUTT.** Thank you, gentlemen.

Mr. **SMITH OF TEXAS.** The gentleman from Florida, Mr. Weldon, will be recognized for his questions.

NASA'S CHARTER

Mr. **WELDON.** Thank you, Mr. Chairman. This has been a very informative hearing for me. I was very supportive of X–33 and X–34 and I was quite disappointed when they were canceled. I thought they had some very interesting technologies that I wanted to see demonstrated. And I am certainly glad, at least the military is considering keeping those programs alive.

Mr. HoAE4eser, I wanted to get back to what you talked about in your opening statement, and you were getting into it a little bit with Mr. Nethercutt here a second ago. What you are saying is there is a potential we are not going to get a vehicle out of this. We are going to get a toolbox of technologies and get some validations of technologies at taking this technology to an operational system is we are going—I assume is going to require an extension of the program, perhaps a reinvention of the program with a new name and a lot of funding behind it. And then in the process, of course, of, you know, integrating everything that could be new hurdles that could develop. And that the problem essentially rests with the charter of NASA. Is that correct what you were referring to? Or at least the Presidential directive of 1994, that created the division of DoD doing expendable and NASA doing reusables?

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Mr. **HOAE4ESER.** The—yes, in fact, what we are really talking about there is when we first started the SSTO program, the overriding objective was to demonstrate capability. We disconnected that capability and the functions that that system would do from the technology. We didn't care what technology we used. If we went down to the hardware store to pick out a piano hinge to—for a latch in the system and that worked, good enough.

And, however, NASA's charter very clearly states that they are to develop advanced technologies in support of developing a reusable launch vehicle——

Mr. **WELDON.** So if I can just interrupt you for a second——

Mr. **HOAE4ESER.** Yes.

Mr. **WELDON.** And there is a lot of people on this Committee who would like NASA to develop a cheaper, more robust, safer to operate, reusable system to replace the shuttle——

Mr. **HOAE4ESER.** Uh-huh.

Mr. **WELDON** [continuing]. And we would like to have that within the next 10 or 20 years. You are saying—and he would like to see it in 3 or 4, but I would like to see it more like 10 to 20. But I have got parochial interests there. We have got to go into the charter, the—to change the language of what NASA does if we, as a committee, are ever going to get that kind of performance out of them. Is that what you are saying?

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Mr. **HOAE4ESER.** As—I look at this Committee as sort of the board of directors and NASA is out there to execute what you tell them to execute. And, in this case, if you want them to go out and develop a capability and demonstrate a capability, that is quite a bit different than developing technologies or a set of technologies that can be used in reusable launch vehicle.

As a system design engineer, I know that when I am told to go and build a rocket that has to get up to a certain altitude with a certain velocity, I have—I still—I—even though I have the technology out there and it exists today, I still have to integrate that technology. And that takes time. It takes 3, 4, maybe 5 years. So even though at the end of this we have a product—may have a product plan, and this is from what I have heard today, since I am not directly involved in the program, if that is what you get at the end of this, you still have to go from there, to take that product plan and integrate it—or put it into an integrated system design that actually flies.

My actual—frankly, I just—I—because I haven't been directly involved in the program, we did, in fact, have a good understanding at the time we conducted our studies, and that is why I included some of the charts. It appeared, even in 1990, that we had, using existing or emerging capability and technology, we could develop a reusable launch vehicle that met most of our functional goals. So if that is what you would like NASA to do, I would submit to the Committee that that is what you should tell them that they should do.

Mr. **SMITH.** Mr. Weldon, could I respond to this real quickly? This program is set up to do exactly what you are asking for, which is to end up with a vehicle in the 2010, 2012 time frame that replaces—or you begin to phase out the space shuttle and begin to phase this new architecture in. In order to do that, the development period is about 5 or 6 years, which gets us to this middle-of-the-decade decision on what does that vehicle look like, what does it do? We could start today building a new system, but we don't believe that it would result in the safety and reliability that this country needs. The satellite manufacturers have told us the number one thing they want is safety and reliability. They want reliability up.

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Mr. **WELDON.** Well, we certainly need that in any——

Mr. **SMITH.** In many human cases as well.

Mr. **WELDON** [continuing]. Human cases—yeah.

Mr. **SMITH.** So we are taking the first 5 or 6 years to develop the capability to, in fact, reach those goals. It takes that long to understand the technologies, to develop the capability in this country, to be able to integrate it into the vehicle. This program is putting those tools in place to make that decision.

Mr. **WELDON.** What do you say in response to that?

VEHICLE DESIGN ARCHITECTURE

Mr. **HOAE4ESER.** Well, if—and in my submitted testimony, I—one of the key recommendations I made was to ask the question, you know, of the system design study groups, if you were asked to design a vehicle, what would technology—what would be the technology you would use if you would use it wisely to design a vehicle today?

Mr. **WELDON.** So you are saying, let us talk about a vehicle first, then do the technology, rather than technology and then a vehicle.

Mr. **HOAE4ESER.** You have—and I have heard a lot of discussions about the design architecture. And I am—again, I am not fully cognizant of those design architectures. I am assuming that there are maybe one or several vehicles within that architecture. But as a product engineer, in developing systems, I need to know what I have to design to. And based on that, I also—it will also—it will also give me an indication as to where I should put my technology dollars to reduce my risk because I may be at the margin on that composite tank or aluminum lithium tank. And so I really better have a technology program to back me up if that tank fails and I can continue to move ahead without loss of a lot of time, money, and effort.

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Mr. **WELDON.** I just have one more quick question, Mr. Chairman. Did the DC–X have a composite tank?

DC–X PROGRAM

Mr. **HOAE4ESER.** Originally, it did not. The DC–XA, however, included a composite tank in the design. They retrofitted it from an aluminum lithium tank into a composite tank.

Mr. **WELDON.** So it flew with a composite cryogenic tank.

Mr. **HOAE4ESER.** Yes. It did.

Mr. **WELDON.** So why was it easier to create a composite tank for DC–X than it was for X–33? Was it the shape of the tank?

Mr. **HOAE4ESER.** It was the shape. It was the fidelity of the tank, the weight of the tank, the——

Mr. **WELDON.** Size.

Mr. **HOAE4ESER** [continuing]. Load of the tank, the size of the tank. I mean, it was a——

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Mr. **WELDON.** Size—every—a whole bunch of things.

Mr. **HOAE4ESER.** It was a relatively simple approach. It was the first approach.

Mr. **WELDON.** Right.

Mr. **HOAE4ESER.** We bring the knowledge of that team, because my deputy—my program was the program manager on DC–XA, so he brings all that knowledge. The X–33 was a far more complicated tank, far more difficult stresses and loads on the tank, and the capability was not there, obviously, to develop that tank yet.

Mr. **WELDON.** Thank you, Mr. Chairman.

Chairman **ROHRABACHER** [presiding]. Mr. Smith will have the next round of questions, but I would like to just take my prerogative for one moment. Steve, does that mean that if you had your choice right now, rather than the policy that we are talking about, the Space Launch Initiative——

Mr. **HOAE4ESER.** I am sorry?

Chairman **ROHRABACHER.** Rather than the Space Launch Initiative, as it is being structured now, your advice would be to go back and pick the DC–X, for example, right now, and just move forward on that —with that model, considering the fact that we have passed it up and the model that we passed it up for didn't work, but the DC–X would have worked? And——

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Mr. **HOAE4ESER.** Not——

Chairman **ROHRABACHER.** But your advice now is for us not to have this broader-based approach and but instead go for something like DC–X, which you believe would work.

Mr. **HOAE4ESER.** The—not necessarily the particular DC–X design. However, the studies, the system design studies that we are talking about, should really fundamentally ask the question, what technology should we use we today or what—can you build that capability or a capability for a reusable launch vehicle, single-stage, two stage, or whatever, with the technologies that we have today. That has got to be—because that drives you to get a capability quickly——

Chairman **ROHRABACHER.** I understand that. But you are—so you are not here suggesting that—let us go back to that original——

Mr. **HOAE4ESER.** No. Definitely not.

Chairman **ROHRABACHER.** Well, I don't know. It seemed like a pretty good idea to me at the time, and I was disappointed when they made the other choice. But, obviously—and obviously you were too. Mr. Smith.

Mr. **SMITH OF TEXAS.** Thank you, Mr. Chairman. I would like to return to a couple of subjects that I think were touched upon earlier, perhaps, in the testimony of Mr. Rogers and Mr. Smith, and this will help, frankly, clarify for me a couple of questions that I had and perhaps you have already responded. But let me direct my first questions to Mr. Rogers, and, Mr. Smith, if you want to respond, you are welcome to as well.

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SPACE TRANSPORTATION MARKET

Mr. Rogers, based upon the current space launch market projections, do you think that there is significant interest and capability by various industry leaders in developing an operational Second Generation Reusable Launch Vehicle?

Mr. **ROGERS.** There hasn't been, there isn't, and there won't be. Does that help you?

Mr. **SMITH OF TEXAS.** No. Your earlier testimony was strong enough, but that was pretty good too. Okay.

Mr. **ROGERS.** I am known as America's sweetheart in my own world and I must—I am close to losing my mind at this hearing.

Mr. **SMITH OF TEXAS.** Well, I don't want my question to cause that, but I thank you for your answer on that.

Mr. **ROGERS.** You are the first man that mentioned market really, essentially. Why, do you suppose, that Lockheed's X–33 program was allowed to lapse by Lockheed if for another few hundred million dollars they could have fixed the tank problem——

Mr. **SMITH OF TEXAS.** Uh-huh.

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Mr. **ROGERS** [continuing]. And built themselves a vehicle and gotten rich? Why do you suppose that was? Now, we are putting in 5 billion and waiting 5 years. Why did Lockheed Martin do that? Let me give you a hint. A very senior executive of the Lockheed Martin Company testified before the Senate a few years ago that he went to Wall Street and said we can build this vehicle for about this cost—will you finance it, and they said, no, because you can't make money with it. And I have heard nothing today about anybody making money. I have heard nothing about anybody creating a space launch. I have heard nothing about anybody doing any market prompting.

Of the six—of the $767 million to be spent this year in the Initiative, $1.8 million will be given to market-related studies and to market prompting, zero to 13 significant figures. Thank you for your——

Mr. **SMITH OF TEXAS.** Thank you, Mr. Rogers.

Mr. **ROGERS.** Thank you for your question.

Mr. **SMITH OF TEXAS.** Thank you, Mr. Rogers. Mr. Smith, do you want to tackle that or do you want the next question?

Mr. **SMITH.** No. Actually, I wouldn't mind commenting to that.

Mr. **SMITH OF TEXAS.** Okay.

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Mr. **SMITH.** The Department of Transportation, Department of Commerce, and FAA put out outstanding reports on the economic benefit of space transportation. And in one of the recent quarterly updates, they talked about how they went out and interviewed the current marketplace, the commercial satellite industry, primarily. And almost every company said the most important thing to them was reliability, because they are today spending more money on insurance than they are on launch costs. That is why we are focusing on reliability and safety.

But we have got to rebuild the capability in this country to go build U.S. systems to give us the reliability and safety we need so that that market will mature. One of the reports from 1999 showed that this is a immature, infant market today. That it could grow leaps and bounds if we, in fact, start to make those kinds of improvements. One of the other things that NASA is doing, the Second Generation Program being the next 10 years, is focusing on technologies that go beyond that for the next, you know, 25, 30 years, so that you can get to the point where space tourism—you can get into the areas where the market really takes off. So we are trying to influence the market. We are just——

Mr. **SMITH OF TEXAS.** Okay.

Mr. **SMITH** [continuing]. Doing through the capability to provide reliability, which is where we think the focus should be.

2ND GENERATION RLV TRANSITION TO 3RD GENERATION RLV PROGRAM

Mr. **SMITH OF TEXAS.** And thank you, Mr. Smith. My next question for you is, how are the Second Generation Reusable Launch Vehicles being coordinated or integrated with the Third Generation?

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Mr. **SMITH.** Actually, we do a pretty job of that because we co-locate both teams in the same building. We plan things together and we review our programs together. We also evaluate it every year. We update the plan together. So we continue to look at it from a technological standpoint and a programmatic standpoint together on a continuous basis.

Mr. **SMITH OF TEXAS.** Well, okay. Mr. Smith, last question is this—during the initial development of the X–33, there were a lot of technological advances made. How are those technological advances still being used?

LESSONS LEARNED FROM X-VEHICLE PROGRAMS

Mr. **SMITH.** Actually, that is a great question. In several areas, we are taking what X–33 did and we are building on it—integrated vehicle health management system. They actually did a lot of work in that area. We don't have to go back and do that work again. The composite tank—actually we learned a lot from failing that tank. We learned maybe perhaps more than we would have if we have flown it successfully.

You learn a lot from failures. And we learned about the composite tank work. We are building on that as part of our air frame with both Northrop Grumman and Boeing. The avionics work-up that we are paying for, you know, is to build upon the activities in X–33 and some of the metallic thermal protection system work that oceaneering is doing is also built on that technology. So we got a lot out of it.

Mr. **SMITH OF TEXAS.** Okay. Thank you, Mr. Chairman. I don't have any other questions.

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Chairman **ROHRABACHER.** Thank you very much. An interesting point that you made, Mr. Rogers. Mr. Lampson would like to ask a few more questions.

GREATER REVIEW OF NASA ACTIVITIES

Mr. **LAMPSON.** More in closing than anything, and I will try to be very short. Mr. Li, you were talking earlier about the additional reviews that were—that are going to be necessary to see to it that we don't get into the same kinds of problems with our development in these contracts and such. With NASA's mantra having been faster, better, cheaper, and don't necessarily ask for more dollars as we go through this, how are we going to pay for it?

Mr. Li. It is included in the—they have, in their estimate, they——

Mr. **LAMPSON.** Well, then what is it coming out of? What is—what are we—what is—what are we taking money away from to be able to do that? What is suffering because we are going to now change our manner of review?

Mr. Li. I think it is a matter—a realistic way of looking at it in—if you——

Mr. **LAMPSON.** If you know it is needed, there is no question——

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Mr. Li. Exactly. I don't know—if you were to ask me what would be the cost avoidance and what other program would have received this money if they were not doing this, I can't answer that. But I do believe that this particular type of oversight is needed to make this thing work.

Mr. **LAMPSON.** And I totally agree with that. I would love to know more about where those dollars come from because we are critically in need to do things, like what Mr. Rogers so desperately wants to talk more about, about going to Mars, in which I have to agree that probably every one of us up here also concur. And my last—actually, it is a comment. I direct a question toward the Chairman. Mr. Chairman, would you consider supporting funding for oversight by more civil servants at NASA to accomplish these things?

Chairman **ROHRABACHER.** Not until I study the issue more than I have right now.

Mr. **LAMPSON.** Thank you, Mr. Chairman. Thank you, all. Very good.

Chairman **ROHRABACHER.** You know, there is—we seem to go in—the pendulum seems to swing and, you know, before the X–33, I remember it was—the pendulum was we going to make sure that NASA was—you know, was going to lead the effort. And then, all of a sudden, it was the bureaucrats were getting in the way and all the engineers were complaining that yet government employees looking over everybody's shoulder and increasing the costs. And then in the X–33, we gave them this big hunk of cash, almost a billion dollars, and got out of the way. And now, it seems that people want to swing back in the other direction.

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THE LACK OF MARKET-BASE SOLUTIONS

I thought Mr. Rogers' observation about Lockheed's decision not to move forward was very persuasive. I mean, if there would have been a market that they would have identified with and if, indeed, there were only a couple hundred million dollars away from saving the program, that could have been—there could have been some market solution, even much less, a government solution. But obviously that analysis was not there.

Now, whether or not you can create that—whether or not you can create a situation where the market is available or whether that has to happen naturally, and there has to be a certain—the timing has to be right with the development of other technologies, I don't know.

But I have appreciated all of your testimony today and I think the insights that you have—each one of you have provided us, will be something, in and of itself, will be valuable and together may help us in that—putting together that vehicle that we think is going to come out of all those piles of technology. And this is part of that process too. And, Mr. Rogers, you certainly may——

Mr. **ROGERS.** Yes. Mr. Chairman, let me, at this time——

Chairman **ROHRABACHER.** Yes, sir.

Mr. **ROGERS.** I have the advantage of having grown up, along with NASA, in an extraordinarily effective, technology development, private sector encouragement, business creation. It is called satellite communications. And I would like to show you how deeply we are in trouble in space transportation, giving you a few facts of——

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Chairman **ROHRABACHER.** Could you—towards your microphone.

Mr. **ROGERS.** Microphone.

Chairman **ROHRABACHER.** Yes, sir.

Mr. **ROGERS.** If the Initiative is carried through and it is as followed on, as was described today, we may 50 years after Yuri Gagarin's first trip, have somebody outside of the government fly a vehicle or two that will be, to a very great extent, paid for by the Federal Government. In satellite communications, the first revenues were generated after Sputnik within 7 years, and the government did not pay for the satellites and it did not pay for the boosters that launched the satellites.

And so I began to wonder a few years ago about why this was the case, until 1 day the obvious dawned on me. In satellite communications, we had not only NASA and the Department of Defense—we had AT&T and the Bell Telephone laboratories. We had IT&T and the Nutley laboratories. We had a Federal Communications Commission. We had markets, national and international, that were being served by undersea cable and short wave. We had committees of the Congress, not only Science, but Commerce. All of that institutional infrastructure is lacking in the space transportation area and the Initiative is not designed to see it put in place.

We are in very, very deep trouble. And so I, as a sometimes technical person, I take a great deal of comfort out of listening to the discussions of field strengths and ohms and gears and cathodes and, you know. But that—and they are not the problems, Mr. Rohrabacher. We have got to find out how to prompt the private sector to begin to think seriously about making larger sums of money beyond the ELV stage that Patty Smith reported on.

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Within—since the first satellites were launched, Patty's group has shown that the space transportation area, absent carrying people, is up to $60 billion a year. In the Human Space Flight area, the total amount of money generated, until 2 months ago, was zero. Zero. Then, something like 20 million was generated, and it went abroad. That is how far off we are.

Chairman **ROHRABACHER.** Mr. Gordon suggests—and I think that might be a good thing for you to write a column about this, so—put this in the newspaper, which, perhaps, the Wall Street Journal would like to hear about this. And I think that it is—as I say, it is an insight that we could use to our benefit. And I thank you for being here today——

Mr. **ROGERS.** Thank you.

Chairman **ROHRABACHER** [continuing]. And sharing that and your other observations, as well as the other witnesses. Mr. Li, again, thank you for the good job that you always do. And, Steve, and, Dennis, thank you very much, and we appreciate it. We are going to be much closer oversight now, Dennis.

Mr. **SMITH.** We welcome you. We really——

Chairman **ROHRABACHER.** Okay.

Mr. **SMITH** [continuing]. Look forward to it.

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Chairman **ROHRABACHER.** Thank you all very much. And I would like again to thank the witnesses for testifying before us today. Please be advised, Subcommittee members may request additional information for the record. And I would ask other members who are going to submit written questions, to do so with a 1—within 1 week of the date of this hearing. And that now concludes this hearing, and so we are adjourned.

[Whereupon, at 4:30 p.m., the Subcommittee was adjourned.]

APPENDIX 1: Biographies

BIOGRAPHY FOR STEVEN JAMES HOAE4ESER

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Mr. HoAE4eser is currently assigned as Lead for National Missile Defense (NMD) program metrics development and implementation under the Program Manager's Special Projects and Program Support group. His award winning work helped lead to a highly successful NMD Technology Immersion day conducted summer of 2000 for senior executives in the Dept. of Defense, U.S. Congress and Administration representatives. Mr. HoAE4eser also acted as the Boeing NMD System Design Lead under the program's System Engineering and Integration, Integrated Product Team.

As President of Vela Technology Development, he led a team managing the development of a high-end adventure tourism space travel company. He was responsible for all day-to-day operations, developing business plans, financial forecasting, contract negotiations, capital acquisition and company expenditures. The company was established by building a team of senior experts, capable managers, and industry teammates.

As Chief Technical Advisor followed by becoming the Executive Director of the Space Transportation Association, Mr. HoAE4eser participated in and coordinated the organization's technical analysis related to U.S. and international space launch markets and was responsible for the development and implementation of this industrial trade organization's policies.

As one of three principle individuals conducting preliminary technical investigations and garnering the necessary political and industrial support needed to establish the Pentagon's Single-Stage-To-Orbit (SSTO)/ Single Stage Rocket Technology (SSRT) Program, Mr. HoAE4eser was selected as the Chief Systems and Technology Analyst to the Program Office. The SSTO/SSRT core team structured and managed the rapid low cost program approach that produced the world's first fully reusable rocket system.

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Prior to his work on the SSTO/SSRT program, Mr. HoAE4eser managed several contract support efforts and was the technical manager of the General Research Corporation space transportation and orbital transfer system database. He also served simultaneously on the Strategic Defense Initiative Organization's Advanced Launch System (ALS) action team responsible for technology evaluation and development of strategic defense user requirements.

While only a 1st Lt. in the Air Force Steve was selected over more senior officers to be the program manager responsible for developing the concept and program plans for a first time ever classified space system capability. He also acted as the principal Air Force interface to NASA for all related advanced space systems activities. Lt. HoAE4eser was also given responsibility for the identification and oversight of preliminary investigations into advanced SSTO launch system concepts and related propulsion and subsystem technologies on the Military Aerospace Vehicle (MAV) and Advanced Military Space-flight Capability (AMSC) programs. Additionally he acted as coordinator between the Trans-Atmospheric Vehicle (TAV) program office activities at Wright-Patterson AFB, OH and Air Force Head Quarters Space Division.

Steve lives in Northern Virginia with his wife Nancy and children, Mandy 19, Katie 16, and R.J. 11.

BIOGRAPHY FOR THOMAS F. ROGERS

Thomas F. Rogers is a physicist, a communications engineer, and a private investor. He is Chief Scientist of the Space Transportation Association and Chairman of his family's private operating foundation, the Sophron Foundation.

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He holds B.Sc. (Providence College) and M.A. (Boston University) degrees in physics, and has held professional positions with university, industrial, government, and not-for-profit organizations. He has held senior Federal government positions.

His scientific work focused on ultrasonic propagation effects in solids and electromagnetic propagation effects in the Earth's atmosphere. He made the first photographs of ultrasonic beams in a solid and discovered electromagnetic-acoustic effects in nickel. He made the first calculations of atmospheric gaseous absorption at wavelengths between the short centimeter and far infrared electromagnetic regions, and he led an experimental group that employed aircraft to explore distance and altitude dependencies of tropospheric and ionospheric scatter radiowave propagation modes.

I He did research and development work during World War II at the Radio Research Laboratory of Harvard University and, later, at the Bell and Howell company and the Air Force Cambridge Research Center.

While at the Air Force Cambridge Research Center he was a member of the group that first compressed video information and transmitted digital data *via* telephone lines, and he headed a national group that worked on the guidance of our first intercontinental ballistic missile, the Atlas. Also, he organized both a radio wave propagation and a communications laboratory, the latter of which he headed.

He organized, and headed, the Communications Division of the Massachusetts Institute of Technology's Lincoln Laboratory and was a member of the Laboratory's Steering Committee. That Division transmitted the first television signals *via* an orbiting spacecraft, establishing a microwave circuit that spanned the United States. And it advanced communications with remote, submerged submarines.

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First as an Assistant, then a Deputy, Director of Defense Research and Engineering in the Office of the Secretary of Defense, he was responsible for research and development supporting the command and control of our nuclear strike forces. He provided the basic design of the world's first global satellite communications system and oversaw its acquisition and initial deployment. He initiated work on mobile satellite communications. He conceived of using satellites for navigation and position-fixing, and prompted Defense studies that led to the GPS–Navstar system. And he supported the earliest work on high-energy lasers.

He was the first Director of Research in the Office of the Secretary of Housing and Urban Development, where he inaugurated Federal urban research and development, and helped found the Urban Institute.

He was a member of a group of the President's Science Advisory Committee, and a member of the Federal Council on Science and Technology. He was a Vice President of the Mitre Corporation.

For the past twenty-five years he has been an advisor to several Federal Executive and Legislative Branch offices, including the Departments of Defense, State, and Commerce, the Federal Aviation Administration, the National Aeronautics and Space Administration, the Voice of America/United States Information Agency, and the Federal Communications Commission. He has also participated in several studies on space, communications, and health service delivery conducted by the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and their National Research Council.

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He was a member of the National Academy of Sciences/Institute of Medicine/Robert Wood Johnson Foundation group that created early emergency medical systems/services, including the 911 emergency number, in over forty locations across the United States.

In the civil space area he was a member-at-large of many professional groups that advised the National Aeronautics and Space Administration on space applications. He was a member of NASA's Space Program Advisory Council and the National Research Council's Space Applications Board.

He directed a study of Civil Space Stations and the U.S. Future in Space for the United States Congress as a consultant to its Office of Technology Assessment. He is particularly concerned with opening up space to the general public and reducing the cost of space infrastructure.

The Space Transportation Association is concerned with expanding space transportation services and increasing their efficiency and, in so doing, seeing much more use made of space. Most recently, he directed the Space Transportation Association portion of the cooperative STA–NASA study on space tourism.

The Sophron Foundation established pioneering multi-county programs in Northern Virginia for housing the elderly in crisis. These were later taken over and operated by the counties. It supported a dental care program for the disadvantaged in one of the counties, and it inaugurated and continues an orthodontic program for disadvantaged children. It supports novel civil space initiatives, and is now emphasizing the conduct of life sciences/biomedical research in Low-Earth-Orbit of potential importance to the general public.

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He is a member of a Fairfax County, Virginia, advisory committee that is concerned with improving the delivery of health and social services to the County's frail and elderly population.

He has published over fifty professional papers and book chapters, has lectured widely and has testified, oftentimes, before the U.S. Congress.

He has received several professional awards, the most recent (1999) the NASA Distinguished Public Service Award.

He is a Fellow of the Institute of Electrical and Electronics Engineers and is a member, and former Chairman, of its Aerospace Policy Committee.

He is a member of the Cosmos Club. He is a member of the International Academy of Astronautics. He is on Boards of Directors of three companies that are pursuing civil space business interests. His professional biography appears in *American Men and Women of Science* and *Who's Who in America.*

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APPENDIX 2: Answers to Post-Hearing Questions

RESPONSES TO QUESTIONS

Submitted by Dennis Smith; questions proposed by The Honorable Dana Rohrabacher, Chairman, Subcommittee on Space and Aeronautics, Committee on Science, U.S. House of Representatives

QUESTION 1: Mr. Smith, what is the process for determining the top level requirements and program goals for the Space Launch Initiative? Why did NASA cancel the X–33 and X–34 programs?

ANSWER 1: NASA used the results of the Space Transportation Architecture Studies (STAS) as the basis for formulating the top-level program goals of the Space Launch Initiative (SLI). The STAS were NASA-sponsored, industry-led studies conducted in four phases and concluded in the summer of 2000 to identify private sector options for reducing NASA's launch costs. The STAS results led NASA to establish top-level goals for SLI in safety, reliability, affordability, commercial convergence, competition, assured access, and evolvability. Building upon the findings of the STAS, NASA also developed an evolved set of missions and needs and solicited industry input on innovative ways to address potential future NASA requirements with commercial systems. Industry teams were asked to evaluate the impact of individual mission requirements against costs. In response, the industry teams generated a diverse set of preliminary architecture options that could meet commercial needs as well as perform the NASA-unique missions. This integrated set of requirements and mission needs served as the initial set of requirements for the Space Launch Initiative. The overall goal of SLI is to substantially reduce the technical and programmatic risks associated with the development of a 2nd Generation RLV. The 2nd Generation RLV program includes a Systems Engineering and Requirements Definition phase, as well as a Risk Reduction phase. The Systems Engineering and Requirements Definition phase will develop the detailed technical and programmatic requirements necessary to link technology to technical and business risk-reduction efforts. The Risk Reduction phase will develop and maintain the system level requirements to meet the safety, reliability, affordability, competition, commercial convergence, assured access, and evolvability goals. NASA has established an independent External Requirements Assessment Team (ERAT) to review and revise these requirements at regular intervals leading up to the mid-decade SLI competition.

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Early SLI planning was based on the successful flight demonstration of both the X–34 and X–33 vehicles. When technical and programmatic difficulties were experienced, resulting in schedule slippage and requiring increased investment by NASA and our industry partners, NASA reviewed various options for resolving these problems.

The X–33 Cooperative Agreement required industry to bear the burden of increased costs on the program. However, Lockheed Martin made a decision last year that the current commercial market could not justify their private investment to fly the X–33. NASA was forced to choose the best option of several unappealing options to protect the taxpayers' interests: (1) increase the U.S. Government's investment in the program by hundreds of millions of dollars; (2) cap the program at the amount agreed in the X–33 cooperative agreement, thereby eliminating any possibility of flight; or (3) allow the X–33 to compete for additional funds within the Space Launch Initiative. NASA chose the latter approach, so that we could assess whether added investment in the current project would provide the best approach to meeting SLI goals, or whether the investment should be made in other critical risk areas such as propulsion system design, development and testing, and crew escape technologies.

As a result of open competition via NRA 8–30, we determined that the cost/benefit of the X–33 did not warrant additional government investment and SLI funds could contribute more to our overall goals if they are applied to higher priority areas. The X–33 cooperative agreement expired at the end of March. Lockheed Martin retained the option to complete the program with their funding and has continued discussions with the Air Force to assess other funding sources to complete the program.

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Like X–33, NASA decided that any additional funding for X–34 risk reduction should be competed within the SLI evaluation process. We evaluated the project within the context of SLI and did not enter negotiations to continue the project. We suspended all X–34 activities and are working with Orbital to close out the contract and disposition the hardware according to contract terms.

QUESTION 2: Mr. Smith, the X–37 has received past support from both NASA and the Air Force because of its potential in improving orbital flight operations. In light of NASA's difficulty in successfully completing experimental RLV flight demonstrator programs, does NASA intend to fund the X–37?

ANSWER 2: The X–37 provides one of several options for obtaining the flight data to support the advancement of key technologies. NASA is currently in discussions with the contractor and Air Force to define a viable program plan that directly supports the goals and objectives of SLI. Until that time the X–37 program will continue under the existing, funded cooperative agreement.

QUESTION 3: Mr. Smith, the FASTRAC Single-Stage Engine development program was a two-and-a-half year NASA design project intended to support the X–34. According to Art Stephenson, the FASTRAC engine development effort was solely an educational exercise. If true, wouldn't it have been far more beneficial to learn how to build a flight ready engine? Does this mean that the X–34 Program was solely an educational *exercise as well?*

ANSWER 3: The FASTRAC (MC–1) engine was designed by MSFC engineers and built and assembled by contractors. The engine design was developed to demonstrate low cost propulsion technologies and design. A benefit to the NASA workforce was that it provided NASA engineers valuable expertise in the design and test of rocket propulsion systems. The expertise gained through the process is now being applied to the SLI propulsion activities.

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The engine development was successful and achieved a high level of maturity, as it accumulated more that 880 seconds of system level testing during 42 hot-fire tests. Several engines were assembled and one was integrated into the X–34 vehicle prior to the X–34 program cancellation. We anticipate that the technologies demonstrated in the FASTRAC program will benefit future launch vehicle efforts.

The X–34 was not an educational exercise—the program was developed as a demonstrator of key technologies associated with rapid operational turnaround of low-cost rocket vehicles.

QUESTION 4: Mr. Smith, in addition to demonstrating reusable launch vehicle technologies, the X–33 program also sought to reduce the cost of ground launch operations for RLVs. How will your agency advance ground- and flight-operational techniques intended to reduce RLV operations costs in the aftermath of the X–33 cancellation?

ANSWER 4: Within the 2nd Generation Program structure, there are 10 task areas. Task area 4 is dedicated to Operations. Under the initial round of contract awards, four companies were awarded contracts in this area —Boeing, Sierra Lobo, PHPK Technologies, and Lockheed Martin. Focused efforts are to include the investigation of propellant densification and loading, advanced checkout and control systems, autonomous operations, improved umbilical systems, and improved vehicle tracking and communication systems. In addition, the Kennedy Space Center is leading several tasks focused on operational improvement, the architecture definition contractors are modeling the integrated systems to define requirements and potential efficiencies, and the 2nd cycle of NRA 8–30 will likely contain additional requests for operations technology ideas from industry.

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The Kistler flight demonstration contract and X–37 will also provide operations data in a flight environment.

QUESTION 5a: A continuing program goal for the Space Launch Initiative in FY 2002 is for NASA to use privately owned and operated RLVs in support of its civil space missions. Currently, FAA's regulatory role is to license all U.S. commercial launch operations. How does FAA licensing commercial launch services procured by NASA impact the 2nd Generation RLV Program schedule?

ANSWER 5a: The 2nd Generation RLV program is looking at and defining the impact of licensing RLVs.

The final STAS studies included a contract with Space Access Aerospace, working with the FAA to study design requirements that would simplify certification processes. These studies will continue within the total integrated systems engineering processes and will be based on emerging, competitive architectures. We are also working with Kistler to understand their regulatory and licensing experiences with the K–1 vehicle. NASA and the FAA expect that the bulk of the regulatory activities will be performed during full-scale development after the mid-decade competition and those efforts will be improved by the inclusion of regulatory requirements in SLI studies and design efforts.

QUESTION 5b: How does NASA plan to coordinate with the FAA concerning launch safety issues involving second-generation launch architectures?

ANSWER 5b: NASA is contracting with industry and working directly with the FAA to understand regulatory and launch safety issues. We are also establishing an independent market- and business-related think-tank to investigate innovative methods for commercialization of the 2nd Generation RLV launch service.

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QUESTION 6: Can you explain the management structure for the Alternative Access to Station investment area within SLI? Will this program remain under your jurisdiction at the Marshall Space Flight Center?

ANSWER 6: The Alternative Access to Station (AAS) project is an integrated project managed within the 2nd Generation RLV program office. The project is intended to procure the capabilities necessary to provide alternative cargo delivery to the ISS. Program formulation for the AAS program is nearing completion and is being integrated between the Human Space Flight and AeroSpace Technology Enterprises to assure complete integration of AAS investments to ISS requirements. NASA will initiate additional contracting activities in the near future once the plan is fully coordinated with the Administration. I will be glad to continue briefing you and your staff as program decisions are made.

QUESTION 7a: Since the inception of the Space Launch Initiative, NASA has stated that the purpose of the Alternate Access to Space Station (AAS) is to purchase commercial contingency and Shuttle-backup cargo delivery services to the ISS. Your statement indicates that NASA has already awarded, as part of the NRA 8–30 procurement, a technology demonstration mission under MS that will develop rendezvous and docking capabilities for use in future 2nd Generation RLVs. The Committee has been made aware that approximately $80 million in other ISS-related flight demonstrations is being funded from the AAS budget.

To what extent is AAS now focused on demonstrating technologies for cargo delivery to the ISS, as distinct from buying services?

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ANSWER 7a: Alternative Access funding is intended to enable NASA and private industry to establish and use alternative means of access to the International Space Station. These funds will be used to purchase services when they become available, and NASA is currently reviewing procurement options for pursuing those services or developing the required technologies. To enable some providers, key technological gaps may need to be developed and demonstrated first, including proven, domestic automated rendezvous and proximity sensors, software, and avionics.

The Alternate Access to Station (AAS) mission will provide important benefits, including contingency capability, operational flexibility, increased competition, near-term flight opportunities, and development of capabilities to meet Station-unique needs. Additionally, the U.S. government market served by AAS will help incubate the business base for the 2nd Generation Reusable Launch Vehicle (2GRLV). The Office of Aerospace Technology (OAT) will work closely with the Office of Space Flight (OSF) International Space Station Program Office (ISSPO) on AAS, and NASA envisions that funding for Alternative Access may be transferred from the OAT account to the OSF account when services become available for acquisition.

QUESTION 7b: How much of the AAS six-year budget runout of $318 million will be obligated to buy services, or initial demonstrations of services, as distinct from technology development and flight tests?

ANSWER 7b: The total expenditures made available for services will be determined by the outcome of the initial project phase, which runs through FY 2002.

A complete project plan is in final review and will be made available to you as soon as it is completed and coordinated with the Administration.

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Responses to written questions submitted by Cong. Gordon resulting from the June 20, 2001, hearing at which Dennis Smith testified on the Space Launch Initiative.

QUESTION 1a: NASA has indicated that reusable launch vehicle (RLV) design concepts will have attained a Preliminary Design Review (PDR) level of maturity by the end of the Space Launch Initiative in 2006.

What level of vehicle design maturity has industry indicated will be required if sufficient investment capital is to be attracted to allow private development of an operational RLV: PDR, Critical Design Review (CDR), or flight-tested full scale prototype?

ANSWER 1a: Private investment in the 2nd Generation RLV architecture will be driven by technical, design, business and market risks. The SLI program will balance investments to address risks in each area; however, NASA does not expect that full-scale development of the system will be privately financed under the current market conditions, whether we get to PDR or CDR by 2006.

There are insufficient resources to fund a flight-tested full-scale prototype within the current 2nd Generation RLV budget, but it should be noted that the Space Transportation Architecture Studies that led to the SLI indicated that such prototypes were not needed prior to full-scale development.

While industry might not be prepared to commit to funding in 2006, SLI will get us to the point where a full-scale development decision can be made, whether by the Government or private sector, with significantly reduced overall risk. The program will mature the technology and design to assure that a 2nd

Generation RLV architecture can address both commercial and civil launch needs, thus enabling the highest feasible launch rate combined with the most reliable launch service. In most technical areas, the SLI program will mature the designs to a PDR level, but will combine the design activities with subscale and large-scale hardware testing to assure that the designs are capable of meeting commercial and civil reliability, affordability and performance needs. These activities will be integrated through rigorous systems engineering and requirements control to insure that the integrated system can be built and operated consistent with the program goals. SLI will also invest in the design tools and advanced design environments that will enable highly efficient, cost-reducing design of the full-scale 2nd Generation system.

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To provide the greatest chance of an affirmative decision to proceed with full-scale development, all aspects of the program will be externally reviewed and sanctioned on a yearly basis to assure us that all investments are relevant to at least two competing, commercially viable systems.

QUESTION 1b: How much money in addition to the $4.8 billion to be expended in the Space Launch Initiative do you estimate would be required to achieve the CDR milestone? the flight-tested full scale prototype milestone?

ANSWER 1b: The SLI program does not have enough information at this time to estimate the additional costs associated with the design and development of the full-scale system. Historical estimates are derived from weight-based algorithms that do not accommodate the anticipated breakthroughs in technology and the design efficiency that will be gained from the SLI program. Therefore, SLI is investing in developing high-fidelity cost estimating capabilities to define realistic and credible design and life-cycle costs for the full-scale development effort. We are establishing a separate think-tank activity to challenge traditional estimating techniques and develop new methodologies that better capture the technical and design advances that will be achieved. Costs associated with the development and certification of the baseline Space Shuttle system were on the order of $35–40 billion to complete the flight-testing and certification of a full-scale prototype in today's dollars. We anticipate that those costs could be reduced by two-thirds due to SLI investments in design, technology and tool development.

QUESTION 1c: If industry indicates that additional development beyond the PDR milestone will be required before sufficient private investment could be attracted, would NASA seek additional funding for such development activity?

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ANSWER 1c: NASA will assess the progress of the 2nd Generation RLV program, along with the state of the launch services market, at multiple critical decision points. At those key milestones we will work with our stakeholders in the Executive and Legislative branches to decide how much, if any, additional funding will be requested to enable us to proceed with full-scale development.

QUESTION 2: How sensitive to flight rate is the cost per pound to orbit for reusable launch vehicles?

ANSWER 2: Flight rate is one of the most significant drivers in reducing the cost of delivering payloads to orbit. However, it is not the only factor, and the relative importance of the cost elements depends on the launch system architecture involved. With any reusable system, the size of the initial investment is a significant factor, as is the expected life of the vehicle, which is why we are concentrating so hard on bringing down the development and first unit costs, while significantly increasing the safety and reliability of the systems. Recurring operations costs are obviously major contributors as well, and we are investing a significant portion of the 2nd Generation RLV resources in operations technologies. In addition, industry studies have indicated that as we increase the safety and reliability of the launch vehicles and their associated ground support and operations systems, cost per pound of payload will benefit from reduced insurance rates for payloads.

QUESTION 2a: For the vehicle architectures under review in the SLI, what is the RLV flight rate that would be required to achieve a cost per pound to orbit of $1,000?

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ANSWER 2a: Flight rates will be specific to particular architecture and the design reference missions that it can support. Estimates in most architecture studies have been in the 30–40 launches per year but include a flexible architecture that can fly commercial, defense, and civil missions in varying configurations. SLI will continue to investigate the impact of flight rate and assess realistic operational limits and will include that data in our reviews. We would be glad to provide updated data as it matures.

QUESTION 2b: What would be the impact on cost if the market only could support a Flight rate half as big?

ANSWER 2b: As described in the above response, at this time we can not make an accurate assessment based upon the maturity of the data at this time. I will be happy to provide additional details on the specifics of flight rate versus cost per pound as it becomes available. A key point to consider is other factors that affect cost such as inherent reliability and operational efficiency. All factors are being considered to develop a complete system level assessment of cost, reliability and performance factors and can be made available to you as they continue to evolve and mature.

RESPONSES TO QUESTIONS

Submitted by Allen Li; questions proposed by The Honorable Dana Rohrabacher, Chairman, Subcommittee on Space and Aeronautics, Committee on Science, U.S. House of Representatives

Subject: NASA's X–33 and X–34 Programs

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Dear Mr. Chairman:

On June 29, 2001, you asked me to provide additional comments on several issues that I raised in my June 20, 2001, testimony before your Subcommittee on areas the National Aeronautics and Space Administration (NASA) needs to address in managing its Reusable Launch Vehicle Program. I am pleased to submit the following comments for your consideration.

1. What are your conclusions regarding the usefulness of cooperative agreements as a NASA contractual mechanism and should they be terminated?

Cooperative agreements with commercial firms, such as the one used in the X–33 Program, can be useful in limiting the government's investment in a research and development project by providing for cost sharing with private industry. However, such agreements can pose risks to the government when the extent of private investment is based on assumptions about the potential commercial viability of a project.

Under the Federal Grant and Cooperative Agreements Act of 1977,(see footnote 11) a procurement contract is used when an agency's purpose is to acquire property or services for the direct benefit to the government. When the agency is merely transferring money to a commercial entity to carry out an activity with a public purpose, and there is substantial government involvement, the act generally requires the use of a cooperative agreement. This was the case for the X–33 Program. NASA's specific objective was to demonstrate the technical, operational, and business feasibility of a single-stage-to-orbit commercial reusable launch vehicle, and it sought to work with private industry in doing so. Given the purposes of the X–33 program, NASA's use of a cooperative agreement in this instance was in accordance with the act.

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The X–33 cooperative agreement was NASA's first large-scale attempt to implement a program using this method. Previously, NASA had used cooperative agreements to implement relatively small programs, mostly science-related efforts at academic institutions.

In terms of potential usefulness, the X–33 cooperative agreement limited NASA's exposure to cost growth and allowed industry to embark on such a program at relatively modest investment. NASA's industry partners assumed the risk of cost growth in exchange for the prospect of a competitive edge and potential economic benefits.

However, as we indicated at the hearing, the business-related assumptions initially underlying industry's willingness to assume the risk of cost growth did not remain valid. The anticipated demand for commercial launch services did not materialize. Eventually, program cost growth, difficulties developing the needed technologies, and weakened launch market projections undermined the anticipated economic benefits. Since NASA's cooperative agreement policy limited its contribution to a fixed amount, the X–33 Program, in effect, took on aspects of a fixed-price contract for basically a research and development program.

2. What was the reason behind NASA's aggressive and rapid-style management of the X–33 and X–34 programs?

The 1994 White House Space Policy established a goal to make a decision on the full-scale development of a single-stage-to-orbit reusable launch vehicle by the end of calendar year 2000. To meet this goal, NASA implemented the Reusable Launch Vehicle Program, incorporating a "fast-track" management approach and "new ways of doing business." A key element was the creation of industry-led partnerships. NASA believed that private industry, with limited government involvement, would be able to develop these vehicles, which incorporated new and unproven technologies, more rapidly, cheaply, and quickly than could be done by NASA using its traditional acquisition approach.

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3. Your written testimony stated that NASA plans to generate adequate program cost estimates for gauging management reserves in the 15 to 20 percent range as a way of avoiding problems encountered in the X-vehicle programs. You expressed concern as to NASA's timeliness in preparing these cost estimates. Why?

In May 2001, NASA awarded the first contracts under the 2nd Generation Reusable Launch Vehicle Program. At the time of our testimony, we reported that the program manager planned to update the cost estimates this summer before NASA conducts a separate, independent technical review and cost estimate in September 2001. We believe that program cost estimates should have been completed and available prior to the award of any contracts in order to adequately assess the reasonableness of contractor proposals and the sufficiency of reserves set aside to meet the risk inherent in these proposals. NASA's own program guidance requires that such cost estimates be prepared before proceeding into program implementation.

Other NASA programs, such as the International Space Station and the Propulsion Module Project, have also experienced schedule delays and incurred additional costs due to design changes and program management problems. Timely and realistic cost estimates and budgets would help ensure potential risks are identified and the cost to resolve such risks is included in the project plan. Further, adequate reserves help protect the funding of other ongoing programs that otherwise might be used to cover the cost growth.

4. How much did the lessons learned in the Young report influence NASA's management style regarding the restructured X–34 Program?

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The Young report(see footnote 12) was a NASA-initiated study assessing the causes of the failure of two missions to Mars—the Mars Climate Orbiter and the Mars Polar Lander—and other deep space missions. It would be difficult to quantify the extent that the Young report or any of NASA's internal reports influenced a particular change to the X–34 Project. We did find that NASA restructured the plan for the X–34 Project in response to both X–34 Project technical reviews and other internal assessments of NASA programs, including reports of the failed Mars missions, the Shuttle wiring problems, as well an assessment of NASA's approach to executing its "Faster, Better, Cheaper" projects. X–34 Project management reviewed these reports and assessments, identified common problems, and took corrective measures to prevent the same problems from reoccurring with the X–34 Project. For example, NASA consolidated the X–34 vehicle and engine projects under one NASA manager and relegated the contractor to a more subordinate role. The restructured plan also added several risk mitigation tasks.

If you have any questions about this letter or need additional information, please call me on (202) 512–4841. Copies of this letter are also available on GAO's homepage at *http://www.gao.gov* Key contributors to this letter included Jerry Herley, Noel Lance, Carlos Garcia, Charles Malphurs, and Cristina Chaplain.

Sincerely yours,

Allen Li, Director, Acquisition and Sourcing Management, GAO

RESPONSES TO QUESTIONS

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Submitted by Steven J. HoAE4eser, 5970 Burnside Landing Drive, Burke, Virginia 22015

Questions submitted by Congressman Dana Rohrabacher, Chairman, House Subcommittee on Space and Aeronautics, Suite 2320 Rayburn House Office Building, Washington, DC 20515–6301

Dear Congressman:

It is with deep concern that I provide responses to the additional questions submitted to me by the House Subcommittee on Space and Aeronautics regarding the Space Launch Initiative (SLI) program in your letter dated June 29, 2001. Without changes, I fear this program mistakenly delays the production of near term RLV system capability risking further loss of American Global space transportation leadership to foreign competitors.

However first, I would like to clarify for the record that I am an employee of the Schafer Corporation not Boeing. Schafer however is currently under a subcontract to the Boeing Company on the National Missile Defense program. I work at an on-site Boeing facility as part of the subcontract terms.

Now in response to the Committee's questions for the record of the June 20th Hearing submitted to Steve HoAE4eser, I am please to submit the following responses.

Question: Mr. HoAE4eser, it is anticipated the SLI will produce reusable launch vehicle hardware for possible systems integration beginning in 2003, whereas the DC–X Program delivered flight worthy hardware two years after final review of the concept development phase. Why can't the 2nd Generation RLV Program produce flight hardware ready for use within three years?

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No program management or technical obstacle exists today that would prevent the production of a 2nd Generation RLV Capability Demonstrator within three years. My research and experience indicates that using existing and emerging technology (when needed) such flight hardware could be produced and be ready to fly an initial series of tests for around the $900 million NRA funding projected by NASA. Included in this program would be key hardware and software subsystem technology refinements to provide prudent back-ups for risk areas. Lots of advanced technologies would be nice to have, but are simply not necessary. This is using technology wisely.

However, as currently structured the projected NASA 2nd Generation RLV investment produces only a) a set of planning documents of as yet unknown quality, design detail, and content, and b) a set of hardware and software technology tested to an as yet unknown level of technical maturity. The current 2nd Generation RLV program schedule logic I have seen would seem to indicate that NO flight worthy hardware will be available even in prototype form until beyond 2005. It needs to be emphasized that NASA's current SLI strategy for the first three years will not produce plans for vehicle designs and the vast majority of the hardware and software technology products will not be flight worthy. An additional 7 year multi-billion dollar program is required under the NASA plan to design, build & integrate flight worthy hardware.

Question: Mr. HoAE4eser, you stated that there are flaws in the SLI's "foundational premise" for making program decisions? What is the specific nature of these flaws?

The foundational premise for SLI's program decisions are based on a belief by many in NASA that *technology is not yet ready to build 2nd Generation RLVs.* NASA has convinced themselves that the failure of a few very high-risk subsystems means that we cannot yet build reusable launch vehicles (RLVs). One need only review the Marshal (Space Flight Center) press releases following the X–33 cancellation to see this bias. The reality is that these programs proved only that the subsystem designs selected and tested by NASA for the X–33 and (as Mr. Li testified) the high-risk program approaches NASA used were flawed.

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Mr. Chairman, I have researched numerous workable RLV designs, at least one dating from as far back as the late 1960s. Our analysis on the Pentagon's Single-Stage-To-Orbit (SSTO) project in the early to mid 1990s was based on actual DC–X flight data and using available technology wisely, showed that we could build and fly an equivalent 2nd generation RLV capability demonstrator in just over three years. I am also aware of at least three workable aerospace contractor RLV designs that exist today which apply existing or emerging technologies that appear to meet *or exceed* NASA's 2nd Generation goals and objectives. Why are these design concepts so visibly absent from the discussion table?

Of greater concern is that this foundational premise is being used to drive our 2nd generation RLV programs backward not forward. By justifying technology selection and SLI program management decisions using "architecture designs" rather than to vehicle system designs our Nation's RLV developments are pushed back three years or more from flight hardware.

It is very important that the Committee fully understand the significant impact of NASA using an "architecture design" basis for SLI decisions. An architecture design in aerospace is a term that is far less concrete than the use of the word in the building construction industry. In construction, an architectural design means a full and complete site design that includes the landscaping, all the parts of a building, and detailed design drawings. This architectural design can be used directly and immediately by the builders thus reducing the project cost and schedule to a minimum.

In aerospace (especially in as it is used in the SLI program), an architecture design provides a list of aerospace systems along with their general performance that address the needs of a flight operations environment. Unlike the construction industry, the aerospace architecture design does not select or provide detailed system designs only general system concepts. More over, the aerospace architecture designs can be easily manipulated. The required system performance can be adjusted to fit the performance of an existing technology or to justify the need for an advanced technology.

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Linking the SLI program decisions to innocuous architectures designs leaves tremendous room to justify almost any technology decision. This could make direct accountability for SLI program decisions by the Committee virtually impossible.

I recommend that the committee obtain or receive summary briefings of the original contractor Space Transportation Architecture Study results and compare them with those provided through the NASA filter. My experience is that such comparisons of the raw data with those filtered by higher management are often highly enlightening.

Question: Mr. HoAE4eser, what do you think needs to be done to avoid the problems that existed in the X–33 and X–34 Programs?

The answer is not what I think but rather that the managers of this program must understand and apply time proven rapid program management rules as was accomplished so successfully on the Pentagon's SSTO/Delta-Clipper Experimental program. In summary there must be:

A small highly competent government management team; careful selection of people with track records of success for pivotal positions is essential

Daily contact with contractors to avoid misunderstandings and cut down on correspondence

Task/on-call analysis teams and seasoned subject matter experts

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A short single line of authority; the program manager should report directly to the Deputy Administrator or higher

Minimize micromanagement—(but establish and maintain a system for management visibility)

Encourage and reward innovation at all levels

Use technology wisely; avoid technology development programs

Agreement to requirements prior to award and contracting

Timely and adequate funding

Do not over engineer the design; better is the enemy of good enough.

Question: Mr. HoAE4eser, do you see success in NASA exercising close and continuing oversight of the technology development phase of SLI?

Regardless of how you define success, NASA must exercise management visibility. This paramount goal can only be accomplished using timely reviews (weekly but not less than monthly) by reviewing metrics in program management team meetings.

Metrics are measurements for the purpose of determining project progress and overall condition by observing the change of the measured quantity over time. Management of technical activities requires that three basic types of metrics be established: 1) Product metrics that track the progress of hardware, software and document development; 2) Earned Value which tracks conformance to the planned schedule and cost, and; 3) Management process metrics that track management activities.(see footnote 13)

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Mr. Smith mentioned Technical Performance Measures (TPMs) would be used on the SLI program. Properly established, these will track performance refinement for technology products. TPMs are only a small part of the set of rigorous metrics that should be collected in a management visibility system or MVS. NASA should provide evidence that such a MVS is put in place and is being used on a continuous basis for SLI management.

To assist in communicating technologic maturity to Congress and others the use of a technology maturity index has also proven invaluable. The maturity index that is being used on the contract I am currently working was actually derived from a NASA Technology Readiness Level (TRL) assessment approach. We took this TRL approach one step further by expanding it from hardware maturity into software maturity. This rating provides an excellent feel of the technology readiness for application to flight systems and would prove invaluable in tracking the progress of this program.

RESPONSES TO QUESTIONS

Responses by T.F. Rogers, Chief Scientist, The Space Transportation Association; Chairman, The Sophron Foundation

Question No. 1: "Mr. Rogers, do you believe that NASA's intent to use a privately owned and operated reusable launch vehicle for its space missions will translate into the agency procuring all its launch services in the near future, and if not, why?"

I would understand that (a) "privately owned and operated" implies "privately financed" as well; (b) its "space missions" implies *all* of such missions; (c) "in the near future" implies a time appreciably short of a decade; and (d) that, in the human space flight area, the word "launch" implies both launch and recovery, i.e., "space transportation" is a more generally accurate expression than "launch".

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NASA should be working, actively and appropriately, to see the day come about soon when it can look to our private sector to meet *all* of NASA's needs for surface-LEO space transportation of cargo and persons including astronauts, and for the propelling of space probes to great distances. There is one special case: it may be that NASA will need special Earth-Moon and/or Earth-Mars transportation of astronauts, and this capability may not be able to be provided by our private sector at the outset.

I am not as hopeful that this will come about as soon as I was before the failure of our X–33 and X–34 programs. And, unfortunately, their follow-on program, the NASA Space Launch Initiative (SLI), has such a limited focus that, unless it is appropriately amplified, I now doubt that we will see a private sector Shuttle replacement for well more than a decade—a time that I do not consider to be "in the near future".

As to "why ?" I am not now very sanguine, please see my answers, below, to the other Questions and my summary statement at the conclusion.

Question No. 2: "NASA officials have stated that coordination with the FAA would occur later in the 2nd Generation RLV Program process. In your view, Mr. Rogers, when should the FAA become involved with the process?"

Immediately.

In making decisions about what space transportation characteristics are needed, and can be provided, in a Shuttle-fleet replacement context, we must be in a much better position to do so than our present knowledge and experience will allow and that the SLI is now expected to provide. "[L]ate in the 2nd Generation RLV Program process", is too late given our need to move as quickly as possible and the present character of this Program.

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Two examples:

a) The next generation fleet should serve large private sector markets (a) in order to see space transportation unit costs come down, sharply, (b) to generate the capital needed for the private financing needed to acquire and operate the new fleet(s), and (c) to help regain the constituency in support of our civil space program (including activities such as the SLI) that has, to an important extent, been lost during the past decade.

A half dozen years ago, NASA concluded that the creation of a large "space tourism" business offered the best and earliest possibility of so doing. And it conducted a study thereof (in cooperation with the Space Transportation Association) to inquire into what our Country should do to see such a new space business created.

Thus, we have known for some time that (a) objective and acceptable "ground rules" must be established that would help to decide who, from the general public, is/is not qualified, physically, emotionally, and socially, to take a space trip in the near future; that (b) generally acceptable methods and means are devised to constrain the likelihood that "space sickness" would make such a trip an unsatisfactory experience; that (c) the time required in training prospective passengers is kept to a generally acceptable minimum, lest the potential market size be sharply and unduly constrained.

b) To date our Shuttle fleet has demonstrated that it has a fatality expectancy of 1 in somewhat more than

100 human space trips; vehicle improvements now underway should see this number judged to be 1 in some 400.

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This latter number is lower than that now attained in the U.S. commercial aviation world by roughly 10,000 times.

What level of safety should be striven for in the earliest "space tourist" business days?

The answer will have impacts upon vehicle characteristics, production and operations costs, size of market, and our space and transportation cultures. Arriving at this decision will be a matter of considerable economic and social study—study of a particularly grave and novel character—study that will take some time.

The FAA should be working in parallel with NASA to address such matters today. The analytical and experiential studies that are called for will be complex, difficult and contentious. For instance, the FAA would bring an outside and badly needed professional viewpoint to the study by the ISS government parties, now underway, of the various safety and training issues that arose in conjunction with Dennis Tito's space trip. There is no reason not to have such activities underway now, and not passed off until much later, when questions could arise about the objectivity of such NASA-led studies that did not draw upon the decades of FAA experience in the commercial aviation world.

Further, we should also see our *DOC* involved in related space commercialization matters.

Short of the Moon there is nowhere for people to abide and work; it must be provided—thus the ISS. But the U.S. acquisition cost alone of its part of the installed ISS is now judged to be well over $60 billion (without including the financing of this large public sum) and the annual Operations and Maintenance (O.&M.) costs are now expected to be some $5 billion *per* year over the next 20 years.

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In private sector commercial-industrial terms, this is a truly great sum to provide housing for a maximum of 6 people in a remote setting. If "space tourism" is to became a viable and large business (and other space business also prompted to wax) we must see to the provision and operation of LEO hotels as part of the overall "space transportation equation—hotels able to house and support many more than this number of people at unit costs reduced by orders of magnitude *re* the ISS. The fullest use should be made of our pioneering ISS experience in so doing.

The DOC has, at its National Institute of Standards and Technology (NIST), professional capabilities that relate to today's most advanced surface construction areas.

And the DOC also has had considerable experience in dealing with the problems and opportunities of our travel and tourism business—one of our Country's (and the world's) largest businesses.

Thus, the DOC should be challenged to arrive at programs to use their capabilities and experience in working with the FAA and NASA to advance the prospects of marked space transportation improvement.

Question No. 3: ''Mr. Rogers, you believe that the government agencies and the private sector should work together in transitioning from a large Federal Government space presence era to a next generation fully reusable launch vehicle private sector era. How should this issue be addressed within the context of SLI?''

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This is a difficult question to answer at the present time—and for a fundamental reason.

When a producer of aircraft (say, a Boeing) is deciding upon the manufacturing, operating, and maintenance qualities to provide in a new type of cargo- and/or passenger-carrying commercial aircraft, it must consider a myriad of technological, economic, market, traveling public preference, crew characteristics, . . .questions.

In arriving at answers, it turns primarily to the airlines—it is the airlines' business to know, intimately, the answers to such questions, and they can provide them (to a Boeing) based upon their actual operating experience.

But, in the space transportation area, we have no such recourse available to the heads of the SLI and the aerospace companies that are expected to work with NASA thereon in the design of one or more next generation vehicles. None. For there are no commercial spacelines! While we do have United Space Lines (USL) in operation, we must appreciate that USA is not driven by the necessity of obtaining the financing of vehicles, or of competition, ... There has been only *one* personally paying space trip passenger, and he was carried to/from space with the use of Russian space capabilities.

This is where we are today. That is, we do *not* have any private sector business interests dealing, operationally, with commercial space transportation activities and issues. *None.*

And I do not see any activity in SLI that will provide this badly needed information.

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We simply must focus, imaginatively, upon obtaining private sector space transportation experience in operations, maintenance, finance, market creation and enlargement, ... And we must do this as soon as possible. We must do so in parallel with the vehicle-focussed technology improvements that the SLI is working upon.

Something can be done, i.e., NASA/SLI should adopt one of the suggestions that I made in my testimony—the SLI program's "Alternative Access" element should be markedly enlarged, soon. Doing so would see an early and straightforward engagement of our private sector space transportation interests in actual production, operating, market, financing, . . .matters. That is, we would begin to obtain actual experience, and actual data and information, of vital value.

[Following is a copy of that part of my written statement.)

We must include the presence of "classical" free enterprise and competition in the entire process by which new space transportation vehicles are financed, produced and operated and used to provide various space transportation services. Free wheeling, imaginative, entrepreneurial, let's get rich, competition, with essentially all of the business decisions being made outside of NASA.

Therefore, at the outset no-more-than two page requirement document should be prepared by NASA that describes, very simply, how many people should be transported to/from the ISS each year, and how much cargo, consumables and otherwise, to support them and their ISS activities.

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In doing so NASA would demonstrate that it appreciates one of the fundamental reasons why we decided to acquire a LEO space station; that we would then be able to construct anything we wished to in orbit—of any weight, size or sophistication—almost independent of the surface-LEO vehicle payload-carrying capability. For, except for people, having an ISS and its crew allows us to assemble things in orbit, including satellites, that can be brought up in pieces, one or several at a time.

And it would demonstrate that all of the decisions regarding the vehicles, their operation, their financing and their use, are to be made by our private sector so that their utility and economic value to their owner-operators, their users, and the Country will be maximized—just as we do with railroad trains, aircraft, cruise and cargo ships, automobiles, trucks. . ..

This document would form the substantive basis for a request for competitive procurement of space transportation services to be provided by our private sector in meeting the basic U.S. ISS activity requirements.

Any and all transportation U.S. interests would be encouraged to acquire the vehicles and develop the operations that they decide could meet these surface-ISS transportation requirements. And to secure the private financing required to do so.

Once any new vehicle-fleet owner-operators has satisfied the DOT's FAA that it can meet the NASA articulated requirements while meeting appropriate FAA regulatory requirements, the Government would place an order with them for, say, the equivalent of two Shuttle trips' payload capability *per* year for, say, 5–10 years. And to pay for these services at the marginal cost ($100 million *per* trip) of such Shuttle trips. N. B. These funds would *not* come from the "Initiative" 's budget, but the Shuttle program's.

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The first contract would be made with the first owner-operator to obtain FAA approval; then the second; etc., to the extent required by the ISS needs.

The owner-operator contractor(s) would agree to employ all of its new vehicle-fleet's large operating capacity not used in meeting the contracted ISS needs to seek out, diligently, other uses for their vehicle-fleet. And, each year, to renegotiate downward the price to be paid by the Government for the services that it receives, with both party's taking into appropriate consideration the vehicle-fleet's additional revenues and profits for the year from other than ISS carrying.

With the vehicle-fleet's large non-ISS unused capability in hand and a large guaranteed government payment arriving each year, the owner-operator can be expected to explore such potentially large space transportation markets as the conduct of space sports the use of low local-force-of-gravity laboratories by scientists to conduct studies related to the diseases and disabilities of our aging population; space tourism, the dispersal of today's 150,000,000 pounds of nuclear waste material far out into space; to see one or more large space solar power (SSP) space segments installed for R&D/demonstration purposes; . . ..

Keeping the FAA's early 2001 space launch economic study in mind, and with reference to two recent passenger-carrying market studies, it is reasonable to judge that such additional space transportation markets could be built up to generate revenues of $ billions, or even $10s of billions, *per* year.

In brief, this course would be the modern space analogue of the 1920s role played by the Federal government to advance the prospects for aviation becoming soundly commercial—it then offered the public market of seeing the mail carried by air.

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DOC, DOT, DOD and NASA, and related airline, package delivery, hotel, business school, "think tanks", and other appropriate private sector interests should be brought together to see how best our Country can make the transition from today's ELV *cum* Shuttle *cum* large Federal government presence era to a next generation fully reusable vehicle primarily private sector era.

Question No. 4. "What barriers must NASA overcome to achieve convergence between civil and commercial launch requirements? Should we promote convergence between government and commercial space launch requirements?"

I continue to have difficulty in responding to the so-called requirements question.

First, let's set aside any requirements for carrying much cargo and any passengers to/from the Moon and/or Mars. If/when that day comes, quite separate kinds of consideration will have to be dealt with than what we are considering today in order to meet civil and commercial space transportation needs. And let's set aside meeting any unusual military requirements.

Then recall why we wanted a space station. While there were/are several reasons, one should be clearly appreciated here: with professionals on the station, and many kinds of tools and equipment also there, we will soon be in a position to construct anything that we wish to in LEO by sending individual elements thereof to it where they would be assembled. That is, we would be able (with one important limitation) to separate the weight and volume characteristics of any orbiting space structure from the weight- and volume-carrying capability of the surface-ISS transportation vehicle. Note that the ISS itself is being acquired in

LEO by assembling it of segments carried there by a Shuttle vehicle that has a much smaller payload-carrying capability than that required for a complete ISS. (The one exception is the minimum vehicle capability required to carry a human being to/from the ISS.)

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The Shuttle, or a vehicle much smaller than a Shuttle (depending upon overall financial considerations related to vehicle size and cost) would be fundamentally adequate. For we will soon no longer need to have the vehicle carry the volume, power, . . ., required to do up to two weeks of LEO activity involving people. That will soon be done on the ISS.

And, inasmuch as the order of $100 billion in public funds has already been spent by the U.S. to obtain the ISS, an extraordinary reason would have to be presented for proceeding to spend another great sum ($ billions/$10s of billions) to provide us with another vehicle to serve the ISS, or the Hubble telescope, or . . ..

That is, I would leave the decisions about requirements essentially to our private sector. For, in all of the requirement papers that I have seen to date, essentially no mention is made of the most important requirement at all: that *any commercial space transportation business must be conducted so as to realize a sufficient profit.* Our private sector space transportation business interests, as they ready themselves to visit Wall Street to obtain vehicle acquisition and initial 0.&M. financing, will be the ones to decide what requirements are to be met, and what kind of vehicle and what kind of operations must be in hand to secure an adequate profit. (And we should keep in mind that when L–M approached Wall Street to obtain financing commitment for the future VentureStar they were turned down, because the latter interests could not foresee a sufficient and confident profit.) And, to repeat, that is *the* requirement.

In Summary:

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It is very important that all of us appreciate that NASA's SLI focuses upon space vehicle technological improvement, *not* on the overall improvement of space transportation. And while I support what the SLI program is expected to do *re* vehicle technology improvement, the success of this program alone would not allow space transportation to be markedly improved in the terms stated/implied in Question No. 1, i.e., the next generation of vehicle-fleet(s) must, finally, be privately owned, privately operated and privately financed. For there is much more to improving, markedly, upon today's Government owned, operated and financed Shuttle fleet than improving upon vehicle technology, and NASA's SLI simply does not reflect an appreciation of this fundamental consideration.

It is not too late to see the SLI amplified in order to see it address additional important space transportation improvement objectives. Activities to do so should be underway now, in parallel with technology improvement. And it should be noted that none of the suggestions made in my testimony, and here, would call for further costly public funding.

NASA and the Congress should give these suggestions consideration. Doing so would see an early and straightforward engagement of our private sector space transportation interests in actual production, operating, market, financing, . . . matters. That is, we would begin to obtain actual experience, and actual data and information, of vital value.

(Footnote 1 return)

The X–33 was intended to be a 1/3 scale prototype of a fully-operational RLV called the VentureStar. Because high flight rates are necessary to reduce costs, the VentureStar would have to launch commercial payloads to become cost-effective. This meant it had to be a privately-owned launch vehicle, as U.S. law does not permit the U.S. Government to launch payloads into space for commercial customers. NASA also hoped to reduce the cost to the taxpayers of developing an operational vehicle by procuring launch services from the private sector, thereby paying the marginal cost of only those launch services the government needed and ensuring that the taxpayers did not foot the entire bill of developing a fully-operational VentureStar. Thus, it pursued the X–33 through a cooperative agreement with Lockheed-Martin.

(Footnote 2 return)

Rockwell International was an industry partner with Orbital Science Corporation in the development of the commercial reusable vehicle.

(Footnote 3 return)

Lockheed Martin made agreements with Allied Signal Aerospace, B.F. Goodrich Aerospace, Boeing-Rocketdyne Division, and Sverdrup Corporation for the X–33 Program.

(Footnote 4 return)

NASA's use of a cooperative agreement allowed the industry partners, and NASA, to withdraw from the agreement without penalty at any time.

(Footnote 5 return)

We reported on X–33 costs in *Space Transportation: Status of the X–33 Reusable Launch Vehicle Program* (GAO/NSIAD–99–176, Aug. 11, 1999).

(Footnote 6 return)

Audit Report: X–33 Cost Estimating Processes, NASA Office of Inspector General, IG–99–052, Sept. 24, 1999.

(Footnote 7 return)

Final Report of the X–33 Liquid Hydrogen Tank Test Investigation Team. National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama 35812, May 2000.

(Footnote 8 return)

These assessments include NASA internal reports on failures in the Mars Program, Shuttle wiring problems and an assessment of NASA's approach to executing "Faster, Better, Cheaper."

(Footnote 9 return)

A space transportation architecture is defined as an Earth-to-orbit launch vehicle, on-orbit transfer vehicles and upper stages, mission planning, ground and flight operations, and support infrastructure.

(Footnote 10 return)

Note 1: At time of appearance before the Subcommittee, Mr. Steven HoAE4eser was not employed by the Boeing Company.

(Footnote 11 return)

31 U.S.C. sec. 6301 *et seq.*

(Footnote 12 return)

Mars Program Independent Assessment Team Summary Report, March 14, 2000.

(Footnote 13 return)

Systems Engineering Fundamentals, Defense Systems Management College, Oct. 1999.

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NO INSERTS IN THIS HEARING