

**Statement of**  
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**Before the**  
**Science and Technology Committee**  
**U.S. House of Representatives**

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Mr. Chairman and members of the Committee.

It is a distinct honor to appear before you at this hearing recognizing the 50<sup>th</sup> anniversary of NASA, as well as of the House Science and Technology Committee itself, and particularly to do so in the presence of such distinguished colleagues. I should perhaps note at the outset that I am appearing as a private citizen and not representing any of the organizations with which I am or have been affiliated.

Some fifty years ago, as a graduate student in aeronautical engineering, I was passing under the tower of Princeton's graduate college when another student excitedly called to me that the Soviets had just launched a "sputnik," Frankly, my first words were, "What's a 'sputnik?'" I was soon to learn—and I recall a feeling almost as if a body blow had been delivered to me. It was akin to learning of such events as the death of President Kennedy, the loss of Challenger and Columbia, the tragedy of Desert One, the Apollo fire, or 9/11. This was the midst of the Cold War; America was supposed to be preeminent in science and technology. That Russia had beaten us into space was unfathomable. And it carried broad repercussions.

It was a period when America's leadership in science and technology was largely taken for granted ... it had been little noted that the underpinnings of that leadership were gradually eroding. Our investment in science and technology was not commensurate with the notion of world leadership. Our public schools were showing signs of neglect, particularly when it came to the teaching of mathematics and science. Our production of scientists and engineers was stagnating.

As it turned out, the Soviets had inadvertently done us a great favor. America was awakened ... and remained awakened throughout the remainder of the Cold War. NASA was formed, not only to assure leadership in aeronautics but now in space as well. This very committee was formed to assure that the health of our nation's scientific and engineering enterprise would be subjected to continuing attention by the Congress. The Advanced Research Projects Agency was created within the Department of Defense. Our public schools took steps to improve the quality of education our children were receiving, particularly in mathematics and science. And more and more young people were attracted to the fields of science and engineering.

Mr. Chairman and members of the Committee, fast-forward, if you will, fifty years ... to an era of globalization, driven in no small part by the explosion in science and technology. Americans are once again confident of our leadership in these fields. After all, who discovered the laser, the transistor, the integrated circuit? Who sequenced the human genome? Who created the personal computer, the internet, GPS and the i-Pod? NASA's former Administrator, Dan Goldin, tells of being criticized by a citizen for investing so much in earth satellites. The critic asked, "Why do we need meteorological satellites ... we have the weather channel?"

Little noticed is that there were almost twice as many bachelor's degrees in physics awarded the year before Sputnik as now. Little noticed is that the number of

engineers graduating with bachelor's degrees declined by over 20 percent in the last two decades prior to a recent up-tick, the latter mostly due to an increase in foreign students; or that the number of PhD's in engineering granted by U.S. universities to U.S. citizens had declined by 34 percent in a single decade. Or that nearly two-thirds of the PhD's in engineering granted by U.S. universities go to foreign nationals; or that our public schools consistently rank near the bottom of the class in mathematics and science as compared with their global counterparts, surpassed by such nations as Azerbaijan, Latvia and Macao.

This time there is no Soviet Union to give us a precipitous wake-up call. China *may* do us the favor ... more likely this time we must awaken ourselves. But once awakened, we all know that America can accomplish extraordinary deeds. Not long after NASA was formed, now-Senator Glenn strengthened our national pride. In a time when our nation badly needed encouragement, Neil Armstrong and Buzz Aldrin, aided by Mike Collins, gave us the ultimate lift. Soon, ten more of my friends walked on the moon—and all returned safely. As Buzz Aldrin has said, "It's amazing what one person and 100,000 of his friends can accomplish." NASA's original charter emphasized the positive impact the space program can have on education. In my own experience there is nothing that excites small children like space (and dinosaurs!).

As a witness to these past 50 years of effort in space and as a member of the committee that was established by the White House and NASA on the Future of the U.S. Space Program not long after the loss of Challenger, I believe I have learned many lessons. Perhaps I might share a few of them on this occasion. It, for example, has been my observation that:

- The most effective space program is a balanced space program, one that utilizes humans for those functions where humans excel and uses robots for those functions where robots excel. As the aforementioned White House/NASA committee noted in hindsight, we would not have risked the lives of seven humans to place a communications satellite on orbit. Nor, for that matter, would we expect a robot to have performed the repair of the Hubble Space Telescope.
- Given a balanced space program, first priority nonetheless goes to the conduct of research. It is here that the greatest return per dollar can frequently be realized and where fundamental new knowledge can be derived.
- The human space program is justified by the need of human beings and nations to explore the unknown ... to push back frontiers. It cannot be justified solely by technological spin-offs or scientific returns, even though these benefits are often not insignificant. Sir Edmund Hillary standing atop Mount Everest is simply different from using a rocket to launch an instrument package to the top of Mount Everest.
- Transportation remains the primary stumbling block to a vigorous, affordable space program. Unfortunately, it is very difficult to justify the discounted cost,

and risk, associated with developing a new launch vehicle based on future cost savings alone, particularly with any realistically foreseeable traffic model. Nonetheless, as our committee noted eighteen years ago, the nation badly needs a new, highly flexible heavy-lift-capable expendable launch vehicle in its inventory.

- The tipping point in affordability of near-earth space operations will arrive when space *tourism* becomes commonplace. Unfortunately, this is a bit of a chicken and egg problem ... but so, too, was the problem faced by the airline industry until the surge that was brought about by World War II. Although some years away, space tourism will one day become affordable to a not inconsiderable number of the earth's inhabitants. That will change everything.
- The next logical centerpiece of the civil space program would seem to be the landing of humans on Mars, probably with a return to the moon as a precursor. Six robots built by NASA have of course already made successful landings on Mars and have done yeoman's work ... but, eventually, humans will set foot on that planet. The only question is what flag or flags they will bear.
- In spite of the absence of a commitment to a major new project, there continues to be strong grassroots support among America's citizens for the space program. It would nonetheless be unwise to initiate a new "centerpiece" project without a strong national consensus for that specific undertaking, and a consensus that appears likely to endure. Any such pursuit will require the continued endorsement of *at least* six Congresses, three presidential administrations and twelve budget cycles. When a new centerpiece project, presumably involving human flight, *is* in fact initiated, no "date-certain" should be set for its accomplishment. Rather, a step-wise schedule should be established with the initiation of successive stages dependent upon successful completion of prior stages. One predictor of a successful space program is continuity: including continuity of funding, stability of objectives, and persistence of personnel.
- Major development projects should not be initiated until at least three conditions are satisfied: First, the mission concept is clear; second, only engineering—not new science—is required; and third, adequate funding can reasonably be expected to be available.
- There exists a critical mass in a nation's space program below which success becomes tenuous. Unfortunately, I am unable to define what that level is—but space activity is much like heart surgery: it is better to do a lot of it ... or none of it.
- It is unwise to pursue space projects "on the cheap." It is, of course, essential to be efficient, particularly when entrusted with the taxpayers' resources—but space is highly unforgiving; it is intolerant of cutting corners. Projects are best served when "done right" ... that is, conservatively ... including extensive testing and, importantly, the provision of reserves in funding, technical approaches and, where

applicable, in schedule. To do otherwise will almost always increase both cost and the probability of failure.

- The greatest challenge faced in the years ahead by the industry that supports NASA will be that of providing, and keeping, an adequate cadre of world-class scientists, engineers and engineering managers who choose to dedicate their careers to space activities. The same will be true of NASA.
- Finally, space is a risky business. We should never tolerate carelessness or neglect. Nor should we accept wastefulness of any type. But, as stated in the closing sentence of the report of the Advisory Committee on the Future of the U.S. Space Program, “If we as a nation are to place a greater premium on letting nothing go wrong, on not making errors, and on ridiculing those who strive but occasionally fail, than we place upon seeking potentially great accomplishments, then we have no business in space.”

I believe that America can take enormous pride in what NASA has accomplished these past fifty years—all of which, to America’s great credit, has been done in the glare of the public spotlight. NASA, like any other organization populated with humans, is not perfect—but if it sets perfection as a goal I am confident that we will have much to look forward to in the *next* fifty years.

Thank you for granting me this opportunity to share my views with you.