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The Future of the Space Program

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Thank you very much and thank you for inviting me.

This is kind of the bottom line: NASA explores space with robotic spacecraft and with humans. The robotic program has been very successful. The human program has lacked focus for a long time. However, in January 2004, President Bush unveiled ambitious plans to return humans to the Moon and to eventually send them on to Mars. As you might imagine, in this particular time in our country's history, increasing the funding of NASA is not particularly politically the wisest thing to do given our other problems. NASA tried this fifteen years ago (the Space Exploration Initiative) and utterly failed. So the question is what are the chances that NASA would become focused, properly funded, and be able, in fact, to send humans back to the Moon and possibly on to Mars?

NASA has two distinct cultures, robotic missions and human space flight. I have been associated almost exclusively with robotic missions since working in the Apollo Program. But today I will discuss mostly what I am least qualified to talk about: the human space flight program. I will not talk about space commercialization or the military space program for that matter. I will spend a little bit of time talking about the robotic program and most of my time talking about human space flight.

NASA has explored nearly every planet including the Earth, and has explored the universe with powerful telescopes like the Hubble. That is a pretty good result for federally funded pure science. About ten percent of the whole NASA budget has been devoted to these science endeavors.

I'm going to talk about one of those programs, the Mars Exploration Rovers (MER) which are operating on Mars right now. Two rovers landed on Mars in January of this year. The engineering was amazing. They came in from outer space to achieve pinpoint landings on two different places on Mars. There were exceedingly complex landing systems on the spacecraft. This is the scene from one of the rovers (on screen). This is not the desert southwest; this is on Mars. This is the path of the rover. Right now it is about here (on screen) working its way up to the top of this mountain. This is the Spirit rover.

The Opportunity rover landed in a small crater. Here you see (on screen) the rover wandered over to look at these white rocks and then wandered back over and, eventually, out of the crater. It turns out that the white rocks have all kinds of evidence that there was a standing body of water here a long time ago. The water was deep – at least a lake and possibly an ocean.

This is the Mars exploration program as it exists today: There are five spacecraft presently operating at Mars (three in orbit, two on the ground), one to be launched next year, a couple more later this decade. I am an active science participant on three of these missions. My particular association with the mission to be launched next year, Mars Reconnaissance Orbiter, is with something called SHARAD, a radar on the spacecraft designed to probe into the subsurface of Mars. One of the best things about

my involvement is that I get to go to Italy often, as its space agency manages the radar program, and I've been there four times this year. Past the end of this decade what NASA does at Mars will depend on the discoveries of the different spacecraft, but generally it will involve the search for life.

That's enough about robotic stuff. Now we will get to the part that I don't know anything about. Do you know why the United States sends humans into space? Good question. Now in fact, here's one possible answer: to bring them back safely. I had one of those health-screening procedures done last month. It looks like most of this audience should have had this procedure done by now. It's the one where the day before is worse than the event itself. If you've had it, you know what I'm talking about. I had never met this doctor before they rolled me in for the procedure. Before I went to sleep, he said: "What do you do?" "I'm a professor at Washington University." "What do you do there?" "Well, I'm in Space Science." He then rattled off all the names of the Mars missions. He then said: "I don't know why we send people into space. We just kind of send them up there and bring them back. Basically we send them up there to save their lives, if we can." These words from a random taxpayer pretty much sum up NASA's dilemma in the human spaceflight program.

To understand the future of the human spaceflight program, it is important that we understand its historical context – the past. In the chronology of human spaceflight, here are the launch dates (on screen). The Mercury and Gemini programs, which preceded the Apollo program, are deeply rooted in the St. Louis region (The McDonnell Company). The Apollo program ended in 1972. Leftover Apollo hardware led to a space station called Skylab in 1973 and 1974, and the last bit of the Apollo hardware

was used during a period of US-Soviet détente in 1975 and called the Apollo-Soyuz Test Project.

After Apollo, NASA decided what it wanted to do was have a presence in low earth orbit (LEO): the Space Shuttle became operational in 1981, and there was a series of Shuttle dockings with Mir, the Russian Space Station, in the time period 1994-1998. The International Space Station became operational in 1998.

The 1980s was clearly the decade of the Space Shuttle. Then, the Challenger Space Shuttle disaster of 1986 caused a refocusing of the question: To what purpose are we sending people into space? The answer is given in 1989 and called the “Space Exploration Initiative.”

On the 20th anniversary of the Apollo 11 landing, President George H. W. Bush calls for construction of the Space Station Freedom (originally announced by President Reagan in his State of the Union address on January 25, 1984). He also calls for sending humans back to the Moon, and ultimately to Mars. The President notes that it is humanity’s destiny to explore and America’s destiny to lead. He asks Vice President Quayle – we all remember him – to lead the National Space Council in determining what would be needed to carry out these missions in terms of money, manpower and technology.

Following this announcement NASA Administrator Richard Truly initiated a study to see what it would cost to do the job. The answer is approximately \$500 billion and change – a truly staggering figure – and today it’s even larger of course. Congressional reaction to NASA is hostile. One of the key problems is that Bush has a democratically controlled House to contend with. Basically, NASA is repeatedly rebuffed in its efforts to

gain support for the plan. Bush seeks international partners, but that doesn't work either.

In August of 1990, Bush puts together an external committee headed by Norman Augustine, of Lockheed-Martin fame, to make recommendations for the space program. What those recommendations basically say is: "Don't do the Space Exploration Initiative." Focus on space science and Earth science, while transitioning human exploration out of LEO on a "go-as-you-pay" strategy. The President orders NASA to implement these recommendations. Dan Goldin is brought in as the new NASA Administrator on April Fool's Day 1992, and he shuts down further the idea of sending humans beyond LEO. The Clinton Administration in its 1996 National Space Policy officially removes human exploration beyond low Earth orbit from the national agenda.

Here is a key paragraph out of the Augustine Committee 1990 report:

The civil space program and its principal agent, the National Aeronautics and Space Administration, are today the subject of considerable criticism. The source of this criticism ranges from concern over technical capability to the complexity of major space projects; from the ability to estimate and control costs to the growth of bureaucracy; and from a *perceived lack of an overall space plan* to an alleged institutional resistance to new ideas and change.

Pretty harsh criticism of NASA fourteen years ago.

Fast forward to February of last year, when the Columbia Space Shuttle accident occurred. This is the Columbia launch (on screen). This is a weather radar sequence of the debris of Columbia coming in across the Texas/Louisiana border (on screen). The report of the Columbia Accident Investigation Board (CAIB) focused on what went wrong and how to fix the Shuttle, but it covers some other issues, too. It talks about problems with the NASA "culture." From the report:

The organizational causes of this accident are rooted in the Space Shuttle Program's history and culture, including the original compromises that were required to gain approval for the Shuttle, subsequent years of resource constraints, fluctuating priorities, schedule pressures . . . and *lack of an agreed national vision for human space flight*.

Cultural traits and organizational practices detrimental to safety were allowed to develop, including: reliance on past success as a substitute for sound engineering practices; organizational barriers that prevented effective communication of critical safety information and stifled professional differences of opinion . . . and lack of integrated management across program elements.

So, things hadn't changed much since the Augustine Report, thirteen years earlier. Some of this can be laid at the feet of Dan Goldin and his "Shoot-the-Messenger" style of management. If you brought him bad news, he would fire you. After awhile he got no bad news.

The CAIB report finishes with "A Look Ahead," with the question: "What should NASA be doing?" From the report:

The Board in its investigation has focused on the physical and organizational causes of the *Columbia* accident and the recommended actions required for future safe Shuttle operation. In the course of that investigation, however, two realities affecting those recommendations have become evident to the Board. **One is the lack, over the past three decades, of any national mandate providing NASA a compelling mission requiring human presence in space.**

President John Kennedy's 1961 charge to send Americans to the moon and return them safely to Earth "before this decade is out" linked NASA's efforts to core Cold War national interests.

Since the 1970s, **NASA has not been charged with carrying out a similar high priority mission that would justify the expenditure of resources on a scale equivalent to those allocated for Project Apollo.**

NASA has had to participate in the give and take of the normal political process in order to obtain the resources needed NASA has usually failed to receive budgetary support consistent with its ambitions. The result is an organization straining to do too much with too little.

A second reality, following from the lack of a clearly defined long-term space mission, is the lack of sustained government commitment over the past decade to improving U.S. access to space by developing a second-generation space transportation system. Without a compelling reason to do so, successive Administrations and Congresses have not been willing to commit the billions of dollars required to develop such a vehicle.

I remember having a conversation with Chris Kraft, the head of the Johnson Space Center, back in 1981 just before the first Space Shuttle launch. He was scared to death of that rocket, of putting humans on it. The first Space Shuttle flight was successful and before the second Space Shuttle flight, he had retired. Smart man.

Basically there has not been money around, or a justification sold to replace the Shuttle. The Shuttle does provide access to the International Space Station, but what do we do there? If you go to the International Space Station website, there are the words:

What in the world are we doing in space? Why spend the time and resources to build a laboratory in space when we have plenty of them on Earth?

The answer is a unique tool called **microgravity**. Microgravity opens a new universe of research possibilities. It unmask phenomena that gravity on Earth can obscure. Research in microgravity has enabled new insights into what happens inside a fire, how soil grains shift during an earthquake, why certain thick fluids flow easily under pressure, and what is the best way to spray water onto a fire.

Scientists are putting microgravity to work to understand the growth of proteins as near-perfect crystals. Cells grown in space can also produce longer-lived cultures to help us understand the growth of tumors and perhaps give insight into how we might control this growth process.

There has been considerable debate over the efficacy of the microgravity program. This from a National Academy of Sciences report: *Assessment of Directions in Microgravity and Physical Sciences Research at NASA* (2003):

“The recent financial problems of the International Space Station (ISS) have brought a major uncertainty to the future of the microgravity program. Many of the facilities that were destined for the ISS have been delayed, and the crew time available has been drastically curtailed. The financial crisis has also affected the ground-based research program. Whether this is a temporary setback or the beginning of the end of the microgravity program remains to be seen.”

The purpose of the space station, essentially, is just to maintain the space station, rather than do anything else. That’s a bit harsh, I know, but it is a reasonable approximation of reality.

So, at the end of 2003, NASA’s human space flight program is a mess. The timing for the return to flight of the Space Shuttle is uncertain, the justification for the International Space Station is weak, and still existing is “. . . **the lack, over the past three decades, of any national mandate providing NASA a compelling mission requiring human presence in space.**”

Then, amazingly, in the middle of a war, President Bush makes an announcement on January 14th (2004) that we are going to start a program again to send humans to the Moon and on to Mars. From CNN: “**Saying ‘the desire to explore and understand is part of our character,’ President Bush Wednesday unveiled an ambitious plan to return Americans to the moon by 2020 and use the mission as a steppingstone for future manned trips to Mars and beyond.** The president unveiled what he billed as a “new course” – shifting the long-term focus *from* the Space Shuttle and the International Space Station *to* the creation of a new manned space vehicle that will be flying with a crew in 10 years and will return humans to the moon within 16 years.

Bush proposed spending \$12 billion over the next five years on the effort. *The overall NASA budget would stay at about 1 percent of the federal budget, according to White House figures.*”

The new course actually retires the Space Shuttle, hands off the space station to our international partners, and builds a new vehicle called the Crew Exploration Vehicle that will go beyond low Earth orbit. Flash forward to February 3rd of 2004; this (on screen) is part of NASA Administrator Sean O’Keefe’s presentation to Congress on the fiscal 2005 NASA budget: O’Keefe points out that the fundamental goal of the “Vision for Space Exploration” is “. . . to advance U.S. scientific, security, and economic interests through a robust space exploration program.” We’re going to send humans to the Moon and Mars, we’re going to have a continuous, vigorous robotic space program, and we’re going to develop lots of new and great technology to do both things.

Here are the details and the plans in the new space policy: (1) Return the Space Shuttle to flight, scheduled for May of next year. (2) Retire the Space Shuttle by the end of this decade. (3) Finish the International Space Station, and use it mostly for studying astronaut health and probably get rid of things like microgravity. (4) Develop the Crew Exploration Vehicle for test flights by the end of this decade, and have it fully operational by the middle of the next decade. (5) Begin a series of lunar robotic missions by 2008, and return humans to the Moon by 2020.

The President created a commission (President’s Commission on Implementation of the United States Space Exploration Policy; a.k.a. President’s Commission on Moon, Mars, and Beyond) early this year to evaluate his new space exploration vision. The Commission went to work almost immediately, worked like a

dog, and issued its report in June. Some of the recommendations are very straightforward:

- The space exploration vision must be managed as a significant national priority, a shared commitment of the President, Congress, and the American people.
- NASA's relationship to the private sector, its organizational structure, business culture, and management processes – all largely inherited from the Apollo era – must be decisively transformed to implement the new, multi-decadal space exploration vision.
- The successful development of identified enabling technologies will be critical to attainment of exploration objectives within reasonable schedules and affordable costs.
- Sustaining the long-term exploration of the solar system requires a robust space industry that will contribute to national economic growth, produce new products through the creation of new knowledge, and lead the world in invention and innovation. This space industry will become a national treasure.
- International talents and technologies will be of significant value in successfully implementing the space exploration vision, and tapping into the global marketplace is consistent with our core value of using private sector resources to meet mission goals.
- Implementing the space exploration vision will be enabled by scientific knowledge, and will enable compelling scientific opportunities to study Earth and its environs, the solar system, other planetary systems, and the universe.

- The space exploration vision offers an extraordinary opportunity to stimulate mathematics, science, and engineering excellence for America's students and teachers – and to engage the public in a journey that will shape the course of human destiny.”

Over the spring and summer there was considerable skepticism in Congress (from both Republicans and Democrats) over the new space exploration plan. Most of the criticism centered around other higher national priorities and uncertain costs. The outcome of this whole proposal is not going to be clear until after the election. We have the election. I am in Rome that week. This is how I saw it (Italian newspaper shown on screen).

So, what happens? To remind you, Bush puts forward the Vision for Space Exploration in January 2004, along with the budget to support it. NASA is busily reorganizing itself; the Commission issues its report in June. One doesn't hear much about the Vision over the summer and early fall except harping from Congress. But guess what? The budget is passed, essentially intact, late in November. This is from *Florida Today*, November 22, 2004:

CAPE CANAVERAL – Sending people to the moon and Mars is no longer just President Bush's vision. It's officially the United States' new mission in space.

Congress voted Saturday to give NASA all of the \$16.2 billion it sought for 2005, money not only to return the Space Shuttles to flight but also to start designing a replacement spaceship and planning moon missions.

The NASA budget got lumped in with everything else in a two-foot thick budget document that left some members of Congress complaining they did not have enough time to read it before they had to vote on it. Still, the House voted 344-51 to approve it Saturday afternoon. Senate approval was expected hours later.

The 6 percent increase for NASA was remarkable in many ways. First, tight budgets forced the president and Congress to all but freeze spending for projects unrelated to fighting terrorism or national defense.

Also, Congress has grown cold to NASA's requests for big investments in new space projects. *A similar proposal by President Bush's father was dead on arrival in Congress.*

This time, the political dynamic was different. Bush introduced the new vision Jan. 14, then let Vice President Dick Cheney and NASA Administrator Sean O'Keefe sell it to Congress. They got help from a quiet, but effective lobbying effort by the aerospace contractors who stand to profit from the projects.

Meanwhile, Bush said nothing about NASA during the presidential campaign, although his top budget aides threatened to veto any spending bill that did not include full funding for his space plan.

The most influential negotiator was House Majority Leader Tom DeLay, R-Texas, who represents thousands of space workers at the Johnson Space Center in Houston. DeLay told counterparts he would not let the budget bill come up for a vote Saturday – when there was a midnight deadline for passing a 2005 budget – unless NASA got what Bush asked for.

This was a shocking outcome to the process that had started on January 14, 2004. The question is: Will the United States do this now? I have no idea. Astronauts on the moon in fifteen years? Is this déjà vu to the Space Exploration Initiative of 1989-1990? Will this peter out, or are we really on our way to the Moon and Mars with humans (in addition to the present flotilla of robotic spacecraft)?

What's actually going to happen now? We have four years of the Bush administration ahead, and as long as he has a Republican Congress, the Vision will likely remain funded. By the time Bush leaves office in 2009, the Crew Exploration Vehicle will be well under development. In fact it will be, according to the schedule, very close to a test flight. The plans for lunar exploration will be far along. The plans for retiring the Shuttle will be far along. This will all happen barring some other national

tragedy like 9/11, in which case all bets are off. Congress may be well down the path to committing to the Vision with considerable investment by the time Bush leaves office. Maybe there will be enough momentum to sustain the Vision no matter what the new administration is in 2009. But if the new administration comes in and says “we don’t want to do this,” then they are basically saying we don’t want to have a human spaceflight program.

It will be interesting to see what happens. Right now I guess we could say for those who think the Vision is a good idea, this budget is the best possible news. Maybe finally NASA will have a reason for having humans in space, which they have not really had since the Apollo era. That’s it. Thanks.

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Postscript, June 2005: It is now 6 months since I gave this talk. The FY 2006 NASA budget deliberations are going well in Congress, particularly for the Vision. On June 13th, NASA selected the Lockheed Martin Corporation and a team of the Northrop Grumman Corporation and the Boeing Company to compete for building the Crew Exploration Vehicle. The new NASA Administrator, Michael Griffin, is aggressively reshaping NASA to support the Vision. And the first new Space Shuttle flight since the Columbia accident is scheduled for next month. *For now, things are humming.*