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REAUTHORIZING THE VISION FOR SPACE EXPLORATION

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE, AERONAUTICS, AND RELATED SCIENCES

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

ONE HUNDRED TENTH CONGRESS

SECOND SESSION

MAY 7, 2008

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CONTENTS

	Page
Hearing held on May 7, 2008	1
Statement of Senator Nelson	1
Statement of Senator Vitter	3

WITNESSES

Dickman, Major General Robert S., (Ret.), U.S. Air Force; Executive Director, American Institute of Aeronautics and Astronautics (AIAA)	29
Prepared statement	30
Johnson-Freese, Dr. Joan, Chair, National Security Decision Making Department, Naval War College	12
Prepared statement	14
Kranz, Eugene F., Advisory Board Member, Coalition for Space Exploration; and Former Flight Director and Director, Mission Operations; NASA	5
Prepared statement	9
Tarantino, Dr. Frederick A., CEO and President, Universities Space Research Association	19
Prepared statement	21
Whitesides, George T., Executive Director, National Space Society	33
Prepared statement	35

REAUTHORIZING THE VISION FOR SPACE EXPLORATION

WEDNESDAY, MAY 7, 2008

U.S. SENATE,
SUBCOMMITTEE ON SPACE, AERONAUTICS, AND RELATED SCIENCES,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Subcommittee met, pursuant to notice, at 9:30 a.m. in room SR–253, Russell Senate Office Building, Hon. Bill Nelson, Chairman of the Subcommittee, presiding.

OPENING STATEMENT OF HON. BILL NELSON, U.S. SENATOR FROM FLORIDA

Senator NELSON. Good morning, everybody.

And we are delighted to have a very distinguished panel as we discuss NASA and where it should be going. Ultimately we will try to etch that into law through the NASA authorization legislation.

The purpose of this hearing is to get the ideas of this distinguished panel as we bring to a conclusion the drafting of this legislation. We will then go into what is called a markup, which is the discussing, amending, and passing of a bill in Committee, and then sending it on, ready for action on the floor.

It's my hope that we can get the NASA authorization bill moving on a fairly rapid track. With all the other distractions of this year, such as the appropriations bills that we have to do, and particularly in the political crucible of a presidential election year, we are trying to get all of these things done.

NASA is in trouble. This little agency has been asked to do too much with too little. And that is the problem. It's my hope that, within the last 8 months or so of the Bush Administration, we can get the President and the Vice President, who set the vision for the future of NASA, to adequately fund it. And, of course, in, how many months have we got to go? May, June, July, August, September, October, November, December, 8 months, we can convince the new President to properly fund all that NASA is being asked to do. And it's a lot.

We have payloads that have to be launched by the Space Shuttle in order to complete the Space Station. Then it must be equipped. It must have supplies. And it must have scientific experiments. One of those scientific experiments is still sitting on the ground, already paid for, a billion and a half dollars. The Alpha Magnetic Spectrometer. Fifty universities and 25 nations have participated in the creation and building of this scientific experiment which will

go onboard the Space Station, but is configured to ride to the Space Station aboard the Space Shuttle.

It is a complementary experiment to the one that is going to be turned on in Geneva, Switzerland, in the next couple of months. That experiment is this accelerator that is about 15 miles in circumference and is going to smash two protons together in order for us to try to understand subatomic particles. The AMS experiment for the Space Station is a complement to that. It's going to collect subatomic particles out there in space called cosmic rays. And so, you see, NASA, at this point, can't even get around to flying the Alpha Magnetic Spectrometer to the Space Station.

If that's not enough, NASA says it's going to have to shut down Space Shuttle so it can use that money to proceed with the Constellation program, which is the rocket, Ares, and the capsule, Orion. NASA doesn't have enough money to do both, so it has to shut down the Space Shuttle first before it has the money to proceed with the Constellation program. Resulting in the situation we are now in, where we are going to have at the very least a 5-year gap. And what happens in that 5 years? We will not be able to get to the Space Station on an American vehicle. We're going to have to pay for the Russians to build additional Soyuz vehicles in order for us to get to the International Space Station, which is about $100-billion investment that we have paid $75 billion.

Now, to put it in my Southern vernacular, that's pitiful. And yet, that's the situation that we find ourselves in.

Who knows what Vladimir Putin is going to charge us. And, oh, by the way, is he going to let us have a ride? What are the geopolitics going to be like in 2013–2014? Is Russia going to be cozied up to China? China clearly has an ascendant space program. They have their sites on the moon, in the published reports, they say, 2020. That's NASA's target, as well, if we get ourselves geared up. But, at the rate we're going, we're not geared up.

And yet, this is the 50th anniversary of NASA. I didn't know they had produced a coffee table-size book on the 50th anniversary, but I started flipping through that, and, oh, all that glory came back. All of those exceptional achievements of NASA captured in those photographs.

Yesterday, John Glenn, Bart Gordon, and I introduced John Hendricks, the head and founder of the Discovery Channel, and Dr. Griffin. NASA found this old crinkled-up 9-millimeter film of some of the glory of things that have never been seen, going back to Mercury and Gemini and Apollo, and they collaborated with the Discovery Channel, digitized it, and put it into high definition television. They showed us some snippets yesterday when we announced this project. I'm telling you, when you see Ed White for the first time open up that door of Gemini and start to float freely out there, this is stuff that we've never seen, and this is all in high definition, living color. It's incredible.

The future holds a myriad of challenges, and if these trends that we see right now don't change, then the bottom line is that NASA has to do too many things with too few resources. We're going to rue the day that this occurred, because either we're going to have another accident, which everybody in the space team works day and night to avoid, but, spaceflight is risky business, or we're going

to see ourselves drift, and we're going to be overtaken by other countries, and it could be the Chinese.

I can tell you, and I know the Senator from Louisiana feels the same way, no American wants us to be a second-rate power in space. We were before, when the Soviets took the high ground. And with a lot of grit, determination, and political will, we decided to overcome. And we did. And we have. And we still are, every day, overcoming. But, that could be slipping. And we don't want that.

So, the purpose of this hearing is to find out what you think from the experts. Where do you think we ought to go? And then we'll be fashioning this authorization bill.

So, let me turn to our Ranking Member, Senator Vitter.

STATEMENT OF HON. DAVID VITTER,
U.S. SENATOR FROM LOUISIANA

Senator VITTER. Thank you very much, Mr. Chairman.

I agree with all of your comments and all of your perspective. This is not a partisan issue, this is not an ideological divide. I agree completely.

And, indeed, as a conservative, I believe the Federal Government should concentrate on select things that really only the Federal Government can do properly or adequately. And, at least for the time being, well into the future, space is definitely one of those things which can also have enormous benefit to other advances for our economy. So, I agree with you completely, and I want to thank you for this hearing, but also for this hearing in the context of a path leading to the drafting and introduction and passage—this year, hopefully—of a NASA reauthorization bill.

I know the conventional wisdom up here is that nothing can happen this year. Well, I don't buy that conventional wisdom in a lot of respects, and I believe a NASA reauthorization bill can disprove it; and I think we can do it this year, and we should sure as heck try very, very hard, for all of the reasons you have laid out.

We do have enormous challenges in moving forward with our space program. We're facing, as you said, a period of time when, for purely budgetary reasons, we'll have no U.S.-owned or U.S.-based option for delivering crews and cargo to what will finally be a completed International Space Station, including the U.S. National Laboratory finally ready to be used for research, promised, really, for the past 15 years. And in order to protect that investment, in order to minimize that period of time when we don't have that capability, in order to do the research we've been building toward for 15-plus years, we need to look very hard at this gap, and shrink it, and mitigate it in any way possible.

I think that's very important—again, for all the reasons you have laid out. Even the NASA Administrator, Dr. Griffin, has called the current situation, "unseemly in the extreme." And I believe that's an understatement.

So, this hearing is important, and this process, hopefully leading to a reauthorization bill this year, is important, to look at how we close the gap, to look at anything—the COTS Program, an acceleration of that can possibly lend to that effort; to look at how we try to come up with one to two billion additional dollars, and how ex-

actly we would best use that as we move on to the next generation of NASA.

Now, we have, understandably, focused on the challenges. I think it's important, though, to also note the opportunities. I had a great honor of meeting with Gene Kranz yesterday, and we had a great visit, and he underscored a couple of things, in terms of those opportunities.

First of all, he said, and I agree with him, that we have a truly great plan that makes a lot of sense, that is on a par or better than any plan for the next step that NASA's ever had in its history. We also have, he said, and I agree, a great administrator, who has the confidence of the whole agency and the whole community, very respected here on Capitol Hill. So, we have a lot of things going for us as we take this next big step, but if that gap is too large, the big step is going to be too big to take, folks are going to become disenchanted, and we're going to lose a lot of talent in the program, which will set us back even further.

And so, clearly our biggest challenge is to shrink and minimize that gap, and move forward with this next-generation activity to stay at the cutting edge.

Again, Mr. Chairman, thank you for your commitment to pushing that process forward through a reauthorization bill. And, like you, I'm very eager to hear the thoughts of all of our distinguished witnesses.

Senator NELSON. As we get on down the line, we will try again, like we did last year, to get additional resources for NASA. Last year, we were unsuccessful in persuading the White House Budget Office to support us in a billion extra dollars for NASA so that we could shorten the gap that Senator Vitter mentioned from 5 years down to 3 years. We are going to try to do that again. And my argument will be very simple, "Mr. President, you laid out the vision. The vision is there; but with no money, it's a pipedream and the vision does not come into reality."

That will be an effort by an awful lot of us here on Capitol Hill, in a bipartisan fashion, just as it was last year, and of which it ultimately fell because of lack of support.

Poor NASA, in the aftermath of the *Columbia* disaster, spent $2.8 billion in recovery and return to flight operations. But, NASA had to eat that out of its operating funds. That was not the case 22 years earlier, in the destruction of *Challenger*. The costs of recovery were additionally supplied over and above NASA's operating funds. So, the attempt that we will make again this year is just to reimburse NASA $1 billion of the $2.8 billion that NASA had to eat in the repair and rejuvenation after the destruction of *Columbia*.

We have an exceptionally distinguished panel. Gene Kranz, the former director of NASA's mission operations. He's best known as one of the leaders of the team of NASA flight directors that created a miracle. The miracle was bringing back three astronauts when they had an explosion on the way to the moon, and how they did that in real-time. He's the one that came up with the phrase, "Failure is not an option." How much has that symbolized the exceptional success of NASA over 50 years? Failure is not a option, and they figure it out.

In the back of the room, we're pleased to have one of the early pioneers, Wally Nelson, and his wife, Mrs. Nelson. Will you stand up and be recognized?

[Applause.]

Senator NELSON. Dr. Joan Johnson-Freese, the Chairman of the National Security Decision Making Department at the U.S. Naval War College. She has served on the National Research Council, the Space Studies Board, and Congress's Advisory Panel for U.S. Space Launch Capability Study. She has focused her research and writing on space programs and policies. She's an expert on China. I got to know her, years ago, when she was at the University of Central Florida, doing her space studies there.

Then we are pleased to have Dr. Fred Tarantino. He is President of the Universities Space Research Association. It's a private, nonprofit corporation founded back in 1969 under the auspices of the National Academy of Sciences. Their membership consists of over 100 universities in space-related sciences or engineering. He has previously served in the White House Office of Science and Technology Policy, and as U.S. Chair of a Joint U.S./U.K. Power Working Group.

And we are pleased to have Major General (Retired) Bob Dickman. He's the Executive Director of the American Institute of Aeronautics and Astronautics. They represent over 35,000 aerospace workers and students. General Dickman has served in numerous senior positions in the Department of Defense, including the Air Force's director of space programs and the Department of Defense space architect.

We are pleased to have George Whitesides, who is the Executive Director of the National Space Society. It is dedicated to the promotion of human spaceflight and exploration, as well as space education and development. It was founded in 1974 by the legendary Dr. Werner von Braun and one of the great space afficionados, broadcaster Hugh Downs. You thought I was going to say Walter Cronkite, who today still remains the number-one space afficionado. Mr. Whitesides is a member of COMSTAC. It's an advisory committee to the FAA's Office of Commercial Space Transportation.

Because of the size of the panel, I'm going to ask you all to try to keep it to around 5 minutes so it'll give us time to get into the "warp and woof" of questions. But, Mr. Kranz, I'm going to take the liberty to say that you are not compelled to obey the 5 minutes.

[Laughter.]

Senator NELSON. I want people to hear you. I want people to know what a national resource you are, and have been, as a great asset to this country.

So, Gene Kranz, talk to us.

STATEMENT OF EUGENE F. KRANZ, ADVISORY BOARD MEMBER COALITION FOR SPACE EXPLORATION; AND FORMER FLIGHT DIRECTOR AND DIRECTOR, MISSION OPERATIONS, NASA

Mr. KRANZ. Thank you very much, Chairman Nelson and Ranking Member Vitter. It's a real pleasure to have the opportunity to address you this morning.

I've been involved in aircraft or spaceflight operations for over six decades. During that period of time, I've seen our Nation grow in prosperity as a result of our investments in aircraft and space technologies.

In 1957, I was a fighter pilot in Korea, and, as we would go out on our missions to escort the reconnaissance aircraft along the DMZ, we would be advised by our radar controllers that we had Russian MiGs basically shadowing us. And the Russian MiGs had an altitude advantage of at least to 2,000 feet. Their perch position put them on the high ground; and at any time during our mission, they could choose to attack if they would cross that DMZ.

Returning from a mission 1 day in October, I was advised by my crew chief that they had heard that the Russians had launched a satellite, Sputnik. And this satellite was basically circling the globe every 90 minutes. We didn't understand what this new business of space was about, but it was obvious that the Soviet Union had raised the bar on the high ground. They had achieved a new perch position that the United States was not capable of reaching.

I spent 2 years as a flight test engineer at Holloman Air Force Base, adapting various weapons systems to the B–52, and then answered an advertisement in *Aviation Week* that indicated that they were forming a Space Task Group. They were looking for Americans, young engineers, to establish the feasibility of putting an American in space. At that time, the Soviets had at least a two-and-a-half year, possibly even a longer, lead on us. And the young engineers that we had at the Cape, at Langley Field in Virginia, Goddard Space Flight Center, were truly frustrated by the position of dominance that the Soviet Union appeared to have. We were frustrated. We saw the Gagarin and the Titov flights. We couldn't match those flights.

Finally, we answered with a John Glenn. The John Glenn mission was basically our entry into the big-time business of manned spaceflight. But, the Soviets quickly countered with a dual launch, attempting a rendezvous. So, again, it was obvious, this high ground was owned by the Soviet Union.

We continued to pursue the Soviets. And as we approached the early Gemini program, we attempted to perform America's first EVA with Ed White. But, again, the Soviets beat us to that high ground, they accomplished the first manned extravehicular operations. So, we battled for position until America reached this dominant position. We had accomplished the rendezvous during the Gemini 1976 mission.

We were concerned about the Soviets during that period of time, but we now knew we had the team in place, and we had the technology, we had the manufacturing ability, our contractors were delivering. America was delivering the systems we needed to maintain our perch position now in the high ground.

We raised the bar for the Soviets when we accomplished the lunar landing, and each one of those successive missions was basically a symbol of America's technology. We basically were able to capture the minds and hearts and wills of the people of the free world. We were leaders in space, and we maintained that leadership in space through the Skylab Program. We opened up a mar-

velous array of new sciences. We got involved in Earth resources and the solar astronomy and the medical experiments.

So, we had now raised the bar even further, from a standpoint of our earliest and probably the most productive Space Station that we had up through that date. We met with the Soviets and accomplished a relatively simple rendezvous, but we were always driven in space by this vision that we were given by John F. Kennedy. We had a vision for space. We knew where we were going.

We then moved into the Shuttle Program. The Shuttle Program, to some extent, was different, and I'd like to come back when—later on, and talk about the gap between Skylab and Shuttle. But, again, we maintained this dominant position in space with the advent of the Space Shuttle. It was a marvelous flying machine. It did everything that we had asked for. We rendezvoused, we conducted experiments in space, we recovered satellites, we deployed, satellites, we supported the Department of Defense. We were on a roll there, as Americans, with this new technology, and then we had the *Challenger* accident.

And the *Challenger* accident set us, now, back on a path where we no longer could support the DOD, we no longer could deploy the satellites. We became our own customer. We started running from the risks of our business, and we started to cede the high ground.

We are now in a position, in 2007–2008, where we recognize this high ground will be forsaken, it will be challenged. New people, new individuals, new countries, new leaders will emerge for that high ground. And I am very concerned about our Nation's ability to maintain the leadership, not only in space, but the leadership that produces the technology that keeps the economic engine of our country going, the leadership that inspires our young people, the leadership that is basically going to drive our factories and put Americans to work. Leadership is really the key. Technology drives the economic engine of our country.

In the early years in space, it was power and prestige, it was the Cold War. Now it is technology and economic benefit. These are the fruits that we harvest from our work in space. We're in great danger of losing our ability to keep this economic engine going at full throttle. And this is important, if we are to have a future. It's important to inspire our young people.

Now, back to the gap in the program. I faced a 6-year gap between the time that we had finished the Skylab Program and the time that we began preparation for launch in the Shuttle. This was the most difficult time I ever faced as an engineer in spaceflight operations, because I saw many of my very best people leave. The top leaders in the program and in the organization—my flight director stayed with us—but the mid-level managers, these are the people who came up through the programs—the Mercury, Gemini, Apollo Program. They became the risk managers. They were the ones who would take the place of those people who would retire shortly after the Shuttle Program began. So, I needed these mid-level leaders, but, basically, they didn't see that space was in their near vision. They were very aggressive, they were bold, they were mobile, so they moved into other business. We had learned a lot about space sciences from the Skylab Program, so some of them

went into the—solar astronomy, a few of them became medical doctors. I lost these people.

And they were very difficult to replace, because in the early years, most of our people came in from aircraft flight test. We had a very healthy aircraft program and emerging space program. So, we could draw people in from our contractor base, and use them. But, as we moved into the early 1980s, the Grummans had disappeared, the General Dynamics had disappeared. We did not have this source of young people that we could bring in out of our aircraft manufacturers, and, in particular, out of flight test.

So, in order to meet this need with the new young leaders, we established a boot camp to bring our people through. We took the best of the leaders that we had still remaining with us, and used these as the teachers.

So, it is important that, as you move through this gap, that NASA does not leave this—lose this generation of young people who grew up in Shuttle, went through the cauldron of *Challenger* and *Columbia,* and emerged smarter and wiser and better. It is important that we basically move this gap, basically reduce it to the absolute minimum.

Next thing is to address this question of architecture. I've been involved with two of the graybeard sessions at NASA. That is my only—the only relations I have with NASA today is to basically do a program for all new employees, a history program. I reviewed, after *Columbia,* some of the simulations, how they're training, but, basically, the graybeard activities, we had two of them related to—Jeff Hanley would bring his team in, and they would go through how the architecture was responding to the vision of President Bush. And this vision is respected in your 2005 appropriation.

This is the best game plan that I have seen since the days of President Kennedy. This blueprint for space was turned into an architecture by Hanley's and Griffin's team, and it represents the very solid foundation that we need to move further into space. I would compare it to the DC–3. I worked in a B–52. Fifty years after I worked as a flight test engineer, that system is still delivering for America. The system that Griffin's team is putting in place will be delivering for America 50 years later. It's the right thing.

So, the message that I would give to you and to the U.S. Congress is, "Stay the course. Stay on track."

A bit about the team. Mike Griffin is the finest leader I have seen in NASA in the last couple of decades. He is the leader that we have deserved. He has the respect of the working-level devils. He's built a fine team. He's got the ability to make the difficult go/no-go decisions, because there is nothing in space that's easy. There's always some ambiguity in the decisions you're making. He is the right man at the right time.

And the team that he's put in place—Bill Gerstenmayer, Jeff Hanley—I raised them. They were members of Mission Control. They were my risk leaders. They were the people who, again, grew up through *Challenger* and *Columbia.* They know what it is to make tough, visceral decisions. They're ready to do the job. Keep them in place, because, I think, in addition to the funding issue,

a big change in leadership in this program also represents a significant risk.

I would talk about the issue of public support. You know, I've seen notes in the paper that says the public support is not there. Well, I have talked to—since I've retired, I moved into the speaking and bookwriting business, I flew air shows, I did all kinds of fun stuff, but one of the things that is most enjoyable to me is to meet the public. I've probably talked to almost a million people in 700 corporate events throughout the United States. I talk to the kids. I see the energy that these entrepreneurs have, the Fortune 500 companies have. They recognize their dependence upon NASA for the technology that is going to allow them to remain in business.

Just past Monday it was, I spoke to Olympus USA. Olympus USA, probably one of the top optic countries in the—companies in the world, producing the instruments that are used for diagnostics. They are very interested in learning what NASA intends to do, where they intend to go. I speak to the young kids. I talk to kids sponsored by Sprint and Lego. I've been in inner cities all through the Northeast. I've toured Florida, I've toured Ohio. The young kids want to be astronauts, and I'd rather have them want to be astronauts than mindlessly play this *Grand Theft Auto IV* game in computers.

[Laughter.]

Mr. KRANZ. OK? It is important to inspire these kids, because if we have an education problem, it starts with motivating the kids to study engineering, math, science, and remain in school.

And finally, I'd sort of try at NASA—one final word here and then I'll turn on to these people here—my daughter works in the—for United Space Alliance, and I always get on her case because of all these big, fancy meetings they have, where it seems that the space people talk to the space people, the contractors talk to each other. What they ought to do is take some of that money—and I—and in my time-frame, Chris Kraft, my boss, would say, "Look, you go to Detroit, who are having brownouts, you talk to them about space solar power." It is time for NASA to recognize there is no free ride. We've got a long-term space program that we must get public support for, and it has to come from grassroots. It is time for NASA to direct every NASA and contractor employee to get out in the field, earn their spurs, and talk to Rotaries and the Kiwanis and the Chamber of Commerce and the church group, time for NASA to get off its duff, get out of its comfort zone as engineers. And this is right down to the lowest guy in the organization; they can do it.

So, I thank you for the opportunity to speak today, and really appreciate the work that you're trying to do.

Thank you.

[The prepared statement of Mr. Kranz follows:]

PREPARED STATEMENT OF EUGENE F. KRANZ, ADVISORY BOARD MEMBER, COALITION FOR SPACE EXPLORATION; AND FORMER FLIGHT DIRECTOR AND DIRECTOR, MISSION OPERATIONS, NASA

Chairman Nelson, Ranking Member Vitter, and Members of the Subcommittee, thank you for inviting me here today to present my views on the future of our human spaceflight program as you consider legislation to reauthorize NASA. Before we discuss those issues, I would like to offer some thoughts on NASA's past as we celebrate its 50th anniversary this year.

In 1957, the Soviet Union launched Sputnik. As someone who was present at the time, that event had a tremendous impact of the psyche of our Nation in the midst of the Cold War. Our country responded, first with the creation of NASA from the old NACA, then with the launch of the first U.S. satellites and the initiation of the Mercury program. President Kennedy's lunar challenge to a novice space industry was issued when we had only 20 minutes of human spaceflight experience. Achieving the lunar goal within the decade of the 1960s was possibly the greatest technical and scientific challenge of our age.

Meanwhile, the Soviets were moving aggressively ahead with their own human spaceflight program, starting with the orbital flight of Yuri Gagarin when we had yet to launch our first astronaut.

The Space Race was on! The U.S. was at least 2½ years behind at the start; however, America's capacity as a free nation provided the inventions, the new technology and the talented people to put us on the path to catch and then surpass the Russian space efforts. With the Gemini 76 mission rendezvous in 1965, we had moved into the leadership position in space and the lunar target was firmly in our sights.

By the end of the 1960s, we had moved ahead with successful moon landings. Our country was united in its goal, steadfast in its purpose, and unwavering in its commitment at a time when we were facing division and turmoil in other parts of our society. That united effort put America in the lead position as the dominant space power. This leadership continued through the latter part of the 20th century as we moved on to develop the Shuttle, initiate construction of the International Space Station, launch the Hubble Space Telescope, and send rovers to Mars, among many other space accomplishments. However, I caution those on this Subcommittee, others on the Hill and space industry leaders . . . our leadership role cannot be taken for granted. We face a new challenge that is even greater than what we faced during the Cold War.

Over the past 50 years . . . our country has profoundly benefited from the space program in more ways than it is even aware. In a recent report, the Space Foundation estimated that the value of the world space economy is $250 billion. So many industries—telecommunications, agriculture, medicine, Earth observation, public health and safety to name a few—have advanced and grown due to development of space technologies. Our aerospace industry is the envy of the world, employing 650,000 Americans in high-wage, high-skill jobs. It is one of our few industries that actually enjoys a trade surplus with our foreign competition. Every time NASA accomplishes a great achievement, the interest of our young people in pursuing a career in science and engineering spikes upward. When those kids graduate from college, they may not all end up working in the space program, but many of them end up with leading commercial technology businesses in Silicon Valley and elsewhere. Last, and perhaps most importantly, space plays an integral role in our national security, demonstrated most recently in our conflicts in Afghanistan and Iraq.

So, that brings to me to where we are today and for the foreseeable future. Space is no longer about the United States and Russia. The Europeans, Japan, Canada, India, and China all have active space programs, some working in cooperation with ours; others pursuing their own national objectives separately. Iran, Syria and North Korea are among the other countries that are aggressively pursuing space capabilities.

NASA plans to shut down the Space Shuttle in just over 2 years. By 2010, the Shuttle will have served our Nation with distinction for thirty years. Its final missions have been dedicated to finalizing construction of our National Laboratory in space, the International Space Station, a truly global collaboration. Still, it's an effort largely led and financed by the U.S.

NASA is now in the process of developing the next-generation human spaceflight vehicle, called Project Orion, and its launch system, Ares I. These systems are based largely on proven technologies and systems derived from the Space Shuttle and Apollo programs. In my view, this is a sensible approach from both a cost and schedule standpoint, and one well thought through by Administrator Griffin and his team. The ultimate goal is to return to the moon and to establish a lasting human presence on its surface. The moon remains relatively unexplored and also presents new and interesting scientific prospects, whether it's greater research into its unique geology or use as a fixed platform without atmospheric interference for a new generation of space telescopes. It is an exciting and dynamic initiative.

The funding stream that has supported the Shuttle will be redirected to the major development phase of Projects Orion and Ares. However, this approach, as laid out in the Vision for Space Exploration, will lead to the creation of roughly a 4½ year gap—at least! This decision and impractical, shortsighted approach was not driven

by the current NASA leadership, but rather by the preceding regime in close coordination with "bean-counters" from the Office of Management and Budget.

These decision-makers believed that grounding America's human space transportation and losing tens of thousands of aerospace jobs across the U.S. was desirable in the interests of essentially flat annual budgets. That's irresponsible, and an unreasonable budget level for an agency that currently represents only 6/10ths of 1 percent of the entire Federal budget. The decision to limit NASA to this very meager budget has been well characterized by Senator Nelson as "spaceflight on the cheap." You cannot safely, efficiently and successfully do "space flight on the cheap." While I believe the goals of the Vision for Space Exploration to push to the moon and beyond, and the subsequent endorsement of those goals in the NASA Authorization Act of 2005, are the right approach, I find it disturbing that the Administration budget requests have been well below those called for in the 2005 Authorization Act. The budget resources do not match the goals and requirements, and further reductions, such as the FY07 budget shortfall of $577 million, set NASA and its programs up for failure.

During this gap period, we will have a $100+ billion orbiting lab that will be ready for all of the innovative microgravity research in human health effects, materials science and other areas that have been planned for a long time. But we will have no way to get our crew to it and home again, except on a Russian Soyuz. For that access now, while NASA still has the Shuttle available, we are paying the Russian Space Agency $780 million and getting a waiver from the prohibitions in the IranSyria-North Korea Nonproliferation Act, a law designed to discourage nations from cooperating with dangerous programs of countries that are state sponsors of terrorism. Russia has been a reliable ISS partner, but the Russian Space Agency is under-funded and facing aging infrastructure issues, as well. Memories of accidents and safety issues onboard the *Mir* are still with most of us, as well as the more recent troubles experienced by the Soyuz, making a second ballistic re-entry just a few weeks ago. When this issue of U.S. reliance on Russia was raised in hearings earlier this year, Administrator Griffin testified that it was "unseemly in the extreme." I completely agree.

But there is an even bigger challenge in the future of our space program. China is the new competitor in this second Space Race and the country that poses the greatest threat to our leadership. China has publicly declared a goal of establishing a permanent manned base on the moon. When it is not putting our orbiting assets and those of other countries at risk by testing anti-satellite weaponry in violation of international protocols, China is successfully completing orbital human space flights. In 2004, more than 600,000 students graduated with engineering degrees from institutions of higher learning in China, compared to 70,000 in the U.S., as reported by the National Academy of Sciences. That's eye opening, but even more so is the fact that China also actively uses covert means to access U.S. technology and scientific information. An April 3, 2008 cover story in the *Washington Post* references ten cases in the past year alone where alleged Chinese agents have been arrested or sentenced for the illegal export of sensitive U.S. technologies. Reportedly, Shuttle technologies were a target of this espionage activity. As reported in *The Wall Street Journal* and *Aviation Week,* among other major publications, China is importing "ITAR-free" satellites and other space technologies from a European company, thereby evading U.S. export controls that are intended to safeguard our national security. China is also developing its Long March 5 rocket that will be capable not only of delivering people to the moon, but also landing nuclear payloads anywhere in the United States.

It is time for our country and our Nation's leaders to tune in to these facts and back off of their naïve views of "space on the cheap"—other countries are making the necessary resource investments; and it's time to do the same before the option to respond is no longer an option.

It is important to look at the issues and challenges facing our space program with clear eyes if we are going to be successful in solving them. We need to limit the duration of the U.S. human spaceflight gap and prevent it from growing, to forestall the hemorrhaging of our talented and experienced aerospace workforce and supplier network. The only approach is to provide additional funding, as the Senate has tried to do in the last couple of years, to accelerate development of the new vehicle. I commend many here on Capitol Hill and thank them for their efforts to reimburse NASA for money lost due to Hurricane Katrina and Return to Flight costs. Their efforts to request the additional funding are exactly the kind of support and leadership we need on the Hill, particularly when there are competing national priorities and their colleagues, who oppose the support, would rather leave our Nation's budget lingering in a Continuing Resolution. Administrator Griffin has testified that an additional $2 billion in funds spread equally over this year and next would enable

the agency to cut 18 months off of its delivery time. That would narrow the gap to around 3 years. That is far from ideal, but it reduces our reliance on Russia significantly and may be a short enough time-frame to prevent wholesale loss of critical aerospace skills.

We will be facing a change in the Presidency in just a few short months. I know all three major candidates have taken varied and often vague positions on our space program, as tends to be the case during election season, but it is important that the party taking office recognize the need for continuity in NASA leadership, and make a firm commitment to provide the necessary funding for our Nation's "independent" human space exploration programs. The architecture and program plan for Projects Orion and Ares are sound and any further redesign and debate will only result in incurring more costs and widening the gap. Program restructuring and design changes were major factors in delayed development of the ISS. With this gap looming, we don't have the liberty of unnecessary changes in program direction and mid-course correction.

My last recommendation is aimed more at NASA than the Congress. Our space agency has a public support, or approval rating, of around 70 percent . . . a rating that would leave many politicians envious. Additionally, NASA has one of the highest public profiles of any in the Federal Government and its website is one of the most frequently visited. Within its means, the agency has been reasonable in its public relations efforts and effective at leveraging "space" to build partnerships with Hollywood to get its message out, but on this issue of Shuttle retirement, the gap, and development of the new vehicle, the public is blissfully unaware. Maybe the media with its short-term focus shares some blame, but I believe the agency can do more to educate the public about what looms ahead. Part of that mission also entails better outreach, particularly to young people who communicate in much different ways than just a few short years ago. I've never believed that nonsense about young people no longer being excited or "inspired" about space. When a kid learns about some of the exciting missions the agency is working on, tours the space centers, meets an astronaut, or views the bold and beautiful images of outer galaxies captured by the Hubble, they light up in the same way that kids did in the heyday of Apollo. More creative and less traditional communications efforts have started, but NASA needs to move more quickly into all mediums of communication, fully embracing opportunities offered by YouTube, MySpace and Facebook, as well as continuing to leverage the traditional outreach of speakers bureaus, career fairs and the co-op and internship staffing programs.

Thank you again for inviting me to testify and I stand ready to answer any questions you might have.

Senator NELSON. That's as well said as anybody could say it. Thank you for that. I have a feeling that the way you encapsulated everything there is going to be a message that we're going to spread around so that people will have the understanding of what you've just said in order for America to return to the glory days.

All right. Dr. Johnson-Freese?

STATEMENT OF DR. JOAN JOHNSON-FREESE, CHAIRMAN, NATIONAL SECURITY DECISION MAKING DEPARTMENT, NAVAL WAR COLLEGE

Dr. JOHNSON-FREESE. That's a hard act to follow.

Senator NELSON. Amen.

[Laughter.]

Dr. JOHNSON-FREESE. Mr. Chairman, Mr. Vitter, good morning, and thank you for the opportunity to present my views on reauthorizing the Vision for Space Exploration.

I must begin by noting that the views I offer are mine alone and do not represent the U.S. Navy, the Department of Defense, or the U.S. Government.

This is a topic whose importance and impact extends far beyond the realm of space exploration. The path America follows in human space exploration will, I believe, be read by much of the international community as indicative of America's intentions in the

world, and therefore it will be a key part of how we define the strategic future of the United States.

In my written testimony, I present what I consider the value and importance of the U.S. human spaceflight capabilities, the implications and consequences of a gap in those capabilities, and an assessment of needs in order to accomplish the missions, the multitude of missions that NASA's been given. In the few minutes I have here, however, I'd like to focus on the strategic implications of uninterrupted human spaceflight program for our relationship with the rest of the world.

First, however, let me be completely candid about my general view of the vision. As I wrote, last year in my book on American space policy, I believe that the administration's 2004 vision, especially the timelines, while well intentioned, was a vision bordering on fantasy, and thus, effectively doomed from the start. Nothing in the interim has led me to revise that conclusion, as the vision has never met even the most basic test of a plausible and executable policy; namely, to align benchmarks, strategy, and resources with the stated goals.

Still, some of what the vision wishes to achieve is laudable. It is a tragedy that the United States turned away from its great, even heroic, achievements in space in the 1960s and 1970s. We can, and should, return and maintain our leadership in human spaceflight exploration. Indeed, although it is our common human destiny to explore the stars, America, more than any other nation on Earth, has the magnificent scientific prowess that will lead mankind back to space, to Mars and beyond. It's not just an opportunity, it's our duty.

But, there is more immediate and earthbound reason for America to assert its leadership in space, and I note that I say "leadership," and not "dominance" or "control." The fact is that human spaceflight programs, especially those that stress international cooperation, have consistently been an effective tool for the United States in generating goodwill and soft power with other nations. The U.S. space program is perhaps the very best example of how America's great power is often tempered to serve far greater human goals.

Sadly, that perception of America has been lost over the past few years. When NASA was created, part of the motivation was to present a peaceful civilian face with the U.S. space program, and rightly so, as a stark contrast to the blatantly militaristic face of the Soviet space program. But, 50 years later, that tide has turned. Many nations, friendly and otherwise, now view the U.S. space efforts as centered heavily on what they see as potentially threatening military applications. Our friends and competitors alike too often see our space program as part of an American drive to dominate the cosmos as completely as American power now dominates the planet. Worse, there is a perception abroad—a false one, I might add—that the American human space effort is being bested by China.

And so, we stand at a critical junction. Will the United States continue to be considered as the leader in human spaceflight, aimed at the benevolent exploration and utilization of the heavens, or will we deliberately and knowingly abrogate that role to others

in a future search for military space dominance—futile search for military space dominance? While some might think it's time to pull the plug on the vision, I would suggest that the price of doing so, in terms of international prestige and the consequent benefits of leadership, is too high. America needs to be seen as the leader into the future, and no venture, no journey, is better to do that than human spaceflight.

With that, I'll end my remarks.

[The prepared statement of Dr. Johnson-Freese follows:]

PREPARED STATEMENT OF DR. JOAN JOHNSON-FREESE, CHAIR, NATIONAL SECURITY DECISION MAKING DEPARTMENT, NAVAL WAR COLLEGE [1]

Thank you for the opportunity to present my views on Reauthorizing the Vision for Space Exploration. This is a topic which I consider important beyond the realm of exploration. The path America follows in human space exploration will, I believe, be read by much of the world as indicative of America's strategic future. Therefore, I would like to address what I consider the value and importance of U.S. human spaceflight capabilities, the implications and consequences of any gaps in such a capability, and an assessment of NASA's needs in order to accomplish its given mission as outlined in the Vision for Space Exploration.

As a matter of full disclosure, in my 2007 book *Space as a Strategic Asset* I wrote about the Vision in less than positive terms.

> Politically, the 2004 Bush space vision was always a vision bordering on fantasy. Though perhaps well intended, it was effectively doomed from the start. The vision as announced was a very broad-brush outline of intent, describing a return manned mission to the moon, as well as manned missions to Mars and beyond. But the devil is in the details, and those details must be in some way attached to reality. Three major circumstantial realities predetermined the outcome of that new vision. First were the budget issues. The domestic budget has been, and will likely remain, an effective hostage to the war in Iraq, homeland security concerns, and clean-up for Hurricane Katrina—and like events in the future . . . Second and equally critical, the NASA budget was already consumed by commitments to support existing programs . . . Third, the public view of the NASA program has consistently been that it is desirable, but expendable. The public supports human exploration, and even recognizes that benefits accrue on Earth, but it prioritizes funding for roads, schools, health care, and near-term benefits over space programs, particularly space exploration.[2]

Then, and now, I believe the vision did not consider even the basic tenants of successful strategy execution; matching goals, strategy to achieve the goals, and the resources required to carry out the strategy.

Some individuals involved in the development of the Bush space vision have suggested to me the intent was to give NASA a goal and allow them, the experts, to figure out how best to get there. That would be reasonable except that a multitude of dates were included in the speech unveiling the Vision which inherently negated certain incremental, paced, and subsequently less resource intensive strategies and required instead accelerated strategies which leave little room for error and are more resource intensive.

- Our first goal is to complete the International Space Station by 2010.
- In 2010, the Space Shuttle . . . will be retired from service.
- Our second goal is to develop and test a new spacecraft, the Crew Exploration Vehicle, by 2008, and to conduct the first manned mission no later than 2014.
- Our third goal is to return to the moon by 2020.

The shortsighted and unrealistic timetables included in the Vision, including acceptance of a gap in U.S. spaceflight capabilities between the retirement of the Shuttle and the new vehicle becoming operational, created the Rubic's Cube that we are dealing with today.

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[1] The views expressed are the author's alone and do not represent the official position of the Department of the Navy, the Department of Defense, or the U.S. Government.

[2] Joan Johnson-Freese, *Space as a Strategic Asset* (New York, New York: Columbia University Press, 2007) 16–17.

Announcement of those dates immediately and inherently created a number of dilemmas for NASA, first and foremost, how to keep Shuttle flying to complete the ISS while simultaneously investing every dollar possible in the development of the new vehicle. The gap between Shuttle retirement and the new vehicle becoming operational also raised the question of how to send cargo and crews to the ISS after the Shuttle was retired. There are few options to answer that question. Clearly the U.S. (NASA) will have to pay others to transport goods and people, which then creates a follow-on dilemma of having to pay others for transportation while trying to maximize funds that can be used to develop Ares and Orion as new means of transportation, and as quickly as possible.

Despite the significant execution issues related to the Vision as announced in 2004, in my 2007 book I also wrote:

> In the 1960s, leadership was the motivation that took the United States to the moon, as the country wanted to show itself as the winner in a technology-based competition against the Soviet Union. It was a techno-nationalist show of prowess. Today, post-September 11 and, equally or more important, with the ongoing war in Iraq, the United States needs to again recognize and embrace the leadership opportunity offered by manned space exploration.[3]

The advocacy of human spaceflight as a key expression of U.S. leadership that I expressed in 2007 is even stronger today. Leadership should not be underrated; it is a commodity as important to security as any tank or gun. It is generated as much through soft power as through military might, and human spaceflight, especially cooperative ventures, is a potent soft power tool. In my new book, I cite a quote from Retired Air Force General Pete Worden, now Director of NASA's Ames' Spaceflight Center. Worden believes that "space cooperation is already serving as 'glue' to forge coalitions and keep people working together. As one of the few truly global media, space capabilities should realize their full potential as the basis for 'soft power' influence. This does not exclude economic competition among cooperating players—indeed shared interests in allowing commercial developments are a foundational element of space soft power."[4]

The United States has, unfortunately, lost its edge on engaging the world. A 2007 public opinion poll conducted as part of the Pew Global Attitudes Project indicated that: "Anti-Americanism is extensive, as it has been for the past 5 years."[5] The timing of that tumble from grace could not be worse. As the lone remaining superpower it is critical that if the United States must be seen as a hegemon, it be seen as a benevolent hegemon rather than a rogue hegemon. Unfortunately, the latter image, particularly as evoked by the war in Iraq, has proved hard to shake. Manned spaceflight, especially cooperative programs, has consistently been an effective area for the United States to generate feelings of optimism for the future, goodwill and leadership.

Additionally, when NASA was created in 1958, part of the motivation was to present a peaceful, civilian face for the U.S. space program, juxtaposed to the militaristic face of the Soviet space program. In contrast, in 2008 much of the world considers military space efforts as the focus on U.S. space activities, efforts potentially threatening to them, coupled with a perception that the American manned space effort is being bested by the Chinese. Therefore, we are currently at a critical junction in deciding whether the United States will continue to be considered as the leader in human spaceflight or whether we will deliberately and knowing abrogate that role to others.

A September 2004 report of a task force of the Defense Science Board, a prestigious board of high-level advisors to the Pentagon, focuses on Strategic Communication.[6] Strategic communication is a critical part of soft power as it conveys messages of U.S. intent to the world. Let's be clear: if the United States chooses to abrogate its leadership role in human spaceflight, a message will be sent and received that will have strategic consequences for the United States beyond the space realm. It will be viewed as an indicator of an overall U.S. decline in its ability to lead.

NASA has been caught between a rock and a hard place since 2004. Required to meet unrealistic deadlines with insufficient budgets, it reconceptualized the 2004 Vision in ways unsatisfying to some, but still stretching the bounds of technology de-

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[3] Johnson-Freese, *Space as a Strategic Asset*, 248.

[4] Dr. S. Pete Worden, private interview, 30 March 2008. Cited in: Joan Johnson-Freese, *Heavenly Ambitions: Will America Dominate Space?* (Philadelphia, PA: University of Pennsylvania Press) forthcoming 2009.

[5] Global Unease with Major World Powers, 27 June 2007, *www.pewglobal.org*.

[6] Report of the Defense Science Board Task Force on Strategic Communications, September 2004, 56. *www.acq.osd.mil/dsb/reports/2004-09-Strategic__Communication.pdf*.

velopment and its own organizational capabilities to the limit. The Constellation Program, using the Ares rocket and carrying the manned Orion spacecraft, still seeks to return a crew to the moon by 2020, or earlier, though even 2020 seems like a long-shot. Orion won't be ready until 2016 if everything goes perfectly in development, which rarely happens. That leaves a minimum 5–6 year gap in U.S. human spaceflight capabilities, during which time the United States will be reliant on other countries, particularly Russia, to reach the ISS. Recent problems with the Russian Soyuz capsule used to transport people back-and-forth to ISS raises concerns about that option as well. Alternatively, there has been discussion about development of a private commercial spacecraft that could taxi cargo and crew to the International Space Station, with the NASA Commercial Orbital Transportation Service (COTS) program seeking to encourage investment in that alternative. That program, however, has not been without difficulties and even a successful venture would likely not be ready to carry cargo for at least 2 years and crew for at least four.

During this gap period other space faring nations will not sit idly by, waiting for the United States to get its human spaceflight program back on track. A recent meeting of the Russian Security Council focused on the future of Russian space exploration, as part of efforts to reinvigorate the country's technological programs, outlining the developmental possibilities of the national space program until 2020. According to Sergei Ivanov, First Deputy Prime Minister and head of Russia's military-industrial development, all aspects of space activities were considered separately, including "manned space flights, defense security, socio-economic aspects of space activities, scientific and all ground-based related infrastructure, including the forthcoming Vostochny (Eastern) spaceport." [7]

Chinese human spaceflight activities have taken a slow, incremental approach and still managed to create the perception that China is "beating" the U.S. in a new space race. While far from true, what China has that the U.S. does not is top-down political will. It is likely that China will launch more taikonauts into orbit next Fall, toward fulfillment of their official three-part program: launching taikonauts into space, which was accomplished with Shenzhou V and VI; a space laboratory; and eventually a space station. While there are also reports of Chinese intentions to land a man on the moon, there have been no official announced plans in that regard. Essential to Beijing's more ambitious plans is the development of a new heavy-lift launch vehicle, the Launch March 5.

As recently as March 2007, Huang Chunping, Chief Vehicle Designer for Project 921, predicted that China would be able to send taikonauts to the moon within 15 years. Key, however, was that he said success would depend on Beijing providing adequate funding and successful key precursor missions.[8] There have been other reports as well, including one that garnered considerable publicity. Shortly after NASA announced in 2005 that it would put a man on the moon by 2018,[9] Chinese space official Ouyang Ziyuan was quoted as saying "China will make a manned moon landing at the proper time, around 2017." [10] Ouyang Ziyuan is a key figure in the Chinese robotic lunar mission, Chang'e (which has no connection to the manned program). He was either misquoted—a problem prevalent in sorting through Chinese space intentions—simply speaking in terms of desire rather than official intent, or perhaps just goading the United States. Nevertheless, his statement was widely reported in the United States, bolstering the perception of a space race between the United States and China, with China winning. While U.S. technology and capabilities are significantly ahead of China's in all areas, lack of political will in the United States to support human spaceflight efforts to the level they need to be for milestones to be successfully reached allows for the misperception to be perpetuated.

European space plans are always constrained by resources and ability to find consensus among all its key players. New and worrisome from Europe, however, is their increasingly prevalent concerns, and often suspicions, about U.S. intentions in space. An editorial run in *The Times* (London) after the release of new U.S. National Space Policy (NSP) is illustrative. Entitled "America Wants it All—Life, the Universe, and Everything," [11] it stated that apparently space was no longer the final frontier, but the 51st state of the United States. The editorial went on to say that,

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[7] The *ISCIP Analyst,* Volume XIV, No. 12, 24 April 2008.

[8] Reuters, "Moonshot possible in 15 years," 6 March 2007.

[9] Guy Gugliotta, "NASA Unveils $104 Billion Plan To Return to the Moon by 2018 Spacecraft Draws on Apollo, Avoids Shuttle Foam Problem," *Washington Post,* 20 September 2005, A03.

[10] Reuters, "China Eyes 2017 Moon Landing," 4 November 2005.

[11] Bronwen Maddox, "America Wants it All—Life, the Universe, and Everything," *http://www.timesonline.co.uk/article/0,,30809-2410592,00.html*.

"The new National Space Policy that President Bush has signed is comically proprietary in tone about the U.S.'s right to control access to the rest of the solar system." That same newspaper ran an article entitled "Son of Star Wars takes out toxic satellite with $30M space attack" after the destruction of US–193 in February 2008. While not challenging U.S. motives explicitly, the article cynically stated the satellite's destruction had been "broadcast" by President Bush "as a safety measure" and "the Pentagon celebrated its $30 million Star Wars-style interception in space."[12]

The situation currently being faced is far from ideal. Quite the contrary it is a mess. The United States has spent billions on a space station only to find itself unable to get there after 2010 without paying someone else for a ride, and having a questionable future altogether after 2016. Untenable dates have been set for sometimes competing achievements, without sufficient budgets to accomplish one let alone more. While some might think it is time to pull the plug on the Vision, I would suggest the price of doing so in terms of international prestige, with prestige defined as including leadership implications, is too high. America needs to be seen as a leader into the future, and no venture, no journey, no undertaking represents the future more than human spaceflight.

I believe the Vision for Space Exploration should be reauthorized, to assure the continuation of the U.S. human spaceflight program. That said, budgets are clearly insufficient to allow programs be completed within the current timelines. However, it is not as clear that more money would assure that those timelines could be met. People, institutions and technology are already being pushed to levels that could soon result in a rush to failure. Further, setting deadlines and then missing deadlines does not generate confidence—especially for the country that said it was going to land a man on the moon and then return him safely to Earth within the decade in the 1960s, and did it. The difference, however, was that until 1967 the Apollo budget was sufficient to achieve the goals that had been set. With Constellation that is not and never has been the case. Therefore, consideration should be given to restructuring the entire program, with realistic timelines developed toward achieving multiple, prioritized goals within anticipated budgets. NASA is in the best position to determine that prioritization, but it seems that narrowing the gap between Shuttle decommissioning and a follow-on system becoming operational ought to be a key consideration.

As part of a restructuring, I encourage the consideration of opening the program to more international cooperation. The more countries that are involved, the less the perception of a space race can be propagated. While there are significant political and technical issues potentially involved with international cooperation, there are several models of cooperation that could be employed, and the lessons learned from ISS can be invaluable.

Finally, I return to the importance of soft power and having countries desire to work with the United States by choice, rather than because of its military might or coercion, and the proven ability of human spaceflight to both generate soft power and bolster its image as a global leader. In May 1961, after the Soviet Union had beat the United States into space and established leadership in space exploration, President John F. Kennedy put together a message to Congress on "Urgent National Needs." While the speech covered many issues, its major focus was on the space program. In it Kennedy expressed his belief that a manned lunar landing before the end of the decade should be the principal goal of the American space effort. He stressed this meant a long and costly development program to reestablish the Nation's world leadership in technology, and cautioned that "if we are to go only halfway, or reduce our sights in the face of difficulty . . . it would be better not to go at all."[13] It was a call for the United States to wholeheartedly commit itself to a long-term objective requiring sustained effort, substantial cost, and determination to see it through to a successful conclusion.[14] That, in my opinion, is where we are again, and again we must wholeheartedly but realistically commit to achieving our goals.

Senator NELSON. Thank you, Dr. Johnson-Freese.

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[12] Michael Evans and Jane McCartney, "Son of Star Wars takes out toxic satellite with $30m space attack," *The Times* (London) 22 February 2008, 39.

[13] John M. Logsdon, *The Decision to Go to the Moon: Project Apollo and the National Interest* (Cambridge Mass.: MIT Press, 1970), 127–128.

[14] *history.nasa.gov/SP-4214/ch1-3.html.*

Because of a time commitment for Senator Vitter, I'm going to interrupt the panel here so that Senator Vitter can go ahead and ask a few questions.

Senator VITTER. Thank you, Mr. Chairman. And I—I have to go to a swearing-in of a new Louisiana colleague on the House side in a few minutes, but I'll certainly try to come back. But, before I leave, I did want to get a couple of questions in.

Mr. Kranz, first of all, you praised the plan, which I assume includes the architecture of Constellation. In our reauthorization bill, would you suggest we spend any time, any ink, any paper looking back and re-examining that, even briefly? There has been some suggestion from some folks that we should consider alternatives—again, Jupiter 120 architecture. Would you suggest we turn back, however briefly, before we set forth on a new course?

Mr. KRANZ. No, I've—I believe it's important that we don't waste too much time looking back. You know, in Mission Control—go back to the Apollo 13. The basic objective of 13 was to get the crew on the track back home with what we thought was enough resources to get the job done. We then tuned that plan as we went along.

I have been personally a victim, and I think NASA has been victim, of so many studies that seem to be never-ending, that burn up the resources, delay the schedule, disenchant the people who are executing them. I believe they've had very good visibility on the study, and basically on the architecture. These graybeard sessions we had weren't just NASA folks. We had—our contractor team comes in, we had leaders from Mercury, Gemini, and Apollo. This is, I think, a very well-seasoned plan.

So, I would suggest that the—again, the words I used, "stay the course," and prove that as you will go along, because you're going to have opportunities for improvement. But, I think, the basic plan is very sound, very well-founded.

Senator VITTER. Great. Thank you.

Second question, also for you, Mr. Kranz. Schedule pressure was cited as some contributing factor in both *Challenger* and *Columbia,* in terms of the accidents. Do you think there's a danger of creating significant schedule pressure like that by having a hard Shuttle retirement date of September 30, 2010, versus a policy that says these are the fights and the missions we're going to do, we're going to try to do them by 2010, but not as hard and firm a date?

Mr. KRANZ. No, I went through the shutdown between the Gemini program, where we had to move into Apollo. I never felt, and I don't think the operators, the people down in the launch pads, really feel any pressure. They are—the only pressure they have is that which they put on themselves to do the job as safely and as professionally as human—possible. I don't think any operator—I mean, you can move this aside, you can talk about media, you can talk about, "Whatever you get, follow the budget right on the line," but basically these people know their jobs. They're professionals at getting the job done. And I was very proud of the way that we concluded the Gemini program, right—moved almost directly into the Apollo program—excuse me—Apollo program, and I'm sure that the teams in place right now at the Cape and at Houston will handle this job very professionally.

Senator VITTER. So, the hard date basically doesn't bother you in that——

Mr. KRANZ. No.

Senator VITTER.—sense.

Mr. KRANZ. No.

Senator VITTER. OK.

And, Ms. Johnson-Freese, do you think our dependence on the Russians in the foreseeable future will actually lead to their leveraging that and affecting completely unrelated issues, in terms of our relationship? Or trying to affect those issues?

Dr. JOHNSON-FREESE. Very probably. The Russians became capitalists very quickly. They learned how to negotiate a tough deal very quickly, and I have no doubt that they have also learned the term "spillover," that they will be able to leverage this wherever they can. I see dependence on anybody as an undesirable situation.

Senator VITTER. Right. Well, their being capitalists, I mean, goes to the cost, and that's a big problem, in my mind, that we don't have other options, and so, they, to some extent, can name the price. But, my question is specifically, would you expect them to leverage it beyond dollars into policy in completely unrelated areas?

Dr. JOHNSON-FREESE. I think they will try, Senator. I think they will certainly try.

Senator VITTER. OK.

Dr. JOHNSON-FREESE. Again, again, I'm not very confident about relations with the Russians in the near term, that we can count on them being friendly, as we'd like them to be.

Senator VITTER. Right.

Thank you very much, and I'll certainly try to return, Mr. Chairman. Thanks for your leadership.

Senator NELSON. Thank you, Senator Vitter.

Indeed, if anybody questioned what might be the future difficulty of the United States in dealing with the Russians, that question ought to have been dispelled when we saw that Vladimir Putin made a decision that he was not going to release power. In fact, he's using the fig leaf of the Constitution to have him perpetuate his power. Some people call him the next tsar of Russia. From that position we know what happens to the accumulation of power. That power is not only focused on areas of taking financial advantage, but policy advantage, as well.

Thanks for your questions.

Dr. Tarantino?

STATEMENT OF DR. FREDERICK A. TARANTINO, CEO AND PRESIDENT, UNIVERSITIES SPACE RESEARCH ASSOCIATION

Dr. TARANTINO. Chairman Nelson, thank you for the invitation to this hearing.

On behalf of Universities Space Research Association and our 102 member universities——

I'm sorry? The light's on, yes. Is this better? OK, thank you.

Chairman Nelson, thank you for the invitation to this hearing. On behalf of Universities Space Research Association and our 102 member universities, we appreciate the opportunity to be here today.

USRA was formed by the National Academy of Sciences in 1969 and has the mission of advancing space related science and technology.

A strong space program is essential for our country, and university research is an indispensable part of that success. Universities develop new knowledge crucial for our understanding of space, they're a source of innovation needed to address both the cost of space activities and approaches for new challenges, they also prepare the people who are our future.

I'll focus on five items for the Committee to consider.

First, NASA and the Vision for Space Exploration should be reauthorized in a balanced manner that ensures a strong and healthy space science program. The renewed U.S. focus on both human and robotic exploration beyond low-Earth orbit frees NASA to carry out great new achievements, to explore and eventually settle the solar system. It's important that this program be authorized, recognizing that science and exploration are linked. Science is essential, and recent scaling back of scientific plans should be reversed so the complete vision for our progress in space can be achieved.

Second, the importance of universities to our space program should be made a stronger part of all NASA programs. The position America has in science and technology today could not have been achieved without robust university research. The environment of academic freedom in universities generates knowledge unlike any other. This is especially important in space, where we need to find new innovation to address high costs and to find solutions to new problems. Universities are also the only source of the new highly trained space workforce we require. University research should be embedded throughout NASA's activities in science, technology for exploration, aeronautics, and operations.

Third, make workforce development of tomorrow's scientific and engineering leaders a part of NASA's mission. The America COMPETES Act addresses an impending crisis; namely, that America can lose its technological advantage in the world, and, if that happens, may never get it back. This will have a profound impact in every aspect of our future. Responsibility for the preparation of the aerospace workforce should be a part of NASA's reauthorization. This is a crisis in our country, and space must be a part of the solution.

Fourth, assure adequate emphasis is placed on university-led missions to provide hands-on training for students. Opportunities for students to be involved in hands-on space training have declined precipitously, and it's extremely important to reverse this. To be leaders in space, we must have the best-trained people. In particular, the ability of a Ph.D. student to conceptualize and experiment, design and build the hardware, launch it into space, collect data, and analyze it is essential. Without these experiences, our universities cannot produce the best scientists and engineers in the world. For every experimental opportunity that results in a well-trained Ph.D., there are several master's research opportunities and dozens of opportunities for undergraduates to be involved in space experiments.

A recent National Academies study showed that our current aerospace workforce, the best aerospace workforce in the world

that's now facing retirement, benefited from seven times the number of these research opportunities when they were on campus, 30 and 40 years ago, than are available today. USRA member institutions passed a resolution at our annual meeting last month urging that these opportunities be increased and recommending that NASA be required to spend at least 1 percent of its overall budget on university-led hands-on programs. From our estimates, we believe this is a doubling of present activity, and it's desperately needed.

We also want to express support for the potential of emerging commercial suborbital vehicles being developed to contribute in this area. NASA has expressed an intent to establish a suborbital scientist participant pilot program, and we encourage NASA to pursue this.

And, fifth, reimburse NASA for the cost of returning to flight. As you've noted, NASA spent more than $2 billion implementing Space Shuttle safety improvements to help restore flight operations after the *Columbia* accident. The funding for these improvements came at the expense of aeronautics, science, and exploration programs, and its restoration is urgently needed.

So, in conclusion, NASA must be reauthorized with stronger university involvement in science than it has had in recent years; by including universities in all aspects of the space program, will develop properly trained people for the future and produce innovations required for success.

Thank you for this opportunity to speak, and I look forward to answering any questions you have.

[The prepared statement of Dr. Tarantino follows:]

PREPARED STATEMENT OF DR. FREDERICK A. TARANTINO, CEO AND PRESIDENT, UNIVERSITIES SPACE RESEARCH ASSOCIATION

Chairman Nelson, Ranking Member Vitter, and Members of the Subcommittee,

Thank you for inviting me to testify before you on the reauthorization of NASA and the Vision for Space Exploration. I appreciate the opportunity to provide the Subcommittee with this university perspective.

I serve as CEO and President of the Universities Space Research Association (USRA), a consortium of universities deeply involved in our Nation's space program. USRA was formed by the National Academy of Sciences in 1969, at the height of the Apollo program. We were given the mission of advancing space-related sciences and technology for the benefit of humankind. We are now entering our 40th anniversary year, as NASA completes its 50th.

A strong space agency is critically important for our Nation. At their annual meeting on March 20, USRA member university representatives called for NASA to be reauthorized as the leader of the civil space program for the United States and provided with significantly increased funding adequate to meet its responsibility to carry out a balanced space program, including advancing knowledge in the scientific and technology disciplines related to space and aeronautics, as well as carrying out the enterprise of space exploration itself. They added that the NASA reauthorization should specifically acknowledge NASA's support of universities as partners who generate new knowledge, make new discoveries in disciplines related to space and aeronautics, and train the specialized workforce needed to accomplish NASA's missions.

Citing a decades long decline of small space missions that allow hands-on training, our member universities unanimously adopted a resolution at their annual meeting urging that at least 1 percent of NASA's total budget be devoted to funding competitive opportunities for university-led hands-on training provided by university missions on sounding rockets, high altitude balloons, remotely piloted vehicles, emerging commercial suborbital flights, and university class space flight missions.

The 2007 and 2008 resolutions of USRA member university representatives are attached as *Exhibit A*.

I will focus my testimony on five key recommendations for the subcommittee to consider in its reauthorization of NASA:

- First, that the Vision for Space Exploration be continued, in concert with an assured balanced science program;
- Second, that the importance of universities to our space program be recognized and university research be made a part of all NASA programs;
- Third, that workforce development providing tomorrow's scientific and engineering leaders be made a part of NASA's mission;
- Fourth, that adequate funding be devoted to suborbital missions that provide hands-on training; and
- Fifth, that NASA be reimbursed, through supplemental funding, the cost of returning the Space Shuttle to flight.

Reauthorize the Vision for Space Exploration, in Concert with a Balanced Space Science Program

U.S. space exploration is awe inspiring to Americans and to people of other countries. A renewed focus by the U.S. on exploration beyond low-Earth orbit, both human and robotic, unfastens our space agency to carry out new great achievements for our Nation, bring new scientific investigation of our solar system, and draw young people into science and engineering studies.

Space is strategic for many nations, and we are in the midst of a massive internationalization of it. In 2005, China became the third nation to fly a human in space. European Space Agency nations, Japan, China, Russia, and India are all resourcing and planning major long-range space science programs, including lunar and planetary missions. China is developing a robotic nuclear-powered lunar rover as the second phase of their lunar program. Japan and China sent probes (Kaguya and Chang'e–1) to the moon in 2007, and India's launch of Chadrayaan–1 is scheduled for 2008. While the U.S. scientific community is restricted in its foreign collaborations under International Traffic in Arms Regulations (ITAR), ESA is collaborating extensively with China, India, and Japan in their lunar explorations. A hesitant approach to exploration will cede U.S. supremacy in space to other nations.

Scientific investigation is central to space exploration, and technological innovation is key. The Vision for Space Exploration calls for sustained human and robotic exploration. Beginning this year, the U.S. is undertaking a series of robotic missions to the Moon that are designed to answer important scientific questions and prepare for and support future human exploration activities. The Vision calls for the conduct of robotic exploration of Mars to search for evidence of life, to understand the history of the solar system, and to prepare for future human exploration of that body. The Vision also calls for the conduct of robotic exploration across the solar system, such as, exploration of Jupiter's moons, asteroids and other bodies, and includes advanced telescope searches for planets around other stars.

The Roman poet Ennius wrote, "No one regards what is before his feet; we all gaze at the stars." Exploration of wondrous worlds beyond our planet fascinate and challenge young people in a unique way. Apollo drew a generation into careers in science, technology, and engineering. Today, middle schools all over the country have programs building robots modeled after the MER rovers, and Hubble images adorn classrooms and bedroom walls. Exploration of the Moon, Mars, and other planets is a magnet that attracts young people. A sustained exploration program can and will help our country reverse the decline of students pursuing science and engineering careers.

USRA asks the Subcommittee to reauthorize the Vision for Space Exploration, in all of its aspects, human and robotic, guided by compelling questions of scientific importance, and in concert with a balanced science program across all the disciplines encompassed by our space program.

Include Universities in All Facets of Our Space Program

Universities have benefited greatly from our Nation's space program. Research funding to universities by NASA over the past five decades spurred development of entire academic departments and brought about the creation of new institutes and laboratories at universities in every region of the country. This is made apparent by the growth in USRA membership. USRA expanded from its original 47 members at its founding; to the 102 universities today that have qualified for membership.

But our universities are more than beneficiaries. They are enablers. Without our universities, we would not have the engineering and scientific workforce that powers every aspect of our space program. Without our universities, we would not have the innovation that brings about the technological breakthroughs that enabled our space agency to land an American on the Moon and drive robots across the Martian sur-

face. And without our universities, we would not have the scientific leaders and visionaries that put us at the front of the space race and kept America as the leader in space, through to this day.

Without our research universities, we would not be here today. There would be no NASA to reauthorize. Universities are a central pillar standing up our space agency, and this needs to be recognized. USRA requests the Subcommittee include in its reauthorization of NASA direction that our Nation's research universities be included as essential partners in every NASA program and undertaking. This has been the history of the agency, it is its only future, and it must be affirmed and preserved.

Universities need to be embedded, not only in every NASA science program, but also throughout NASA's technology development programs and operations. Innovation born from our universities can contribute to efficiencies and breakthroughs across the agency; and NASA engagement can strengthen our universities, prepare our students for the future, and foster American innovation. The mission of our space agency and the mission of our research universities form more than an intersection, they form a shared dependency.

Given the importance of university research to the space agency, both in terms of basic scientific research, and breakthrough technology innovations, USRA also asks the Subcommittee to consider in the reauthorization of NASA, inclusion of the agency in the America COMPETES Act. As a comprehensive strategy to foster American innovation, NASA must be included. The goals of the Act, strengthening scientific research, improving technological enterprise, attracting the world's best and brightest workers, and providing 21st century job training, are consistent with work of NASA and the university community that is a part of our space program.

Make Workforce Development of Tomorrow's Space Leaders a NASA Duty

Should education and workforce development be part of NASA's mission? These numbers answer the question for us: The U.S. aerospace and defense industry is losing an estimated 27,000 employees per year, and the average age of NASA's workforce of engineers and scientists is now 46. Twelve percent of NASA's engineers and 21 percent of its scientists are now eligible to retire. Estimates show there will be a need for more than 1,000 new doctoral and masters graduates each year to replace key positions in the retiring NASA aerospace workforce. Without a supply of younger workers to assume future leadership roles as older workers retire, NASA is facing a looming workforce crisis.

The Commission on the Future of the U.S. Aerospace Industry found in 2002 that, "The nation's apathy toward developing a scientifically and technologically trained workforce is the equivalent of intellectual and industrial disarmament and is a direct threat to our Nation's capability to continue as a world leader."

In the international commercial sector, new European and Asian hybrid spectrum geostationary communication satellites are emerging. These feature new L- and S-band broadcasting with increased terrestrial bandwidth and allow mobile service everywhere—including indoors—thus avoiding a flaw that helped drive the first generation of commercial satellite services into bankruptcy. A half-dozen European nations have sophisticated space workforces that compete with American firms for satellite contracts like the one recently let by S2M, a Dubai-based startup that will provide mobile television/audio service across the Mideast and Africa. Japan, China, and India are also cultivating large, highly capable space workforces. Three indigenous South Korean satellites are now in polar orbit and relaying images. Even Iran plans to put its own satellites in orbit, using indigenous launch capability now under development that unfortunately also serves as technology for long-range missiles.

The National Research Council's Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology wrote in their report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* "We fear the abruptness with which a lead in science and technology can be lost—and the difficulty of recovering a lead once lost, if indeed it can be regained at all."

As President Dan Mote of the University of Maryland, a member of the NRC *Gathering Storm* Committee, said at USRA's annual meeting in March of this year, "The USRA can speak to what is needed to attract the best and brightest young space scientists and engineers, such as the hands-on training provided by sounding rockets, balloons, and other small missions. These space professionals are going to be an ever more crucial component of the U.S. workforce, security and prosperity going forward."

The environment is changing before us, and there is urgency to act now. A failure to invest in today's students and young professionals will seal a crisis when that

generation is expected to assume the mantle of leadership within the U.S. aerospace community. USRA asks the Subcommittee to make clear in its reauthorization of NASA that education, and, in particular, preparing tomorrow's leaders in science and technology, is a crucial duty of the agency.

Assure Adequate Funding for Hands-On Training Opportunities

The space workforce in the United States is the best in the world, largely because it is led by individuals who benefited from hands-on training with actual space projects during their university years. These were exciting years for a young person to enter space research, and space attracted many of the best young scientists and engineers. These years were marked by frequent launches of smaller missions many of which were led by university-based teams that included graduate students. These students got plenty of hands-on experience, and learned first hand the difficulties of designing and constructing an experiment or engineering system that would operate reliably in space. Many students also learned from designing and building experiments for smaller, suborbital flights on rockets or balloons, or by observing with an airborne telescope.

Today, there are fewer opportunities at our Nation's research universities for the next generation of scientists and engineers to gain the hands-on training they will need to succeed in aerospace fields. In fact, the number of flight opportunities through which university students can build hardware and analyze related space data has declined steadily over the last two decades. Since 1970, suborbital experimental launches have decreased eighty percent—from 270 launches per year to just 50 planned launches this year.

The Commission on Implementation of United States Space Exploration Policy (Moon, Mars and Beyond Commission) found in 2004 that, "At present, there are insufficient methods for students to acquire hands-on experience in the scientific and technical disciplines necessary for space commerce and exploration."

This is a problem that impacts all space enterprise, large or small, civilian or military, government or commercial. It affects our ability to design and deploy systems for space science missions, human space exploration, global climate prediction, commercial ventures in space, and national security uses of space. All these enterprises require space engineers able to design and construct reliable space hardware, and space scientists who understand the space environment and the rigors of conducting any activity, robotic or human, in space.

The decline in hands-on training opportunities for undergraduate, masters and doctoral students at universities must be reversed, if the United States is to retain its leadership position in space. NASA must address this problem by increasing its investment in proven programs such as sounding rocket launches, aircraft-based research, and high-altitude balloon campaigns, which provide opportunities for hands-on flight experience at a relatively low cost of failure. While U.S. investments in suborbital experimental launches are declining, China and other countries are increasing their investments in research and development of similar projects to provide future generations of scientists the critical training skills that will serve as a foundation for future research.

Opportunities for tomorrow's scientists and engineers can be provided at a relatively low cost. The average research payload for sounding rocket projects range from $200,000 to $2.5 million. The average cost of recent sounding rocket payloads was just over $1 million, while balloon launch payloads range in cost from just $50,000 to $1 million. Launch, labor and infrastructure costs involved with each payload launch adds additional costs that average $2 million.

Airborne research programs, such as the Stratospheric Observatory for Infrared Astronomy (SOFIA), also provide a platform on which instruments can be carried that enable hands-on training. As the Nobel Laureate Professor Charles Townes wrote in 2006, "The [SOFIA] project is particularly good for hands-on training of students and young scientists. They can fly, operate the system, go to the ground to modify and improve the instrumentation, and then fly with it again."

USRA asks the subcommittee to include in the NASA reauthorization a requirement that NASA spend at least 1 percent of its overall budget on university-led hands-on programs such as sounding rockets, high-altitude balloon campaigns, and airborne research. From our estimates, we believe this represents a doubling of current funding levels for programs that provide hands-on research and training opportunities for our Nation's undergraduate and graduate students in space-related disciplines. By increasing NASA's investment in flight opportunities for university experiments, we will double the number of students engaged in this research and entering the space and engineering disciplines.

A white paper on *Educating the Next Generation of Space Scientists and Engineers,* drafted by the Issues and Program Committee of USRA's member universities, is attached as *Exhibit B.*

The National Research Council Committee on Meeting the Workforce Needs for the National Vision for Space Exploration found in 2006 that, "NASA should expand and enhance agency-wide training and mentorship programs, including opportunities for developing hands-on experience, for its most vital required skill sets, such as systems engineering." And on October 16 of 2007, Senator Ben Cardin of Maryland, in a colloquy with Senator Barbara Mikulski of Maryland, cited the NRC report, and stated, "We know that some of NASA's programs involving sounding rockets, weather balloons, and small satellite launches are outstanding examples of worthy Federal investment that not only produces usable scientific data but provides outstanding hands-on learning opportunities for the next generations of scientists and engineers. Our investment in these programs has not kept pace with demand, and that is a problem we may want to address in future years as we consider the NASA budget."

I also want to bring to the Subcommittee's attention an exciting new way in which university-led experiments with hands-on training could be boosted by NASA involvement. Within the next few years, suborbital commercial vehicles being developed by such companies as Virgin Galactic, XCOR Aerospace, Armadillo Aerospace, and Blue Origin, will provide a unique way to engage scientists and researchers. NASA has already taken the first step by issuing a Request for Information to help in the formulation of a Suborbital Scientist Participant Pilot Program.

By providing the opportunity for researchers and even undergraduate students to fly into space along with their experiments, not only can new experiments be conducted, but the opportunity can inspire students to engage in the math, science, and engineering. The participatory approach of the personal spaceflight industry means each suborbital launch can be experienced by thousands of people, with young people able to tune in and watch live video from space as their professors and fellow students conduct experiments in real-time and experience weightlessness and the life-changing view of the Earth from space. The hands-on experience will create a new generation of Principal Investigators who will be prepared to lead the flagship science and human exploration missions, later in their careers.

These new vehicles will provide low-cost access to the space environment for scientific experiments and research. The market rate for these services has already been set by the space tourist market at $100,000–$200,000 per seat, a much lower cost than existing sounding rockets.

We believe the commercial potential here could be energized by the participation of our space agency. USRA requests the Subcommittee authorize NASA to follow through on the Request for Information by establishing the Suborbital Scientist Participant Pilot Program and issuing a NASA Research Announcement soliciting investigations. This will create a university research payloads market for these emerging commercial operations, provide a new way for university researchers to conduct experiments with student involvement and hands-on-training, and bring the involvement of NASA, and its imprimatur, to an exciting new U.S. industry.

Reimburse NASA for the Cost of Returning to Flight

NASA has spent more than $2 billion in the past few years implementing space shuttle safety improvements to help restore flight operations after the *Columbia* accident. The funding for those safety improvements came at the expense of sustaining and expanding other programs for NASA in aeronautics, science, and exploration. Last year, Congress almost provided $1 billion in supplemental NASA appropriations to help the agency recoup those expenses and improve funding for other agency priorities. We hope that Congress will provide this supplemental funding and such other money in FY09, as needed, to help NASA replenish funding stripped from a number of critical programs, including the Vision for Space Exploration.

Conclusion

The first Space Act was passed in 1958 and signed into law by President Eisenhower, a major legislative act of the 20th century. Today, space touches every aspect of American lives and is growing. Over the last 40 years activities in space have become integral parts of national defense, providing intelligence, early warning, meteorology, communications, protection from missile attack, positioning, navigation and timing services. Business and financial transactions use both space voice and data communications. Space-based commercial sensing is used for land-use planning, emergency response, weather and environmental monitoring. The replacement for our outdated air traffic control system will be space based, and GPS will soon be a part of every modern transportation system. Scientific discoveries in our gal-

axy, of our solar system and of our own planet's changing climate are exploding. Space also plays a huge part in educating future generations—motivating youth to pursue science and technology careers.

NASA must be reauthorized to make people and innovation one of its highest priorities. American universities are the greatest leverage we have for affecting America's future in space. They are the source of new knowledge and the training ground for the rock-star scientists and engineers that are our future. They are the fuel that powers better achievements in space, done faster and more cost effectively.

I ask the Subcommittee to consider these five recommendations, as it deliberates the authorization of NASA's future programs: First, that NASA's new Vision for Space Exploration be authorized to move forward, in concert with an assured and balanced science program across the agency; second, that the importance of universities be recognized and university research be made a part of all NASA programs; third, that workforce development focusing on tomorrow's leaders be made a part of NASA's mission; fourth, that 1 percent of the NASA budget be devoted to university-led missions to provide hands-on training; and fifth, that NASA be reimbursed, through supplemental funding, the cost of returning the Space Shuttle to flight.

Thank you for this opportunity to appear before you today. I look forward to working with you and would be happy to answer any questions.

EXHIBIT A

Resolution of the Council of Institutions of the Universities Space Research Association

We being the members of the Council of Institutions ("Council") of the Universities Space Research Association ("USRA"), a nonprofit corporation organized under the laws of the District of Columbia, hereby adopt the following resolution:

WHEREAS, USRA is a one hundred member university association chartered, "To constitute an entity in and by means of which universities and other research organizations may cooperate with one another, with the Government of the United States, and with other organizations toward the development of knowledge associated with space science and technology;" and

WHEREAS, the research and teaching faculty of the member universities of USRA see firsthand the decline in workforce development for space science and engineering brought on by the diminishment of hands-on, low-cost flight opportunities involving students; and

WHEREAS, the Commission on the Future of the U.S. Aerospace Industry found in 2002 that, "The nation's apathy toward developing a scientifically and technologically trained workforce is the equivalent of intellectual and industrial disarmament and is a direct threat to our Nation's capability to continue as a world leader;" and

WHEREAS, the Commission on Implementation of United States Space Exploration Policy found in 2004 that, "At present, there are insufficient methods for students to acquire hands-on experience in the scientific and technical disciplines necessary for space commerce and exploration;" and

WHEREAS, the National Academies Committee on Meeting the Workforce Needs for the National Vision for Space Exploration found in 2006 that, "NASA should expand and enhance agency-wide training and mentorship programs, including opportunities for developing hands-on experience, for its most vital required skill sets, such as systems engineering;"

NOW THEREFORE, BE IT RESOLVED, that the council supports the plan outlined by the USRA Issues and Program Committee to provide multiple flight opportunities involving graduate and undergraduate students; and

RESOLVED FURTHER, that we urge the U.S. Government and others to implement and facilitate a plan to provide space flight opportunities that enable the hands on training for graduate and undergraduate students.

IN WITNESS WHEREOF, the members of the Council have adopted this resolution at their meeting of March 30, 2007.

UNIVERSITIES SPACE RESEARCH ASSOCIATION,
W. JEFFREY HUGHES,
Chair, Council of Institutions.

Resolution of the Council of Institutions of the Universities Space Research Association

We being the members of the Council of Institutions ("Council") of the Universities Space Research Association ("USRA"), a nonprofit corporation organized under the laws of the District of Columbia, hereby adopt the following resolution:

WHEREAS, USRA is an association of 102 universities, including 8 international universities, chartered, "To constitute an entity in and by means of which universities and other research organizations may cooperate with one another, with the Government of the United States, and with other organizations toward the development of knowledge associated with space science and technology;" and

WHEREAS a strong and inspiring NASA is critically important for our nation; and

WHEREAS research universities are extremely important engines of technological innovation in the United States and play vital roles in preparing the next generation of space researchers and professionals, as well as in developing and executing the space missions that help shape a positive, peaceful vision for all nations and give our country a competitive edge in a world that is increasingly dependent on space technology; and

WHEREAS the space workforce in the United States has been led by individuals who have had the benefit of hands-on training with actual space projects during their university years, and whereas the number of these crucial hands-on training opportunities at universities has been declining for decades, and that trend must be reversed if the United States is to retain its leadership position in space; and

WHEREAS future space research and exploration will be enhanced by the substantial and growing technological capabilities of nations other than the United States, and whereas for economic, scientific, and foreign policy reasons, it is vital that barriers to international collaborations by U.S. as well as other universities be reduced;

NOW THEREFORE BE IT RESOLVED, that NASA should be reauthorized as the leader of the civil space program for the United States and provided with significantly increased funding adequate to meet its responsibility to carry out a balanced space program, including advancing knowledge in the scientific and technology disciplines related to space and aeronautics, as well as carrying out the enterprise of space exploration itself; and

RESOLVED FURTHER, that the NASA reauthorization should specifically acknowledge NASA's support of universities as partners who generate new knowledge, make new discoveries in disciplines related to space and aeronautics, and train the specialized workforce needed to accomplish NASA's missions; and

RESOLVED FURTHER, that NASA budgets should reflect the historical precedent that at least 1 percent of NASA's total budget be devoted to funding competitive opportunities for hands-on training provided by university missions on sounding rockets, high altitude balloons, remotely piloted vehicles, emerging commercial suborbital flights, and university class space flight missions; and

RESOLVED FURTHER, that the fundamental research exclusion in the International Traffic in Arms Regulations should be extended to U.S. aerospace firms, Federal laboratories, and non-profit organizations when they are interacting with universities in pursuit of fundamental space research and on university space experiment hardware.

IN WITNESS WHEREOF, the members of the Council have adopted this resolution at their meeting of March 28, 2008.

UNIVERSITIES SPACE RESEARCH ASSOCIATION,
EDWARD J. GROTH,
Chair, Council of Institutions.

EXHIBIT B

Educating the Next Generation of Space Scientists and Engineers

"Our policymakers need to acknowledge that the Nation's apathy toward developing a scientifically and technologically trained workforce is the equivalent of intellectual and industrial disarmament and is a direct threat to our Nation's capability

to continue as a world leader." (The Report of the Commission on the Future of the U.S. Aerospace Industry, November 2002)

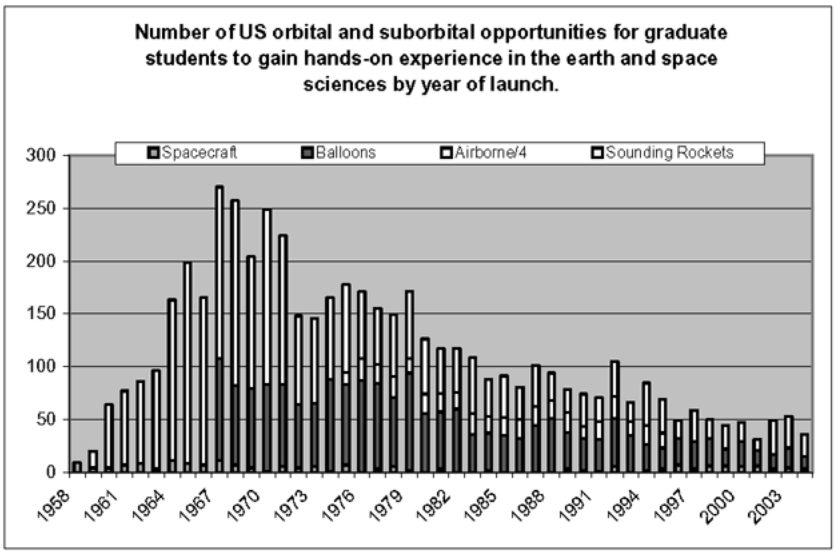
"At present, there are insufficient methods for students to acquire hands-on experience in the scientific and technical disciplines necessary for space commerce and exploration." (Commission on Implementation of United States Space Exploration Policy (the Aldridge Report), June 2004)

There is a significant deficit of scientists and engineers in the United States with meaningful hands-on experience with space instrumentation and space systems, which is jeopardizing the ability of the Nation to maintain a vigorous presence in space into the future, regardless of whether we are in space for reasons of commerce, exploration, national defense, or scientific research. This deficit leads not only to a loss of capability, but also to escalating costs of many of the space systems vital to the Nation's security and industrial competitiveness.

Space scientists and engineers are trained at universities, particularly in the science and engineering graduate programs of those research universities active in space research. To attract good students into these fields requires sufficient funding for graduate stipends from either research projects or graduate fellowships, and projects or research opportunities that excite students so that they choose space research over other possible areas. These projects or research opportunities must also provide the students with the range of experiences they need to become fully trained scientists and engineers.

The scientists and engineers who learned their trades during the first decades of the space age have reached or are nearing retirement. These were exciting years for a young person to enter space research, and space attracted many of the best young scientists and engineers. These years were marked by frequent launches of smaller missions many of which were led by university-based teams that included graduate students. These students got plenty of hands-on experience, and learned first hand the difficulties of designing and constructing an experiment or engineering system that would operate reliably in space. Many students also learned from designing and building experiments for smaller, suborbital flights on rockets or balloons, or by observing with an airborne telescope.

The chart shows that the number of these opportunities peaked in 1968, at the height of the Apollo program. Since then the number of student opportunities provided by spacecraft missions, rocket and balloon fights and airborne observatory sorties has diminished from over 250 per year to consistently less than 50 per year. Most graduate students now never have an opportunity to do hands-on science. Instead the vast majority of science PhD students analyze data obtained from instruments they have never seen and thus have only a vague idea of how they work or how they might malfunction. They certainly don't learn the important skills needed to conceive of, and to help design and construct a space experiment.



The chart hides another phenomenon. As space missions have, necessarily, become more complex, they also take longer to design and construct. The increasing complexity means that fewer universities have the resources and capabilities of managing the complexity, so increasingly missions are being run by non-academic laboratories and research centers. The mission time scale is now significantly longer than a typical graduate student remains in school. Both of these effects significantly decrease the likelihood of graduate student involvement, exacerbating the problem.

This is a national problem. It affects not only space science, but also human space exploration, global climate prediction, commercial ventures in space, and national security uses of space. All these enterprises require space engineers able to design and construct reliable space hardware, and space scientists who understand the space environment and the rigors of conducting any activity, robotic or human, in space.

What Needs to Be Done?

These critical needs are addressed by a proposed hands-on, rapid cycle flight program of moderate risk that focuses on inexpensive system development for suborbital and orbital applications. This program should provide multiple flight opportunities involving graduate and undergraduate students from science and engineering disciplines, and should provide the excitement of discovery to attract those who will become leaders of the future U.S. space enterprise. The program should permit a four-fold increase of hands-on experiences over present levels to return to the peak levels of the 60s and 70s. The proposed level of activity should allow an average of two launches per month or more.

Senator NELSON. Thank you.

And all of your written statements will be printed as part of the record, as well.

General Dickman?

STATEMENT OF MAJOR GENERAL ROBERT S. DICKMAN (RET.), U.S. AIR FORCE, EXECUTIVE DIRECTOR, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS (AIAA)

General DICKMAN. Good morning, Mr. Chairman, and thank you for inviting me to testify in this important reauthorization.

I'd like to thank all the Members of Congress, in fact, and their staffs, for taking the time to meet with AIAA members during our Annual Congressional Visits Day. We come to Congress every April, and, as was the case with you just a few weeks ago, we've been welcomed with hospitality and a willingness to engage our members in open and honest dialogue.

Thank you for including my written statement. I will try to keep my remarks very brief.

As the Executive Director of the American Institute of Aeronautics and Astronautics, I represent a constituency of over 35,000 aerospace professionals and students. We're located in all 50 states and 89 countries internationally.

During my tenure as Executive Director, I've heard countless members at our technical conferences and other venues voice their concerns about the fiscal health and the future of NASA and the impact on our Nation. As you've noted, if NASA were funded at 1 percent of our budget, rather than the fraction of 1 percent that has been requested, they'd still be terribly stretched.

We, as a Nation, are not doing the work we should be doing in basic aeronautical research and development, we're not doing the right things for life sciences and physical sciences, we're not doing the right things for education, as you heard from Dr. Tarantino, we're not doing the right things for space sciences, we're not doing the right things for solar science; and, and perhaps more impor-

tant, because 93 percent of NASA's budget goes to human spaceflight and exploration, we will not execute the program that's included in that vision with the budgets that have been requested.

NASA is too important to this country to be allowed to continue to atrophy. It's too important to our youth, it's too important to our education, to our overall technical strength, to our long-term economic growth, and, as you well know, Mr. Chairman, from your service on the Armed Services Committee, to our national security, as well, and to the many things that are more directly related to the mission of that agency.

I've identified, in a short list, the areas that I believe are at risk. I am not suggesting that NASA funds be reallocated to these areas at the expense of something within their budget. I'm a strong supporter of human exploration. It is among the most important endeavors that humankind has ever undertaken. Instead, I believe that the NASA top line must go up to be a level consistent with NASA's importance to this Nation, to our economic strength, our national security, and the future of mankind. The question is not whether we, as a Nation, can afford more funding for NASA, it's whether we're willing to invest in our own future.

Mr. Chairman, I appreciate the opportunity to share my views and those of the American Institute of Aeronautics and Astronautics on this enormously important legislation, and we thank you for all that you do for this Nation. I welcome the opportunity to answer any questions you may have.

[The prepared statement of Major General Dickman follows:]

PREPARED STATEMENT OF MAJOR GENERAL ROBERT S. DICKMAN (RET.), U.S. AIR FORCE, EXECUTIVE DIRECTOR, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS (AIAA)

Good Morning, Mr. Chairman and members of the Committee. I am Major General (USAF-Ret.) Robert Dickman, Executive Director of the American Institute of Aeronautics and Astronautics (AIAA). Thank you for inviting me to testify on this important issue. I would also like to thank all the Members of Congress and their staff for taking the time to meet with AIAA members during our annual Congressional Visits Day. We come to Congress every year in April and consistently have been welcomed with hospitality and a willingness to engage our members in open and thoughtful dialogue about important issues.

As Executive Director of the American Institute of Aeronautics and Astronautics, I represent a constituency of over 35,000 aerospace professionals and students, located in all fifty states and 89 countries internationally. During my tenure as Executive Director, I have heard many members at our technical conferences and other venues voice their concerns about the fiscal health and future viability of NASA.

At a funding level of only a fraction of a percent of the annual Federal budget, NASA is being systematically starved. NASA is being forced to eliminate or severely reduce some very important work, to the detriment of critical aerospace research and development, and more broadly to the detriment of our aerospace strength and our industrial base. The Vision for Space Exploration was an aggressive, forward-looking proposal when offered by the President and endorsed by the Congress. However, while NASA has undertaken a positive exploration agenda, funding levels have not been at all sufficient to meet those goals. Thus, in order to come even close to meeting the requirements for the Constellation program, NASA has been forced to cut funds from other programs, programs that have been at the core of American excellence in aerospace for half a century.

For example, research cuts since 2003 have reduced fundamental space-related life science and physical science research programs by 85 percent, affecting over 1,700 scientists and nearly 3,000 students. NASA is the sole steward of this research. If NASA doesn't do it, it won't get done—at least not in this country. At the same time, China, Japan and other nations are continuing robust research in these

areas, and those countries are poised to assume the scientific and technological leadership that we are letting slip away.

Furthermore, the Federal aeronautics budget reflects NASA's need to focus its resources on other priorities. In 1994 NASA's aeronautics budget was $1.54 billion. By FY07 the aeronautics budget was cut to $594 million. The FY09 budget reflects further cuts at $447 million. With less than a third of its prior budget in this area, critical needs are going unmet.

It is AIAA's position that stable, robust, long-term Federal civil aeronautics research and technology initiatives funded at the level that will assure U.S. leadership are critical to sustaining a strong national economy, maintaining a skilled workforce and ensuring our national security. NASA must continue to have a leadership role in this effort. The Administration has approved a policy on aeronautics research and an implementation plan to achieve the stated goals. These were drafted with the collaboration of the best talent from academia, industry and government. However, if we cannot execute these programs, and continue to lose our advantage in the basic understanding of aeronautics that has allowed us to develop the world's finest commercial and military aircraft for the past 60 years, it will be the result of inadequate funding, not the absence of a well thought out plan.

Turning from aeronautics to space, our domestic space transportation capability is achieved using a very limited number of vehicle types. Launch vehicle reliability has improved in recent decades, but the cost of space access remains very high, even with the Evolved Expendable Launch Vehicles. Operational constraints and the price of these vehicles limit incentives and opportunities for expansion of space operations, in-orbit capabilities, and space commercialization. Meanwhile, government investment in advanced launch concepts and associated technology that could make space access significantly more robust has dropped to nearly zero, as we focus our attention on the near-term needs of exploration and assured access to space. Absent investment in the truly breakthrough science and technology that would lead to revolutionary changes in space transportation, U.S. access to space in 2040 will not look significantly different from 2020, or 2000, or 1980.

This is not a new problem. Our government-funded launch systems are based on most of the same principles and technologies as the rockets that launched Sputnik or Apollo or the Shuttle in 1981. A little over 50 years after the Wright Brothers' first flight, the jet-powered passenger aircraft that became the 707 was being tested. By way of comparison, fifty years after the first Delta rocket put the Echo satellite into orbit, the Delta II is still the most used American launch vehicle. We have been evolving the technology of the 1950s ballistic missile programs for half a century. Without investment in basic science and technology, that's what we will be doing for the next half century. We've already lost almost the entire commercial space launch market—a market that was once 100 percent based in the United States. If we are still flying legacy-based rockets thirty years from now, our only payloads will be from the government. Anyone with a choice will have gone overseas.

Space transportation is the key to our future role as a space-faring nation. We can regain our leadership role if we apply our technical strength to the problem, but it will not happen without significantly increased NASA investment.

Human spaceflight is an inspiring manifestation of our species' urge to reach and explore new destinations, which also enables discovering much about how we came to be and what might be our future. The U.S. has been a leader in this endeavor from the beginning. This has led to advances in our educational system, it has inspired some of our youth into advanced technology careers, and it has showed the world how U.S. aerospace prowess can benefit all of humanity.

There are some who would draw a distinction between education, the quality of our technical workforce, and programs such as NASA's. However, the economic growth of this country in the latter half of the last century demonstrates the fallacy in that thinking. It would be difficult to find any significant growth sector that didn't benefit, directly or indirectly, from the emphasis this country placed on scientific and technical skills in the early days of the space age. NASA's programs inspired generations of young people to study what today we call STEM—science, technology, engineering and mathematics. Government programs provided scholarships, loans and funding for university and industrial research programs that were the incubators not only for technology, but also for technologists, the scientists and engineers that make it all happen. Without NASA, this country would be a very, very different place now. Looking ahead, though, continued U.S. leadership in human spaceflight is clearly threatened. I am not concerned that other nations are launching humans to space, anymore than I am concerned that other nations can launch satellites to space. It is a natural evolution of an exciting endeavor. What I am concerned about is that NASA is so under-funded that virtually every area in aeronautics and astronautics is at serious risk.

In human spaceflight we expect at least a four-year gap between retirement of the Space Shuttle and the first piloted flight of the Crew Exploration Vehicle (CEV). Current plans are to rely on Russian systems for crew rotation in the interim. Use of the CEV to provide crew rotation for the International Space Station (ISS) is not projected after 2017, jeopardizing the opportunity to reach the full benefit of this unique research facility. There are alternatives to the Ares-Orion for access to the ISS, including commercial and government approaches. However, none will be available without additional funding. Meanwhile, other nations are not standing still. Other countries are working vigorously to develop and/or expand a human presence in Earth orbit, on the moon, and beyond, with the clear potential to eclipse the U.S. leadership status in this area of human achievement and economic opportunity. In this case, the issue isn't whether we have the systems to sustain U.S. access to space and continue use of ISS once the Shuttle is retired; it is a matter of funding.

In 2003, there were over 1,000 research projects focusing on basic non-exploration space physical and life sciences across the United States, which supported over 1,500 scientists, and over 3,000 students. Today, only 5 years later, there are 85 such research projects, supporting approximately 300 students. This is a decrease of 90 percent. NASA is justifiably fond of speaking of the current crop of researchers who were motivated to pursue careers in space-related research by their fascination with the Mercury, Gemini and Apollo programs that culminated in landing astronauts on the moon. But with the absence of NASA-oriented research programs in our universities, where will the next generation of these researchers come from?

Before leaving the area of the science programs, I want to applaud Administrator Griffin for several decisions he's made to keep very capable scientific satellites functioning. Obviously, the decision to do the Hubble repair mission was the most expensive and probably most difficult choice. However, Dr. Griffin has also sustained operating funds for the Mars Rovers and other satellites. I spent most of my professional life engaged in activities related to the development, launch and operation of satellites. The idea of turning off a perfectly good spacecraft that may have cost hundreds of millions of dollars to build and launch, has gotten past the incredibly dangerous trip to space and initial deployment and can still perform a useful mission even when past its intended life in order to save a comparatively small annual operational cost simply makes no sense. The fleet of spacecraft NASA is operating to look at our planet, our solar system and the universe beyond is unprecedented and truly remarkable. NASA deserves nothing but compliments for fielding them—and for continuing to operate them.

I'd like to say a bit more about education. AIAA has worked to advance the state of aerospace science, engineering, and technical leadership for over 75 years. As such, we are keenly aware of the difficulty facing our industry with respect to attracting and maintaining a competitive workforce. Addressing this looming crisis is a major priority for our Institute.

The Report of the National Academies, "Rising Above the Gathering Storm" done at the request of the Congress, documented the problem of the weakness of Science, Technology, Engineering and Mathematics in our educational system and in the areas of interest in our young people far better than anything I could say. The America COMPETES Act is an excellent step—but it is just a step. The more recent "Is America Falling Off the Flat Earth?" by Norm Augustine reminds us that no nation has an inherent right to greatness. Generations of Americans worked to achieve our greatness, and generations must work equally hard to sustain it. What has this got to do with NASA? Everything!

The technical cohort that came into the American workforce during the Apollo era, not the people that built Apollo, but the scientists and engineers who were inspired during that era, are leaving the workforce, without sufficient replacements in the pipeline. While NASA is certainly not the sole source of funding for technology, it provides without doubt the most visible motivation for young people to decide to study STEM-related subjects.

Science, Technology, Engineering and Math education in our Nation's classrooms provides the critical foundation needed for our future national security and economic competitiveness. However, we are too quick to consider these as interchangeable disciplines, and assume the traditional curricula in mathematics and science will provide understanding about technology and engineering.

To oversimplify, a scientist wants to know something that hasn't been known; an engineer want to build something that hasn't been built, wants to satisfy a societal need. The scientific mind will tell you that in your kitchen there is sodium chloride—salt—and lots of other compounds. It will tell you that things melt or boil when heated, that eggs come from chickens, and so forth. But it takes an engineering mind to address the societal need of producing a meal—of translating scientific knowledge into a useful product.

It is important that NASA funds research. So does the National Science Foundation. It is enormously important that NASA be able to take that research and develop useful things from it and provide the information for others to do the same. The list of useful things that have been derived from the space program is too long to be repeated here, since NASA research has led to more than 6,000 patents. My point is simply that increased emphasis and funding must be directed to the Technology and Engineering components of STEM if the Nation is to reap the full benefits of STEM spending. In particular, STEM legislation should provide strong support for Technology and Engineering education at all levels from kindergarten through university. NASA can and must play a central role in this effort, just as it is important that the America COMPETES Act of 2007 be fully funded.

To summarize, I will repeat my comments reported in the April 28 edition of *Space News*:

> "NASA is more than stretched, they are just terribly under-funded. Rather than being funded at a fraction of a percent (of the Federal Budget), if they were funded at 1 percent of the budget, they'd still be stretched.
>
> - We are not doing the work we should be doing in basic aeronautical research and development.
> - We are not doing the right kinds of things for education.
> - We are not doing the right kinds of things for life sciences.
> - We are not doing the right kinds of things for space sciences.
> - We are not doing the right kinds of things for solar science.
> - And we are not going to be able to succeed at the exploration program with the budget we've got."

NASA is too important to this nation—to our education, to our overall technical strength, to our long-term economic growth and to the many things that are more directly in its mission to continue to be so under-funded. I have identified areas that I believe to be most at risk. I am not at all suggesting that NASA funds be reallocated to these areas, because the money is simply not there. Instead, I believe the so-called NASA top line—the total budget of NASA—needs to go up to a level consistent with NASA's importance to the nation, and to America's future.

Mr. Chairman, I appreciate this opportunity to share my views and those of the American Institute of Aeronautics and Astronautics on this enormously important legislation. I welcome the opportunity to answer any questions you may have.

Senator NELSON. Thank you, General.

Mr. Whitesides?

STATEMENT OF GEORGE T. WHITESIDES, EXECUTIVE DIRECTOR, NATIONAL SPACE SOCIETY

Mr. WHITESIDES. Thank you, Mr. Chairman.

My name is George Whitesides, and I serve as the Executive Director of the National Space Society, NSS. Thank you for the opportunity to share with you the views of NSS and our members.

We're an independent grassroots organization composed of 20,000 members, founded in 1974, as you know, with the goal of promoting space exploration and development. The ultimate vision of the society is people living and working in thriving communities beyond the Earth and the use of vast resources of space for the dramatic betterment of humanity. Our members are citizens from every state in our great country, but, Mr. Chairman, I would note that we, of course, have our strongest chapters in Florida.

On behalf of the NSS membership, I would like to share the following five major recommendations for the reauthorization:

First, the Vision for Space Exploration should be reauthorized by the Congress. Endorsed with bipartisan support in 2005, the vision sets out an inspiring path for its human habitation and use of the resources of the solar system.

Second, we recommend space exploration be conceptually and programmatically linked with the solutions to the pressing challenges of Earth, particularly those issues related to climate, energy, and the environment. NASA may be the most well-equipped agency in the world to help solve the monumental challenge of climate change. NASA was instrumental in diagnosing the problem, and now is well equipped to craft solutions. What America must understand is that the full breadth of NASA's skills, people, and technologies will be required to meaningfully respond to and solve the biggest challenges of our time.

Third, the most urgent space issue our Nation faces in the coming years is the human spaceflight gap. Gerry Carr, Commander of the final Spacelab—Skylab mission, excuse me—a man who knows firsthand about these issues, wrote to me the following comments a few days ago. He said, "I thought we had learned the lesson during the 7-year hiatus between the Apollo and Shuttle programs. A huge body of NASA and contractor skill and experience just left to do something else, then the workforce had to be built up all over again, at no mean cost, in order to proceed with the Shuttle and Space Station programs."

Curtis Schroeder, an NSS member from Atlanta, Georgia, put it this way. He said, "We cannot outsource our manned spaceflight needs to other countries if we are to be a world leader."

We are, indeed, confronted by another gap, and NSS believes that Congress should direct NASA to make that gap as short as possible, and should use multiple means of doing so.

We recommend that NASA receive an authorized budget addition of $2 billion this coming fiscal year. With these funds, NASA could implement an acceleration of the Constellation program, fund COTS option D, and get reimbursed for the expenses it sustained following the *Columbia* accident.

Fourth, we recommend that the reauthorization reiterate that NASA should, wherever possible, purchase commercial services. Buying services encourages the innovative powers of the American entrepreneurial spirit in small and large companies, creating dynamics that will, over time, grow our economy, lower the cost of space access, and enable NASA to focus its efforts and funds on exploration of the frontiers. The Senate should commend NASA's leadership for its active pursuit of services, including, in particular, COTS, parabolic flight, and the new area of commercial suborbital spaceflight.

Finally, I would like to close with three areas in which NASA should make highly leveraged investments that could generate significant return in economic utility, public support, and global health and welfare.

First, space-based solar power, in which solar energy is collected in space and beamed down to Earth, is a strategic goal worthy of our imaginations and national spirit. While SSP is not a short-term solution for national energy production, the Nation must begin investing in such technologies now if it is to meet the energy needs of the future. Congress should authorize NASA to perform a new study of the concept and to plan for space-based solar power demonstration.

Second, though it may seem unlikely, if we do nothing, sooner or later we will be hit by an asteroid large enough to threaten life on Earth. Given the nature of this threat, NASA should have an ongoing program for developing defensive strategies. This is environmental protection of the highest order.

Third, and finally, NASA should begin designing public participation into its mission from the start, using the Internet and other modes of communication as a way to enable private citizens to access, engage with, and experience future exploration missions.

Thank you for the invitation to share the perspectives of the members of NNS with you today, and I look forward to your questions.

[The prepared statement of Mr. Whitesides follows:]

PREPARED STATEMENT OF GEORGE T. WHITESIDES, EXECUTIVE DIRECTOR, NATIONAL SPACE SOCIETY

Chairman Nelson, Ranking Member Vitter, and Members of the Subcommittee:

Thank you for the opportunity to share with you the views of the National Space Society on the upcoming reauthorization of NASA.

I serve as the Executive Director of the National Space Society (NSS). NSS is an independent, grassroots organization with over 20,000 members, founded with the goal of promoting space exploration and development. NSS communicates the excitement and benefits of space to the public, and represents the perspectives of the space-interested public to policymakers.

Our members are citizens who live and work in every state in our great country. They include a wide swath of America, from teachers, to students, to business leaders, to elected officials, to even a few astronauts. Most, however, are simply everyday citizens without ties to the space industry, citizens who understand the importance of space to our Nation and its future.

I am proud to represent the voices of our members to you today. In preparation for this testimony, we solicited their views on these issues, in addition to those of our board and policy committee, and the members responded with eloquent and nuanced comment on future space activities. I will share some of their words with you as part of this statement.

NSS was founded over 30 years ago by a group of leading Americans that included Wernher von Braun and Hugh Downs. Their vision, and that of our current Governors, such as John Glenn, Tom Hanks, and Buzz Aldrin, continues to inspire us today. The ultimate vision of the society is:

> "People living and working in thriving communities beyond the Earth, and the use of the vast resources of space for the dramatic betterment of humanity."

While the first part of that vision emphasizes exploration and settlement of space, the second emphasizes how the resources of space can be used to improve life on Earth. These are both crucial, as I will discuss in more detail below, for they hold the key to the long-term future of the agency and its mission.

A. The Value and Importance of U.S. Space Exploration From Economic and Strategic Perspectives

We live in a new age of discovery, in which we learn on a regular basis of new oceans under the crust of distant moons, new planets around distant stars, and new possibilities for life beyond Earth. Our astronauts regularly perform heroic feats on orbit, as they build the International Space Station, the largest and most complex science project in history. Meanwhile, a new generation of space entrepreneurs is emerging, with plans to transform the space sector with new services and lower costs. It is an exciting time.

It has been said that a thousand years in the future, our era will be remembered most for the birth of spaceflight, the moment in human history when we developed the ability to travel to space. It is humanity's ultimate destiny to explore the universe, to develop the ability to live for extended periods off planet Earth, and eventually, to build communities in space. I firmly believe that the individuals who have advanced the space frontier during these early years will be remembered as among the greatest heroes of our era, as those who recognized the historical importance of space to our Nation and the world.

But we live in the present, and together we must confront three interlinked groups of challenges of our time:

- Education, competitiveness, innovation and our economy;
- Energy, resources, climate, and environmental protection;
- Security, diplomacy, and peace.

My primary message to you today is that space is a key part of the solutions to all of these present-day, national challenges. That fact is something that we do not hear enough of today, and it is critical to ongoing public support for future space activities. What America must understand is that the full breadth of NASA's skills, people and technologies will be required to meaningfully respond to and solve the biggest challenges of our time.

Our great country must apply its full abilities to solve these serious tests over the coming years:

- *We must inspire and educate our young people to become the scientists, engineers and innovators of tomorrow.* Nothing inspires children toward the study of science and engineering like an ambitious space program that matters to our country's future. At a time when our education system is falling behind, we must do all we can to motivate children to enter STEM careers, and to offer them jobs once they enter the workforce.
- *We must maintain and build our industrial base, and create innovations which build prosperity.* NASA's spaceflight capabilities are a strategic asset of the country, and its engineers and contractors have long driven critical technological advances that drive our economy. The space sector has grown to a quarter-trillion dollar global industry, and is one of the few in which the U.S. maintains a positive balance of trade.
- *We must shift to new forms of energy production, and develop new resources to power and supply our global economy.* Space-based Solar Power offers a potential future energy source that is clean, fully renewable, and that provides base-load power. Helium 3 resourced from the Moon could provide a much cleaner fuel for fusion power.
- *We must protect the Earth's environment, and seek to forestall rapid climate change.* NASA is the world's foremost climate science agency. Going forward, its world-class system engineering capabilities could help design solutions for climate change on a national and global scale.
- *We must forge new alliances with allies and competitors, and strengthen our economic and national security.* As space becomes increasingly important for the global economy and global security, America must lead to establish a new system for lasting peace and stability in space and on Earth.

NASA can be the keystone to the future, critical to the great challenges of the present, central to solving the issues that Americans care most about. But only if we can put forward a bold program that links the needs of Earth with the potential benefits of space.

The Vision for Space Exploration provides the foundation for such a bold program, and as such, it should be reauthorized by the Congress. Endorsed with bipartisan support, the Vision sets out an inspiring path toward human habitation of the Moon, Mars and other destinations in the solar system. It builds on the hard-won wisdom following the *Columbia* accident: that the risk faced by American astronauts deserves a worthy goal, that of exploration of the solar system. Under the Vision, an official path for human exploration beyond low-Earth orbit was set out for the first time in at least a decade.

We would recommend that two themes within the general direction of the Vision be explicitly directed by Congress within the Authorization:

- *To link the work of human and robotic exploration more closely with the response to the pressing needs of planet Earth, particularly those issues related to climate and energy;*
- *To recommit to engaging, building and using commercial space services as the preferred option for NASA's needs whenever available.*

The first theme anchors the Vision to the real challenges facing America today, creating real sustainability. That, in turn, will help build public understanding and support for NASA's mission. The second utilizes the full powers of the American entrepreneur, creating dynamics that over time will grow our economy, lower the cost of space access, and enable NASA to focus its own efforts and funds on exploration of the frontiers. Both themes will ultimately support the sustainable expansion of

our civilization outward to the Moon, Mars and beyond, and the expansion of the Earth's economic sphere to include those bodies.

Ultimately, space is the main path forward to resolving the great humanitarian and environmental challenge of our time—the global disparity between rich and poor. One of our members, James Martin of Springfield, Virginia, captured the real scope of the issue at hand:

> It seems to me that the great challenge facing the world in the coming decades is a growing contention for resources—most acutely energy—between the industrialized world (the "haves") and those rapidly industrializing countries (the current "have nots") that seek a lifestyle similar to ours. China and India, with the world's two largest national populations, are leading this quite natural urge of the "have nots" to improve their lot in life. This is leading to increased demand on global resources by economic growth in these two countries—a situation that can only get worse. It has been said that we would need three Earths to provide the energy and mineral resources to support the entire human population at a standard of living equal to the current industrialized countries (who make up only ⅙ of the planet's population). This leads to a grim conclusion that the "haves" will increasingly have to fight to defend their current advantaged position (a dubious moral proposition), or we will have to change the "playing field" by accessing energy and mineral resources beyond this planet. Moreover, fossil fuels cannot support a massive increase in global industrialization without pushing us even further into environmental collapse.
>
> There has never been a better time for a fundamental change in our perception of the future. If mankind can access resources beyond Earth, we can offer the hope of economic well-being and a clean environment for all, and avoid debilitating future resource conflicts that will only make us all poorer. America's space program must be oriented toward creating this future.

B. The Implications and Consequences of Any Gaps in the Nation's Space Capabilities

Curtis Schroeder of Atlanta, Georgia, wrote to me, in preparation for this testimony,

> "We cannot outsource our manned space flight needs to other countries if we are to be a world leader."

Perhaps the most urgent space issue our Nation faces in the next few years is the human spaceflight gap between the retirement of the Space Shuttle and the start of Constellation Program operations. This gap, right now estimated to be five and a half years, will be about as long as the gap the Nation experienced between the retirement of the Apollo hardware and the launch of the Space Shuttle.

Our Nation's space program survived that gap, but the environment was much different then. Where we once had a single competitor in space, we now have several. Where before we faced competition in orbital operations rather than lunar adventures, today there are three other nations orbiting hardware around the Moon, with Russia and China both expressing interest in sending humans there, possibly before Constellation's target date of 2020. We are running the risk of falling behind in space, even if no "space race" has been declared.

The consequences of the gap, as seen during the transition between Apollo and Shuttle, are well known and ominous. Loss of funding translates into a loss of NASA's most critical assets: the knowledge, corporate memory, and hands-on skills of its people. With a loss of jobs comes a loss of economic vitality in communities like Brevard County, Florida; and New Orleans, Louisiana, as people move away to look for jobs and take their money and families with them. Once those people are gone, restoring diminished capabilities and communities will not be as simple as issuing a call-back after a brief layoff.

Jerry Carr, Commander of the final Skylab flight—a man who knows about such issues firsthand—wrote me the following comments:

> "I thought that we had learned the lesson during the seven-year hiatus between the Apollo and Shuttle programs. A huge body of NASA and contractor skill and experience just left to do something else. Then the workforce had to be built up all over again at no mean cost in order to proceed with the Shuttle and Space Station programs.
>
> "Where is the incentive to build up our scientific and technical base if we have no space program to which those young minds can aspire? Space exploration is where the United States has shown leadership, and in the current climate . . . we can't afford to abdicate the heritage we have established in space."

Over 20 years ago, a prescient report came out following the Challenger accident, The Report of the National Commission on Space. It made a similar observation then, and today the situation is significantly more pressing:

> "Should the United States choose not to undertake achievement of these economies in launch and recovery capability, then the Nation must face the probability that other nations will rapidly overtake our position as the world's leading spacefaring nation. The competition to get into space and to operate effectively there is real. Above all, it is imperative that the United States maintain a continuous capability to put both humans and cargo into orbit; never again should the country experience the hiatus we endured from 1975 to 1981, when we were unable to launch astronauts into space."

Another gap is indeed upon us. NSS believes that this Committee should make that gap as short as possible, and should use multiple means of doing so.

Fund Acceleration of the Constellation Program

NASA and its contractor team are well on their way toward development of the Ares I launch vehicle and Orion capsule. Starting over or even stopping to re-evaluate the designs would further extend the gap. Therefore, we believe NASA should receive the resources it needs to develop the Ares/Orion architecture as it now stands.

With an additional $2 billion a year, NASA could close the gap to three and a half years. This would also reimburse the agency for the expenses it sustained in adding safety systems to the Shuttle following the *Columbia* accident. However, many of the processes needed to develop the new Ares launch vehicles and Orion Crew Exploration Vehicle are linear in nature and cannot be hurried along by additional money or resources. NSS asks Congress to fully fund these development efforts to meet their best-case schedules.

Authorize and Fund COTS Option D

In addition to supporting NASA's current efforts to reduce the gap, NSS favors providing additional funding for commercial development of crew transportation to the International Space Station. In recent letters addressed to the Senate and House Appropriations Committees, Gary Barnhard, NSS Executive Board Chairman, and Greg Allison, Executive Committee Chairman, argued for additional funding of Part D of the Commercial Orbital Transportation Services (COTS) program. We support COTS Part D because we believe that it could:

- Shorten the "gap" in U.S. human space access after the Space Shuttle is retired;
- Foster technological diversity and competition among the companies providing these capabilities, which also can be used to support other operations;
- Allow innovative providers to use their best practices to develop and provide needed capabilities, outside traditional government organizational or procurement channels;
- Add budgetary flexibility to NASA's ISS servicing efforts, potentially at a lower cost than NASA could do otherwise; and
- Attract outside investment, if the program is properly structured.

Improve Opportunities and Incentives for Commercial Space Activities

As the COTS program matures, Congress can further both commercial development of space transportation systems and provide productive uses for the International Space Station after its scheduled defunding in 2016. This can be done by encouraging NASA to buy services for ISS, to conduct space-based research, and to develop space-based education opportunities where it can to help stimulate services where none exist today. A combination of Space Act agreements and traditional contract vehicles could increase demand for commercial transportation services, fund new space ventures, and serve as a bridge between ISS's status as a government laboratory and its future as a commercial outpost.

The American taxpayer wants to know that the efforts made and money spent to complete the Station have been worth it. One NSS member, Mr. James Grosbach, wrote to me in an e-mail:

> Almost as distressing as the upcoming "gap" is the projected date of 2016 as the retirement date of the ISS. My God, we'll no sooner have the thing built than we'll be looking at abandoning it. Funds should be made available to upgrade and refurbish ISS systems to keep it usable well into the third decade of the century!

In short, NSS members believe that it is both good and proper for the Nation to continue funding and using ISS as a lab for productive science and commercial ventures—either through NASA, the private sector, or a combination of the two.

Develop New Heavy Lift Vehicle

It is critical for exploration of the Moon and Mars for NASA to be authorized to continue past development of the Ares I to a new heavy lift vehicle. NASA currently has baselined the Ares V vehicle, a new development program which will possess the capacity to launch the payloads required for lunar surface exploration.

C. NASA's Needs for Accomplishing the Vision for Space Exploration

Full Funding Under the VSE's Original Budget Run-Out

According to the Congressional Research Service,[1] when the Vision was first proposed in 2004, the Bush Administration stated that $12.6 billion would need to be added to the NASA budget over the course of Fiscal Years 2005 through 2009, with NASA projected budget chart suggesting that $150–$170 billion would be spent on the Vision from FY 2004 to 2020. Most of the money was to come from other NASA programs, such as the retiring Space Shuttle. The $12.6 billion, for example, comprises $1 billion in new money, and $11.6 billion that is redirected from other NASA activities.

In the FY 2005 budget, the White House projected that NASA's total budget would increase about 5 percent per year for FY 2005–2007, then at less than the rate of inflation—about 2 percent—for FY 2008–2009. However, according to Administrator Griffin's budget testimony and actual budget figures, NASA's budget did not meet the expected profile in 2006 and 2007, and received a budget increase of 3.1 percent for the entire agency for FY 2008.

What do these figures mean? In simple terms, NASA needs the money originally proposed for the Vision to ensure its continued success. At present estimates, NASA will require an additional $1–$2 billion to accelerate *Constellation,* repay for *Columbia,* support COTS–D, and protect our national commitments to science.

This funding will require the joint efforts of the next president as well as both parties in both houses of Congress to look after our national interest and make good-faith efforts to sustain the Vision. The NSS believes there is sufficient cause for hope, given this body's bipartisan support for the 2005 Authorization.

A Sustained National Commitment to Space Exploration

One of the virtues, but also one of the challenges, of living in an elected, representative government is that personnel and priorities constantly change. Fortunately, the Nation as a whole, the Congress, and the President have all seen the value of supporting space-related activities since the initial space race of the 1950s. While that support has waxed and waned over the years, the Gallup organization reports that the percent of Americans who want NASA's budget to remain the same or increase has never been lower than 51 percent since 1984.[2] I take that as a hopeful sign for what we can accomplish in the future.

This Nation has always stood for progress, expanding the frontiers of the possible, and improving the lot of its citizens. If the American people are willing to maintain a consistent belief in the value of space exploration, then I believe any future President or Congress would be safe in continuing this valuable national investment. It is about more than following the polls; it is about continuing to support an activity that, to the majority of Americans, stands for progress and a better future. It also means demonstrating this Nation's commitment to being a leader in high technology of all kinds. Space exploration is a national emblem of achievement and soft power of which its citizens can be justly proud. Support for the Vision, then, is not just a matter of material support in the form of passing budgets every year; it is a national enterprise that deserves our constant verbal and moral support.

An Environment That Encourages Private-Sector Participation

NSS greatly admires NASA's exploration efforts; that is why we are here to support them. And we want NASA to continue its role on the cutting edge of technology and the space frontier. However, if we are going to have a true "space economy"—one where individuals and businesses are buying and selling goods and services be-

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[1] Smith, Marcia S. "Space Exploration: Issues Concerning the 'Vision for Space Exploration' Resources, Science, and Industry Division." CRS Report for Congress Code RS21720, Updated June 9, 2005.

[2] Jones, Jeffrey M. "Support for Space Program Funding High by Historical Standards." *Gallup.com http://www.gallup.com/poll/9082/Support-Space-Program-Funding-High-Historical-Standards.aspx* August 19, 2003.

yond Earth orbit—then space activities must be opened more fully to private-sector participation. The long-term viability of space requires it.

As I stated earlier, NASA needs to buy services for ISS, research, and education where it can to help stimulate commercial services where none exist. ISS can become, over time, a pioneering commercial outpost in low-Earth orbit. If there are activities in which the private sector stands to make a profit, then competing, enterprising companies of all types will race to fill the niches. They will diversify, lowering the cost of services available for purchase by the government, as well as broaden the tax base and create new, spinoff niches that the government hadn't considered—that is what it does best.

Other activities Congress and NASA can perform to ensure a welcoming environment for the private sector include:

- Allowing commercial firms to make fixed-price bids on cost-plus procurements so they do not have to reorganize their business processes to meet the administrative burdens of cost-plus contract accounting when dealing with NASA.
- Increasing the use of fixed-price, milestone- or performance-based procurements for certain, smaller R&D projects.
- Using emerging commercial space flight capabilities for space and earth science, aeronautics, and exploration-related crew familiarization and training missions, including but not limited to parabolic flights, suborbital vehicles, and emerging launch vehicles.
- Not demanding a broad use license for intellectual property originating in the private sector as a term of funding demonstrations of the relevant technology, or the development of applications for the technology, but rather agreeing to license this intellectual property for public uses.

The private sector has historically relied on the government to spend money on the difficult, unglamorous things that do not readily generate revenue but are necessary for the functioning of a healthy economy. These include building physical infrastructure, establishing legal "rules of the road," and protecting the individual consumer.[3] Congress and NASA have several excellent opportunities to do all of these things through the following programs:

- *COTS/COTS D Demonstration Programs*—As stated earlier, NSS strongly encourages NASA to fully fund the existing COTS cargo and crew launch demonstration and development programs. Even if the competitors currently receiving funding—SpaceX and Orbital Sciences—do not manage to close "the gap," I believe the capabilities they develop will only serve to strengthen U.S. commercial space transportation. After all, if it is truly NASA's goal to focus on exploration, then it will be left to the private sector to handle basic transportation services to low-Earth orbit. The more providers in the market, the lower the potential cost to the government when it needs services in the future.
- *ISS Crew and Cargo Operational Services*—Once SpaceX, Orbital, or other providers begin to show results, it is incumbent upon NASA to select those services to support ISS *first,* with Ares and Orion providing the backup. If the private sector is truly able to generate the economies of scale necessary to dramatically reduce the cost of LEO access, it would truly be a waste of highly capable exploration hardware to make those trips.
- *Suborbital Commercial Vehicles*—Suborbital commercial spaceflight will transform the public's relationship with space, and unlock new opportunities for scientists and astronauts to fly to space with unprecedented frequency. These advantages have been recognized and supported in multiple speeches by NASA Administrator Michael Griffin.

  These new vehicles will serve as platforms for critical climate science research, and offer space professionals authentic space training at higher volumes and a fraction of the cost of orbital spaceflight.

  Under the leadership of Administrator Griffin and Deputy Administrator Dale, NASA has already taken the lead on this opportunity by creating the Suborbital Scientist Participant Pilot Program, which would enable scientists to fly with their experiments as they do onboard high altitude research airplanes. NASA should take the next step for the program by issuing a Research Announcement this year to investigators, to implement the program as commercial vehicles come online over the next 2 years.

[3] Sadeh, Eligar. *Space Politics and Policy: An Evolutionary Perspective.* ISBN 1402008791, Springer, 2003.

This program should be supported via Congressional authorization, receive appropriations as part of the new NASA initiative in suborbital flight, and be encouraged to expand, for it offers students and researchers the chance to operate space experiments affordably and at high flight rates. It will also encourage a new generation of young people to pursue science and engineering degrees, knowing that they have a good chance to fly to space. Additionally, the U.S. astronauts corps may find it valuable for space training, particularly during the gap in American orbital spaceflight capability.

- *Parabolic Flight*—NASA has recently engaged an outside provider of parabolic flight services after a lengthy competition. This direction is the right direction for the agency, because outside companies can defray their costs over multiple customers, saving the government money while building commercial American capability. The Senate should support this activity, and encourage the agency to pursue similar efforts.
- *Centennial Challenges*—Congress should reinforce the important role Centennial Challenges can play in developing new technologies and capabilities critical to NASA's mission, and in creating economic benefit for taxpayers. This is a relatively low-cost, low-risk way for the government to obtain the benefits of new technology, paying only for success.

All of these activities enable private citizens, especially our young people and students, to learn, develop, and be rewarded for new technologies.

Participatory Exploration Activities

As a tactical and practical matter, NASA must integrate public participation meaningfully at the initial design phases of its missions. This means using the tools of the Internet as means of allowing private citizens access and input into future exploration missions. This goes beyond the simple distribution of images via the Web, to an era in which the public truly experiences space exploration, in real-time and in high resolution. Participatory exploration offers the opportunity for NASA and other space organizations to redefine the public's relationship with exploration, and energize the public about space exploration goals and missions.

Ames Research Center's open forum in the "Second Life" web-based graphical environment, known as Co-Lab, provides one such model for participation. Private citizens are allowed to join in discussions about goals and experiments being developed for robotic exploration of other worlds.

OpenNASA.com has become a sounding board for NASA's Generation Y employees to share their experiences and thoughts about how to improve the agency at a technological and cultural level.

To encourage future interest and mass participation in future missions, NASA could incorporate Web-based interactivity into robotic landers from the start. For example, viewers could vote on where a rover might travel to next, where to place the American flag on a future human mission to the Moon or Mars, or what to name particular features of a landing site.

All of these methods are electronic means of attracting and holding the attention of a generation that has grown up with the Internet and *expects* interactivity—in technologies as well as organizations.

D. Other Relevant Items for the Attention of the Committee

It might seem paradoxical, but while support for NASA remains consistently high, the public often has little specific knowledge of the benefits they receive from the agency's activities. NASA's human exploration missions can be used to address most of the major issues threatening our uncertain world, from energy independence, to economic, national, and environmental security. In other words, the space program can help address issues Americans are concerned about most.

Energy Resources: Space Solar Power

Space-based solar power, supported by lunar resources and human settlements in space, is a solution that could 1 day have tangible benefits directly affecting all Americans, and is a strategic goal worthy of our imaginations and national spirit. While SSP is not a short-term solutions for national energy production, the Nation must begin investing in such technologies at higher levels, so that we will be ready for transitions away from traditional fuel sources in the decades to come. *Congress should authorize NASA and related agencies to create a space-based solar power prototype satellite, to be operated in Earth orbit or at the International Space Station,* as well as other space-based technologies that can address these problems.

The historic investment in aerospace capabilities which America has made through NASA, and related space investments from DOD to Comsat, have matured at a critical time. Robert Hirsch testified before the House Science and Technology

Committee on February 29, that the dean of world oil analysts, Charlie Maxwell, "expects gasoline at $12–$15 per gallon within a few years."

Competition for global oil production has produced these soaring prices. Shell Chief Executive Jeroen van der Veer said, "We are experiencing a step-change in the growth rate of energy demand due to population growth and economic development, and Shell estimates that after 2015 supplies of easy-to-access oil and gas will no longer keep up with demand. As a result, society has no choice but to add other sources of energy."

Coal use in China, India and elsewhere is rapidly expanding. In 2006, China built 100,000 megawatts of coal-fired power plants, according to the International Energy Agency, which far exceeds the entire generation capacity of the United Kingdom. India built 22,000 megawatts of new electricity plants in the last 5 years and has plans to add 70,000 megawatts in the next 5 years.

By 2010, plug-in hybrid vehicles are scheduled to replace some gasoline demand with electric vehicles using "smart" utility meters to charge these at night. The Pacific Northwest National Laboratory found that existing U.S. power plants could meet the electricity needs of 73 percent of the Nation's light vehicles if the vehicles were replaced by plug-ins that recharged at night. Such a huge shift could cut oil consumption by 6.2 million barrels a day, eliminating 52 percent of current imports. But where will all the energy come from in the decades to come?

Many energy "solutions" have been proposed, including conservation, windmills, bio-fuels plants, ground-based solar cells, "clean" coal and nuclear power. While useful, these still merely nibble at the vast energy, economic and environmental problems we face. Robert Hirsch has repeatedly emphasized in Congressional statements what the International Energy Agency has been saying, that we—as well as the other developed countries, are "doing nothing on the scale required" to address our growing global energy shortfall.

One future option is Space Solar Power. SSP offers the potential for reliable, virtually unlimited, clean, baseload energy. The potential advantages are clear:

- SSP can take advantage of our current and historic investment in aerospace expertise to expand employment opportunities. SSP's technologies are near-term and have multiple attractive approaches. Many thousands of STEM jobs, on inspiring work that we understand how to do is needed to bring them to practical fruition.
- Unlike coal, oil, gas, ethanol, and bio-fuel engines, SSP emits very little CO_2, only an antenna is on the Earth (the proper term is rectenna, or "rectifying antenna").
- Unlike bio-ethanol or bio-diesel, SSP does not compete for increasingly valuable farm land or depend on natural-gas-derived fertilizer. Corn and other foodstuffs can continue to be a major export instead of a fuel provider.
- Unlike nuclear power plants, SSP produces no hazardous waste or nuclear weapons-grade material.
- Unlike terrestrial solar and wind power plants, SSP is available 24 hours a day, 7 days a week, in endless quantities. SSP ignores cloud cover, night, storms, dust and wind. Our understanding of the magnetosphere and solar wind interaction—SSP's GSO operating environment—has become highly mature since 1962.
- Unlike coal and nuclear fuels, SSP does not require environmentally problematic mining operations.
- SSP may 1 day provide true energy independence for the nations that develop it, eliminating a major source of national competition for limited Earth-based energy resources and dependence on unstable or hostile foreign oil providers.
- SSP can be easily "exported" anywhere in the world, and its vast energy can be converted to local needs, from appliances in Asia to desalination of sea water in the American West.

SSP would revitalize America by showing that a multitude of space-development-related educational fields, from telerobotics to space transportation, from wireless power transfer to photovoltaics and environmental sciences, are vitally relevant to these great problems. Reduced launch costs, the key enabler, will provide unprecedented access to space and space operations beginning with clean, baseload SSP—reliable power delivery and global energy security at greatly reduced environmental impact.

Resources: Helium 3

Another potential space-based alternative energy source is atomic fusion using helium-3, an element rare on Earth, yet abundant on the lunar surface and in the atmospheres of the gas giants. This connects well with the Vision for Space Exploration, and offers a concrete material which NASA could prospect for.

America's new launch vehicles and manned spacecraft are suitable to support a return to the moon and development of mining and refining technologies, and should therefore continue as planned. Our first outpost on the moon can be supported by engineering projects to create infrastructure supporting solar power satellite production as well as extraction and use of helium-3.

Global Climate Change

NASA may be the most well-equipped agency in the world to help to solve the monumental challenge facing our generation: climate change. NASA was instrumental in diagnosing the problem, and now is well equipped to help ameliorate it.

The connections between NASA and the Earth's environment are deep and powerful. NASA is one of the world's foremost climate change research organization, producing more climate data than any institution on Earth. It also possesses world-class engineering capabilities. There is growing agreement that NASA must make climate and energy research more central to its mission and purpose, and that NASA can play a central global role connecting scientific results with solutions for the planet.

Modeling, Simulation, Visualization

NASA plays a leading role in the international community by analyzing the Earth observation data forecasting potential futures. Modeling and simulation can help to understand how quickly the climate is changing and assist with sustainable agriculture, urban planning and disaster response.

Systems Engineering

NASA has a long history of successfully executing major engineering efforts such as the Apollo moon program, the Space Shuttle, and the International Space Station. In order to architect such large efforts, a mastery of systems engineering is employed. Moreover, in the case of the International Space Station, these engineering solutions have been created in an international context. The next step is to task NASA to conduct system engineering of the planet, organizing global efforts to understand and mitigate the drivers of climate change.

Technology Innovation

Space is a challenging environment. To learn to live and work in the engineering constraints of the space environment has challenged NASA engineers to come to a deep understanding of the challenges of closed environmental systems. Under tight engineering constraints, NASA engineers have innovated by creating lightweight, low power, highly efficient, and closed loop systems. These innovations have direct applicability in the clean technology and green technology sector today. Further, solutions like Space Solar Power, in which energy is collected in orbit and beamed to earth, offer long-term prospects for clean, renewable energy that deserve measured investment today.

The world has known about the "greenhouse effect" since the 19th century, when scientists first began to understand the nature of our planet's atmosphere and how it works. It acquired new urgency during the rise of the environmental movement in the early 1970s. Since that time, NASA's Earth-monitoring satellites and sounding rockets have continued to record the planet's temperatures, both highs and lows, at all levels of the atmosphere. If the world is to act responsibly in response to global climate change, it will require the climate data NASA collects as one of its many useful missions.

Exploring other worlds has also taught us about Earth's climate. The first images transmitted from Venus in 1975 caused astronomer Carl Sagan to call it a "runaway greenhouse." With its thick, poisonous, carbon dioxide-rich atmosphere and 500-degree temperatures, Venus provided a theoretical model of what could happen to our own planet if we allowed our civilization's emissions of greenhouse gases like CO_2 to get out of control. It was the first real example of how space exploration could affect not just our consciousness as a people, but also our behavior and policies. Venus became an object lesson in comparative planetology.

And yet, nearly fifty million miles beyond Earth lies the planet Mars. It, too, has an atmosphere composed largely of carbon dioxide. And yet that atmosphere is very thin, and its surface temperatures range from barely warm to unbearably frigid. Why? What lessons does Mars have to teach us about planet Earth and how we behave on it? Unlike Venus, we can visit Mars using current technologies, and thus

we can go there and find out for ourselves. Climate change is an issue Americans are passionate about. We owe it to our citizens and the people of the world to do all we can to collect the data we need to act wisely for future generations.

Planetary Defense

There are vast numbers of asteroids in near-Earth orbits. Though it may seem unlikely, if we do nothing, sooner or later we will be hit by an asteroid large enough to threaten life on Earth. Given the nature of this threat, the space program is a logical place to start developing strategies for overcoming it. This is environmental protection of the highest order.

In October 1990, a very small asteroid struck the Pacific Ocean with a blast about the size of the atomic bomb that leveled Hiroshima, killing roughly thousands of people in seconds. If this asteroid had arrived 10 hours later, it would have struck in the middle of more than a million U.S. and Iraqi soldiers preparing for war. How would America have reacted to what looked like a nuclear attack?

In 1908, a small asteroid (perhaps 50 meters across) hit Tunguska, Siberia and flattened 60 million trees. That asteroid was so small it never even hit the ground, just exploded in mid-air. If it had arrived 4 hours and 52 minutes later, it could have hit St. Petersburg. At the time, St. Petersburg was the capital of Russia with a population of a few hundred thousand. The city would have ceased to exist. As it was, dust from the blast lit up the skies of Europe for days. Asteroid strikes this size probably happen about once every one hundred years. There was another Tunguska-class strike in the Brazilian rain forest on August 13, 1930.

Sixty-five million years ago a huge asteroid several kilometers across slammed into the Yucatan Peninsula in Mexico. This is the event that is thought to have caused the extinction of the dinosaurs (and many other species). The explosion was the equivalent of about 200 million megatons of dynamite. The blast turned the air around it into plasma—a material so hot that electrons are ripped from the atomic nucleus and molecules cannot exist. This scenario has been repeated perhaps once every 100 million years or so. As many as two-thirds of all species that ever existed may have been terminated by asteroids hitting the Earth.

We know about the asteroid that killed the dinosaurs because we found the crater. But when an asteroid hits the ocean, there may not be a crater. If a 400-meter (four football fields) diameter asteroid were to fall into the Atlantic Ocean, it would cause a tsunami 60 meters high.

The only way to eliminate the threat of asteroids is to detect and divert them. A vigorous space-based civilization capable of reaching, exploring, and diverting asteroids into useful, safe orbits would have enormous economic incentives to find and use every asteroid passing near Earth. The asteroids could be found, diverted, and mined for their materials, including platinum-group metals, water ice, and iron, which could be used to make steel. This would defuse the threat, make a lot of people extremely rich, and keep an entire world safe.

Peace and Security

Civil space must be a key element of diplomacy for the coming years, because space is uniquely suited to addressing certain challenges of the current international landscape. The use of space as a strategic means of diplomacy can strengthen relations with allies, reduce future conflicts with strategic competitors, and engage members of the developing world in productive directions, all while accomplishing projects of value to America and the world.

The success of ISS and its international partnerships has formed a model for how nations can come together to build great things in space. While mistakes have been made and progress has not been as rapid as we would like, ISS has established an important precedent for strategic cooperation in space. We will need such cooperative ventures as we move on to explore and settle the Moon and the planet Mars. And cooperation in space can, we believe, lead to strategic and diplomatic goodwill on Earth-based matters as well.

Concluding Thoughts

Our Nation's human spaceflight program can be about more than just being "great," it can also be about being "good," by meeting the urgent needs of all Americans and the planet as a whole. Such efforts offer NASA a vision the public will follow for the long haul, embracing as it does both economic opportunities for individuals and technological benefits for the common good.

The Nation faces an historic opportunity with regard to space this year. In a time of uncertainty, Congress and the next president can use human space exploration as a means to advance and improve this Nation as part of a sustained commitment to solving the challenges we face today. Space exploration can provide a common keystone for the many issues confronting us today, from education to economic un-

certainty to energy production, planetary health and safety, international cooperation, and economic competitiveness. A re-authorized Vision for Space Exploration, with the recommendations I've suggested, would be an excellent starting point for building a truly spacefaring civilization. Therefore, I encourage you to continue supporting human exploration beyond LEO, and onwards to Moon, Mars, and beyond.

Senator NELSON. Well, thank you all. Your statements were excellent.

There is a symmetry of opinion by all of you, and I think I could sum that up by asking Mr. Kranz a question.

During Apollo, the resources of this country for Apollo were 3 percent of the discretionary budget. Today, they are six-tenths of 1 percent of the discretionary budget. If today's budget of six-tenths of a percent had been applied to Apollo, I suspect we wouldn't have gotten off the ground. Tell me what you think.

Mr. KRANZ. I believe you're right on track. We would have been stuck somewhere in the early Gemini program. I believe that the—the advancement that we had was really a combination of factors. We had the resources to do the job, we had the vision that said what the job was, the talented people were available to us, they were highly motivated.

And one of the things that we tend to overlook goes back to the university. They had—in 1958, they had passed the National Student Defense Loan Program, which then took—provided, basically, a GI Bill for young people to go to college, many of the first in the family ever to do that, and the universities were basically pouring out the young people, the talented young people that we had to provide our ramp-up to the support the program.

Frankly, without the resources that we had in the early 1960s, we wouldn't have made it. We would have seen a Soviet flag on the moon.

Senator NELSON. Well, if we can ever get this message to the advisors to the three Presidential candidates, who are concerned, as they should be, about the future ability of America to compete in a global economy, and are concerned about the educational achievements of our young people, that in the early 1960s wasn't it the space program that turned kids on so much, to want to go into engineering and math and science, and produced a revolution in microminiaturization?

Mr. KRANZ. We had the—the real breakthrough, and it was—you go back to the Soviet missions—twice, they attempted to rendezvous, and didn't make it. The spacecrafts passed within about 3 miles of each other. By this time, America had developed—they couldn't brute—we weren't brute-forcing it like the Soviets were, we had developed the technology, we had the inspired people in the laboratory, and we had generations of young people that were following them. We lived on this seed crop that the universities were providing us, but were inspired to go through these difficult studies of engineering, math, science.

You know, there's a fine report out right now—in preparation for my talks, annually I get a report on what they call the U.S. Council on Competitiveness. It's right down here, on K Street. They just produced a report, several months ago, and it's got some very good news for America. It's also got some threats that you can see in the future, one of which addresses this China question, and, where do

we stand in relationship to the other nations of the world in producing the young people, inspiring the young people? The news is, is that many of these countries are outproducing us, but we still have the best university systems and the best talented young people and the most inspired people. We've got to continue that job.

Senator NELSON. And yet, we are producing a fraction of what China and India are producing in engineers at this point.

Mr. KRANZ. Yes.

Senator NELSON. So, the question is, how do we inspire young people to want to get into these fields? And certainly history would tell us that the Apollo, Gemini and Mercury programs clearly were inspiring.

Let me ask you, Dr. Johnson-Freese, since you are an expert on the Chinese space program, tell us where you think that's going and what's going to be the ultimate competition between China and the U.S. in space?

Dr. JOHNSON-FREESE. Well, I would pick up on what Mr. Kranz was saying, that, in fact, China, like Japan earlier, and like India currently, now that it's announced it intends to have a human spaceflight program, is using—part of what it is doing with that program is inspiring people to go into engineering. In Japan, 15 years ago, the space companies, 90 percent of the workforce was making washing machines and cars, but they drew the best and the brightest in by showing them their space division. So, space is a motivator around the world.

In terms of China, where are they going and where do I see the competition headed? And, by the way, the best-selling book in China in 2002 was, "How to Get Your Child Into Harvard," so they get it.

[Laughter.]

Dr. JOHNSON-FREESE. They get it. Where do I think they're going? I think they have a very deliberate, incremental, yet ambitious, plan laid out, that is broadbased. Like—as in the United States, it has a military component, it has a civil component. I think their civil component is largely based on reading the Apollo playbook and all the benefits that the United States got from it. We will likely see another flight from China, this coming fall, with probably a move toward docking, with a small space laboratory to follow, and, once they have their new heavy-launch vehicle in place, a space station, down the road.

I would note that they have not officially announced a manned lunar landing. They don't like to announce anything until it's sure that they have the technology to carry through. Credibility is important. They have said, more than once, they will not do an Apollo program. They will go to the moon, they will use infrastructure that allows them to keep going. They don't want to, as they say, go and say, "Been there, done that."

Ultimately, I think the competition—personally, I hate to see the U.S. and Chinese space programs characterized as competitive. They fly two manned spaceflights over a 5-year period and are perceived to be "beating" the U.S. space program. That's just wrong.

Where I see the ultimate competition is from the technology, the engineers, and the science that will be generated through the program. A political scientist in China made the comment to me that,

"Now that they have a manned spaceflight program, people will understand they make more than cheap sneakers and ripped-off designer clothing. They are a technology leader."

So, I think the economic and technology competitiveness will come back to haunt us if we, in fact, don't keep our quest to stay ahead.

Senator NELSON. Given the constraints of classification, would you share with us, for the record, what you think that the Chinese were trying to demonstrate when they did their anti-satellite test by taking out one of their old weather satellites?

Dr. JOHNSON-FREESE. Senator, it's difficult to get into Chinese intentions, because we simply don't know. There are many different scenarios that have been laid forth, and I think the one that's increasingly gaining credibility is that, in fact, during the 1980s, when the United States had an active ASAT program, the Chinese started one, as well. It was a technology development program that took, basically, 20 years to reach fruition. And, as many people have said, if you have a technology, it's—one test is worth a thousand words—that it reached fruition, that it was characterized by the engineers running it, China is over-bureaucratized, it's very stove-piped; the engineers who were in charge of that technology development program put it forward as, "It's time to test." I think they severely underestimated international response. I think they now regret underestimating that response. They characterized the debris situation in engineering overall increase in debris rather than the—looking at it in terms of risk to spacecraft. And it was a lot of bad decisionmaking on their part. When they did the prior nonimpact tests, and there was no response, I think they miscalculated on what would be the U.S. and the international reaction.

But, the bottom line, I think it was a technology program, technology demonstration program.

Senator NELSON. Is part of their miscalculation that they miscalculated the reaction of the world community with regard to the tens of thousands of pieces of debris that now threaten everybody's space assets?

Dr. JOHNSON-FREESE. Absolutely. Again, I think that the engineers who were putting forth the estimates, the debris estimates, were not thinking in global terms at all, and they were quite—we actually, I think—now think that their debris estimates were pretty on target, but very foolhardy, very reckless and self-destructive, now—we now look back and see. So, yes, I think they were totally out of line on that, in terms of their estimations of perception.

Senator NELSON. Do you think the world community has responded with a sufficient degree of outrage as to the tens of thousands of pieces of debris?

Dr. JOHNSON-FREESE. The Chinese took very careful aim and shot themselves in the foot with that test. I think they are now recognizing that the international condemnation due them was actually moderated, that, in fact, when they cancelled the meeting in China on the debris committee that was supposed to meet several weeks after, they cancelled it, knowing that the condemnation would be harsh and would be due them, and they simply didn't want to face it. I think the Chinese will be digging themselves out

of that hole for a long time, and that—again, that they are now deeply regretting the situation that they brought on themselves.

Senator NELSON. And others. We had testimony in the Senate Armed Services Committee, by the then-Commander of U.S. Space Command, on just how many of these pieces of debris threaten the assets of any nation's space asset, and how we have to be particularly careful now with the Space Station because of the altitude of the debris field it's going to take quite a while for the Earth's gravity to finally pull it back down to where it'll burn up.

Well, thank you for that. I wanted to get you, shortly after that ASAT test, and it just never worked out in your schedule, so I'm glad to get this on the record.

General Dickman, you had mentioned the commercial aspect of space. I want to say that I am delighted that there seems to be a new attitude in the Air Force in cooperating with the use of old pads at Cape Canaveral for commercial space launches. Thanks to General Helms, who is going to be departing Patrick for her next assignment, they negotiated successfully one of the old abandoned pads to be used by one of these new commercial ventures, called SpaceX. We're trying to get them to, likewise, on any future commercial launches, to utilize abandoned pads, which is the logical thing.

And General Kehler, the new head of Air Force Space Command, seems to be of that bent, of wanting to continue that. Any insight that you have with your wealth of experience in Air Force Space, I would appreciate you sharing that.

General DICKMAN. Well, I think you've characterized the views of General Helms and General Kehler exactly correctly. General Kehler was the Commander at Vandenberg, and, in fact, conducted more—or, oversaw more commercial launches than he did military ones when he was there. He clearly understands the importance of commercial space, not just in the economic sense, but in the importance of having a launch rate that allows the infrastructure to continue to fly.

I might point out that, while we look at Mr. Musks's work at SpaceX and the transition to a commercial pad, that that's really just one in a long series that, in fact, have gone on. For many years, the Atlas pads and the Delta pads were shared between commercial missions and government missions. Complex 37 was converted to a—to the Delta IV EELV in the early days of the EELV program. We believed that there would be more commercial launches than government. Complex 41 was converted to handle the Atlas V; again, intending to be a major commercial venture, as well as government. Complex 46 was transitioned from Navy use to being used by Spaceport Florida. So, I think there's a long history of that marriage between commercial launch and government launch. What—as I think you would correctly characterize, that ebbs and flows with how easy it is for a commercial operator to fly out of Cape Canaveral or out of Vandenberg, and I think you're also right in characterizing the current leadership as being very favorable to making that happen. It, at least, is my view that unless that happens and unless we build a robust commercial space program, the government program—the only ones that'll be flying

from the United States will be government-funded payloads, and that doesn't make any sense.

Senator NELSON. Mr. Whitesides, you had talked also about commercial space. We've mentioned SpaceX, which is part of the COTS Program. They have this parabolic flight experience that's going on down there. What additional steps do you think NASA should take to better leverage these commercial opportunities?

Mr. WHITESIDES. That's a great question. We live in a very exciting time, Senator, where, you know, really, it's sort of the new Space Age, where many of these companies, like Virgin Galactic, SpaceX, and others, are building new capabilities which the country can take advantage of. And I really think that, in the long-term future, sort of the future of humanity, it's these commercial entities that are going to go forth and really take the country into a promising economic direction.

I think that the answer to your question is that NASA should try to buy services from these companies wherever it has needs. So, for example, COTS should be encouraged, developed, and then should be prioritized if one of these companies does, in fact, demonstrate the capability to get to Station. That will free up NASA to explore the frontier with the Constellation program.

Similarly, as Dr. Tarantino noted, there's a suborbital spaceflight program that's under consideration by NASA. That could dramatically increase the flight rate opportunities for scientists, and astronauts for training, and that could be recognized and called out and encouraged, going forward.

Finally, the Parabolic Flight Services Program that you note is a really, I think, important example as a pathfinder for future types of this work.

Senator NELSON. Dr. Tarantino, you were talking about the universities. How many graduate students and undergraduates are typically involved in working on those small-scale, hands-on projects that you mentioned in your testimony?

Dr. TARANTINO. Yes, sir. Anywhere—you will find anywhere from three to five graduate-type theses, Ph.D. and Master's theses, involved in these. And then, as you roll that down to the undergraduate level, there can be a dozen or more each semester involved in some aspect—in some aspect of this.

I would like to point out something, though, that connects with what Gene Kranz was saying when he was talking about the difficulty of maintaining the workforce during the previous gap. Engineering is a very tough profession, when you think about it, because, if you think about it, the better you are as an engineer, the sooner you're putting yourself out of work. And so, engineers are constantly looking for what is going to be their next task or their next challenge. And if we don't have stability in these programs, then, not only are they putting themselves out of work, but we are, also—the government is, also. And the same thing happens in the scientific field, as well, when you talk about professors on campus that want to go into the space sciences, when you talk about students making decisions on whether or not they're going to enter aerospace engineering or space science or not.

Senator NELSON. And do you want to expand your comments on how the universities could work with private spacecraft developers

to expand research in space? And what do you think NASA's role ought to be?

Dr. TARANTINO. Well, you know, we're, quite frankly, quite excited about the possibility of this, because the real barrier that—one of the largest barriers we face, of course, is the cost of access to space. And so, we're very interested in the potential of these commercial space opportunities, to reduce the cost of access to space, and to be able to, therefore, give us more opportunities to get university research payloads.

Senator NELSON. General, you know, we've got this $100 billion thing up there, called the ISS, and it is designated as a National Laboratory. And yet, NASA claims that the loss of *Columbia* set that back. The budget has severely curtailed the research that the U.S. is going to be able to do on the Station. Where do you think that ought to go in order to see that it is utilized to the fullest extent possible?

General DICKMAN. Well, I think, Mr. Chairman, that that's not unrelated to the question of the gap, because the gap is what, in part, will keep us from using the Station to its full capability with American scientists and America experiments. And I think that gap can be approached, perhaps, differently.

If I understand the current approach, one is that COTS may be successful, COTS–D capability for hauling humans to low-Earth orbit, but relies on a vehicle that is some months, or perhaps years, away from being able to demonstrate continued successful flight before you would want to put humans on it, and also a capsule to do that from one contractor, SpaceX; and Orbital, I think, isn't even looking to capability D.

And the other would be to put substantial amounts of funds into the exploration program to accelerate the availability of a capsule and a launch vehicle that simply are not designed, intended, or very efficient, carrying relatively small numbers of people to Station. They're designed to go to the moon.

We have the option to approach that differently. We have launch vehicles that can haul a capsule. Atlas V or Delta IV have a very proven record that can do that. For a relative—for less than the cost of a single Space Shuttle mission, they could be human-qualified and a—forgive me, Mr. Kranz, a relatively simple capsule to go to low-Earth orbit could be built—certainly different than what we would require to go to the moon—to carry scientists, astronauts to Station, and then get full utility out of that.

And so, my vision for the Station is not to shut down in 2015, or 2016, or 2017, it's to keep that operating as long as it's doing effective science. Exactly what Administrator Griffin has decided to do on other programs, like Hubble and like some of the robotic programs, keep flying them as long as they do good science. Don't invest in something all brand new when you can continue to use something that's available already.

Senator NELSON. Now, you realize that there are people who disagree with what you just said.

General DICKMAN. Of course.

Senator NELSON. Mr. Kranz is one of them, in that he doesn't want to see the design of Ares and Orion change. Because he thinks it's going to be setback. But, you're saying that you ought

to take another vehicle, another rocket, and put a simpler capsule on it, and let's get it to low-Earth orbit. Is that what you're suggesting?

General DICKMAN. That's what I would suggest. I don't think we should change Ares and Orion. I think they are the right architecture to do lunar exploration, they aren't the right architecture to support Station with human transportation.

Senator NELSON. Well, are you talking about an alternative such as COTS–D, which is the human rated version.

General DICKMAN. Again, COTS–D is a risky program. We are months, or perhaps longer, away from the first flight of the vehicle under the COTS program from the one contractor who would build one large enough. We have vehicles that can carry that kind of weight to Station today. They're the EELVs. They're proven launch vehicles built by the government and by private investment.

Senator NELSON. So, what rocket are you talking about?

General DICKMAN. Atlas V and Delta IV.

Senator NELSON. Man-rate them, and then stick a simpler capsule on top of them.

General DICKMAN. I believe that could be done for less than the cost of one—divide the Space Shuttle cost by the number of flights, and you can do that entire program for less than that cost.

Senator NELSON. The question is, where are we going to get the money? If all the dollars are absorbed in running out Shuttle until completion of the Space Station, and then putting your money full bore into the Constellation program.

General DICKMAN. Well, Mr. Chairman, I would simply say, the same question of where you're going to get the money is the question if you try to accelerate Constellation. It's the same dollars, it's just a question of whether you use it to accelerate Constellation or you keep Constellation on its current path and build something that has a unique capability to haul humans to Station and back.

Senator NELSON. Does anybody want to respond to that?

Mr. WHITESIDES. Can I, sir, just add one note? Just so that we're all on the same page, I think that the architecture that you describe could—you know, COTS–D hasn't been exercised yet, of course, as a program, and a capsule that goes on top of an Atlas V could be contracted within the COTS–D option, just for the——

General DICKMAN. Sure. Dragon might be——

Mr. WHITESIDES.—record. I mean——

General DICKMAN.—the perfect capsule.

Mr. WHITESIDES. Yes. I'm—yes. I'm——

Senator NELSON. I am told that the cost estimates for human rating of an EELV range from $500 million to a billion dollars. And under this funding profile, I just don't know where we're going to get that.

Mr. Kranz?

Mr. KRANZ. Mr. Chairman, I was involved in the man-rating of the Titan. I was involved in the man-rating of the Atlas vehicle. They were expensive programs that took about a year and a half each to accomplish their objectives. They—some of the things that we found out, particularly in the early Atlas, when we attempted to man-rate it, was that structurally it did not have the ability to handle the Max-q loads, which took a redesign of the system. So,

I believe this question of man-rating is one that is good from a viewgraph standpoint, but when you step up to the cost, the schedule, and then you say you're going to put a "simple spacecraft" on top of it, it would be something I would—at best, it would be something like a Mercury on steroids, I guess, because Mercury was the——

[Laughter.]

Mr. KRANZ. Well, it wouldn't be Apollo. That's what they're building with Orion. But, yes, the simple spacecraft is what I would consider Mercury on steroids. Well, that took about 3 years to put in place. So, I don't see that this helps close gap. I—and all—I see it as, again, a diversion from the basic plan that you've got. As I said, I think you're building the DC–3 or the B–52, and I think this is the right plan.

Yes, it's a bit overdesigned to support the Earth orbital missions, but it gets the job done until something comes along, possibly later on, through COTS or whatever it is that can get the job done. But, I think you've got the right plan, and I think you ought to stay with it.

Senator NELSON. Let's talk about the brain drain. Now, all of you have already concluded that if you can shorten the 5-year gap so that you don't have to lay off a bunch of people, you're a lot better off. That's a function of us being able to get the present President and the future President to be willing to support the additional, $2 billion, $1 billion in this year, and $1 billion in next fiscal year, in order to achieve that. But, what else can be done to prevent the brain drain, since there is going to be this hiatus as we shift from the Space Shuttle to the new vehicle? What else can be done? Any of you all.

[No response.]

Senator NELSON. Well, on the experience of Apollo?

[No response.]

Senator NELSON. Well, let me suggest something. You all reflect on this. NASA's got a bunch of programs. So do other departments of the U.S. Government. What about getting some of these people, that otherwise might be laid off, into some of those other programs on whatever temporary basis that we have of the gap?

Mr. WHITESIDES. Senator—I'm sorry.

Mr. KRANZ. Go ahead. Go ahead. Why don't you go on, and I'll——

Mr. WHITESIDES. I'll always——

Mr. KRANZ. Mr. Chairman, that——

Mr. WHITESIDES.—defer to you, man.

Mr. KRANZ. Well, that, to a great extent, is the option I had available to me during the Skylab-to-Shuttle transition. I had the Earth Resources Aircraft Program, and I was able to move a significant number of my people, particularly those—probably the most critical asset I had were my trajectory-related people, my mission-design people, because they are the ones that will, sort of, lay the groundwork, build the conceptual mission profiles, do all the initial analyses that you need. So, this was one of the areas that I wanted to protect very much. They turned into excellent engineers in the Earth Resources Program. They were scientific equip-

ment operators, they did the design installation, they worked with the principal investigators and the—that was marvelous.

But, this was a relatively short term, and we knew that the Earth Program was diminishing so that they would then come back to us. My concern would be, as I said, I sent some people off into the medical business, and doggone if they didn't decide they wanted to be a doctor. So, that's a two-edged sword. You provide them the business opportunities, but these are young, talented, mobile people that like challenges, and some percentage of those people, maybe your best ones, are going to stay there. So, this is a very difficult issue to address, and I don't have—and I don't see an easy solution.

Senator NELSON. When you say that you moved from Skylab to Shuttle, you're including Apollo-Soyuz in that, so that you actually had a 6-year gap between 1975 Apollo-Soyuz and 1981 Shuttle.

Mr. KRANZ. Yes. That was the true gap. But Apollo-Soyuz was a relatively simple mission that didn't use a significant amount of manpower. Probably the—the majority of the manpower was spent in just the various negotiations with the Soviets, the exchanges—we spent probably more time in transportation than we did actually in working many of the aspects of the mission. That did not require significant numbers of people.

Senator NELSON. All right.

Mr. Whitesides?

Mr. WHITESIDES. Senator, if I could, I think what's coming down the road in the next administration, almost no matter who it is, is a greater emphasis on global climate change and energy. And I believe very strongly that NASA can play a very significant role in that. It doesn't precisely line up with the gap, but I think, broadly speaking, NASA needs to align its missions and become more publicly relevant to that effort. And I think that what we're going to see on a national level is tremendous funds being allocated to efforts related to those issues. And NASA is perfectly situated to respond to those issues, not just on the science-diagnosis side, but as we, as a society, start to plan how we're going to actually implement mitigation steps toward that issue, I think NASA is very well placed to do that.

Senator NELSON. Flesh that out a little more.

Mr. WHITESIDES. Well, what you have inside NASA is certain centers starting to think very seriously about—they see the writing on the wall. I'm thinking, in particular, Kennedy and Ames and other centers, where they're beginning to work on system engineering approaches to how you would think about seriously mitigating global climate change. That involves things like technology, solar cells, fuel cells, other things like that, that—to the entire "architecting the system" of how we make this transition, as a culture and as a society, that even could go all the way to the far future, with mitigation steps in space and space-based solar power. And so, I think that there's a tremendous amount of program and planning that is very well suited to NASA engineers, as they are the people who do the big-picture engineering, really better than almost anyone in our government. And so, I think that there's tremendous opportunities there.

Senator NELSON. Got any thoughts about cooperation between NOAA and NASA on some of this climate observation?

Mr. WHITESIDES. Absolutely. I mean, I think we need to build on that. But, what I would emphasize is that, in my experience, NASA is very good at constructing the largest systems, and that's what our civilization is going to be headed toward, is potentially building very large systems to respond to some of these changes.

Senator NELSON. Given the so-called funding that is projected, the projection for funding of the Space Station is not there in NASA's out-year budget beyond 2015, it seems to me that with $100-billion asset up there, we clearly ought to correct that. I think we're going to try to do that in this NASA authorization bill. But, I see you all smiling, which would indicate to me that you agree with that. Any comments about that?

Mr. KRANZ. I think it's a excellent idea to—we've got a massive investment up there. One of the most difficult times I had as an engineer is when we had all of these Apollo lunar surface experiment packages up and operations going on the moon—they were sort of like the Mars rovers—perfect operation, still getting large amounts of data, et cetera, and the funding ran out, and we were directed to cut the umbilical to that. That was a decision that I think impacted the scientific community, but basically it was sort of like this throwaway mentality that, at times, we have as nations. We sort of get tired of this, and we decide it's time to cut it off.

And I think you're right on track there. We have to come up with some plan that addresses the long-term utilization, because it's a marvelous vantage point, it provides an environment that cannot be replicated any other place. It provides a global perspective. And, as you said earlier, it's a great opportunity to meet the international community in a peaceful environment. The question that's been brought up is, how do you get up there cheaply and economically. But that's a problem that can be worked. But, I think the key thing is, is this has to be part of the long-term plan.

Senator NELSON. In the money that is allocated in NASA's future projections, even though there seems to be unanimity of opinion here that it's not enough, particularly to shorten the gap. Do you believe that what is projected there is an appropriate balance between the programs that are in NASA's future? What do you think about that?

General DICKMAN. I——

Mr. KRANZ. Go ahead.

Senator NELSON. General?

General DICKMAN. Well, I think—NASA has been charged with doing an exploration program that is now taking a disproportionate size of an unfunded—underfunded program, 93 percent of NASA's budget going to human spaceflight or exploration. Earth and planetary sciences are down $260 million from between 2008 and 2009. Aeronautics, down $150 million from 2007, doing maybe a third of the aeronautics we were doing 3 or 4 years ago. There's an enormous amount of work that NASA simply isn't doing today that they were doing 5 years ago, and that I think that what—if I can extrapolate what Mr. Kranz was saying earlier, the enormous amount of work in aeronautics and in other programs are really

what gave us the base to be able to do the space program in the 1950s and 1960s. We're losing that base in NASA. And so, I think there—across the board, we are paying too high a price in other areas in order to do exploration. Not to cut exploration, but to continue to increase the budget to be able to do the things that we've cut.

Senator NELSON. Back to the Climate Change Science Program, the funding for the research programs under this program began to decrease in Fiscal Year 2005, with the largest cuts seen in NASA's budget. There is a projected increase for NASA's part of the Climate Change Science Program for the Administration's request for Fiscal Year 2009. So, that's going to be something that we're going to have to attend to.

All right. What we'll do is, we'll leave the record open for any questions that need to be proffered in writing. We'll leave the record open for a few days so that we can send that to you, if any additional Senators want further questions.

Any other final comments by any of the panel members?

[No response.]

Senator NELSON. Well, you all have added mightily to the repository of information that we need in trying to craft policy etched through a NASA authorization bill. So, I am very, very grateful to you. It's been a stimulating hearing.

Thank you.

And the meeting is adjourned.

[Whereupon, at 11:11 a.m., the hearing was adjourned.]

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