

WASHINGTON ROUNDTABLE
ON SCIENCE & PUBLIC POLICY

**EVALUATING THE NEW
SPACE POLICY:
A Panel Discussion**

By
Lori Garver, Stewart Nozette, Richard Buenneke
and Robert Butterworth

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Washington, D.C.

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Evaluating the New Space Policy: A Panel Discussion*

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Friday, February 20, 2004

Jeff Kueter: Thank you for coming to this latest installment of the Marshall Institute's Washington Roundtable on Science and Public Policy. Today's discussion will consider the new space policy that was announced by President Bush on January 14 and where he set out a new challenge for the nation, the return to the moon and continued human exploration of our solar system. The Marshall Institute's Roundtable on Science and Public Policy is designed to bring scientists from around the country to Washington to talk with public policy makers about issues of importance and to help clarify and raise new questions as the policy-making community considers issues for which science is important.

Space exploration is a recurrent interest to us. Our founder and Chairman, Dr. Robert Jastrow, who is here with us today, chaired the first working group on lunar exploration at NASA in 1959, which was instrumental in getting the United States to the moon the first time. In 1990, the Marshall Institute produced the report, *New Directions in Space: A Report on the Lunar and Mars Initiative*, which evaluated the space exploration initiative of President George H. W. Bush.

The question we face as a nation today is, do we want to return to the moon and go beyond it? That question raises a host of provocative issues for which we have assembled this panel. Please join me in welcoming the panel.

Lori Garver: Thank you so much, Jeff. It is great to be here and I very much appreciate the kind invitation and the fact that the Marshall Institute is hosting this panel. It is wonderful to see Dr. Jastrow, whom I have known over the years, even on the Board of the National Space Society, my first job. So thank you for having me.

* The views expressed by the authors are solely those of the authors and may not represent those of any institution with which they are affiliated.

I am prepared to talk about the question: do we want to go back to the moon and beyond? The answer in my view is an unequivocal yes; we do want to do this. It is going to be difficult and I will give you just a quick brief of what I think the President laid out on that and what we can do as a community to get this done. And of course, I believe that it is important to get it done.

In my view, what the President announced on January 14 is really a re-focusing of NASA. In some ways it isn't very new. I have worked in this community for twenty years and we have all known we were going back to the moon and Mars; it has always just been a question of when and how to provide leadership and a framework to do it. I believe that is what the President laid out and we should all be very grateful, as I am. When I was at the Policy Office at NASA, I would have been absolutely thrilled to have such a presidential announcement and an initiative which was thought through to the extent that I believe these folks did in advance of the announcement. There has been a lot said about the initiative being formulated behind closed doors which I would associate with Dr. Logsdon's remarks in his editorial in *Space News* a few weeks ago. In many ways, this was the only way something like this could be done. All of us would have loved to be part of it and would have refocused NASA in our own specific way, but in my view we need to get behind this effort because it is a very significant new focus for NASA.

Not that we all wouldn't do different things; I just would describe this as different from the first Bush administration's space exploration initiative fifteen years ago, which articulated a less detailed approach. We have learned from that past initiative and it will be very interesting to hear Stu's view on this, since he served in a Space Council at that time. But from my memory, there was not as much specifically done before the announcement, which took place in July in the first year of his presidency, compared to three years into the presidency, as this one is. There are some differences, but it does look like some lessons learned are going into the effort, which should prove beneficial.

One of the differences is that we already have a couple lunar missions laid out, an orbiter mission in 2008 and a lander mission in 2009. Orlando Figueroa of NASA said yesterday that the requirements for those missions are already being developed and that this Fall, we'll probably get some initial Requests for Proposals (RFPs) going out. They have already identified the Centers that are going to work these issues. Those are pretty detailed plans so early into this new policy. The crew exploration vehicle,

probably the first thing out of the blocks, is called Project Constellation. That is probably going to be our first test, both on the Hill for how much support we have in Congress, but also for determining if we can do things differently, which again this vision requires. The Prometheus program was already identified at NASA and is now going to be folded into this initiative.

Again, a lot has been made of the fact that there isn't much new money, but there is a lot of reprogramming and refocusing. People have asked whether this is just one of these Bush initiatives that is put out there, but not intended to be supported because it wasn't announced in the State of the Union address; there is concern that the White House isn't behind it. I do not share those concerns and my view is that it is probably best not to politicize this. Space has historically been bipartisan and we absolutely must keep it this way. So I for one am very hopeful that the refocus will "take" this time, as compared to fifteen years ago.

One of the important elements to its success is the impact on existing programs. The hardest thing for NASA to do is stop flying the shuttle at the completion of the space station. Obviously this is already proving a challenge for people, and industry is divided on it. This is my greatest concern, since it is the greatest threat to the overall program. Just the fact that we are having a hard time accepting the cancellation of the fourth servicing mission for Hubble shows me the difficulty we will have in carrying out this initiative. I think the White House and the Office of Management and Budget (OMB) have been very clear: if we don't do things differently, if we don't cease these programs and scale back, we can't go beyond the present. We have wanted this for so long as a community that we need to get together this time around.

The White House does seem to be very open to, and encouraging of, global participation, especially European. This is also a very positive aspect of the program. The Aldridge Commission on Moon, Mars and Beyond seems to be doing a good job getting kicked off extremely early and scheduling town meetings with the public. These are all excellent signs, in my view, since my background is public outreach and I will never believe that that money that NASA spends is anybody's but the taxpayer's. The real shift in space transportation policy is an important factor. Of course, the actual new space transportation policy has not come out, but the White House is reviewing it and it is going to be quite different from the existing one. The bifurcation between the reusable launch vehicles managed by NASA and the expendables owned by the Defense Department is now obviously over. New development of vehicles will be the purview of the De-

fense Department and that is something new for NASA. I have followed this for a long time and I believe this is as significant as the doctrine of transformation has been at the Department of Defense (DoD). Those invested in the status quo have problems with the transition, but I believe that this can be ultimately beneficial for the space program's constituency, that is, the public, who would like us to go further.

New Vision

- The initiative is designed to refocus NASA on exploration
- Numerous robotic missions to the Moon and Mars will pave the way for a lunar base in 2015-2020 and human trips to Mars sometime thereafter
- NASA will develop a crew exploration vehicle, known as Constellation, for travel beyond low Earth orbit
- The Prometheus program to develop space nuclear power will be a key technology enabler for future missions
- While there is little new money now for the initiative (only \$1 billion over 5 years), the subsequent decade calls for more than \$165 billion in new initiatives

Impact on Existing Programs

- The shuttle must be retired after space station assembly is complete (~ 2010)
- The space station is to focus on research to enable human planetary missions, and NASA is to cease managing and paying for the facility by 2014-2016

External Issues

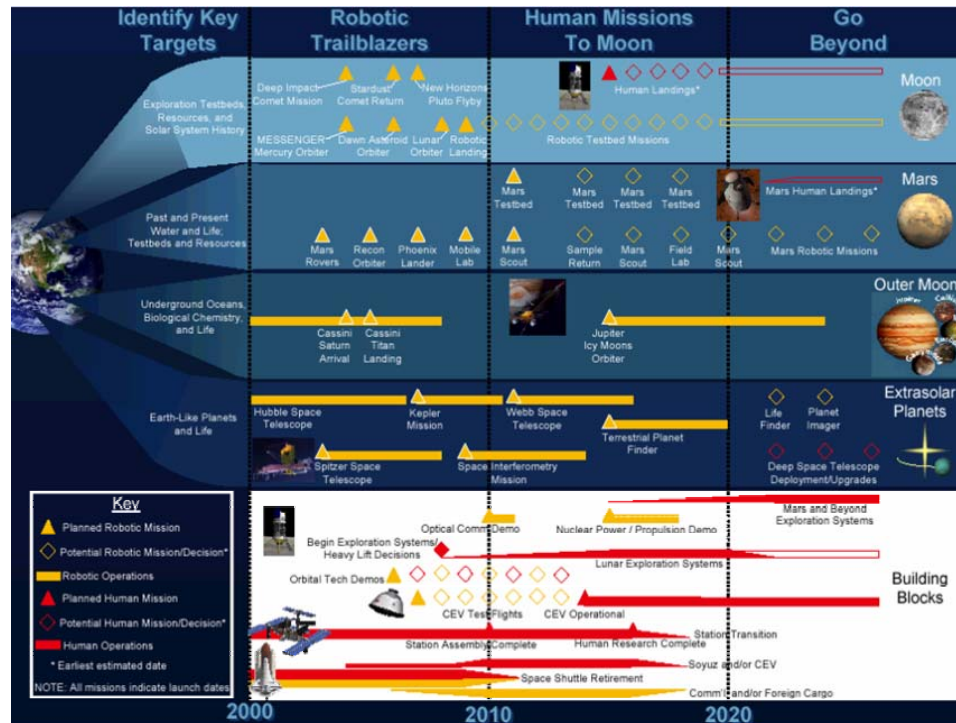
- The White House is eager to have European cooperation on the initiative
- A commission chaired by Pete Aldridge will determine the key architecture elements
- Any necessary new launch vehicles will be built and paid for by DoD

Figure 1

Figure 1 is a NASA chart which outlines the specifics of the robotic and human missions, where we are going beyond the moon and Mars, and tying in all the different programs that currently exist. One of the criticisms has been that all this does is rebundle existing programs. Obviously it does that; there isn't a lot of new money, but it provides a framework for existing programs that allows NASA to look strategically at what they can get out of those programs. Take, for instance, the space station: we have tried to sell the space station as all things to all people over the years. It is now extremely focused on life sciences. That is really nothing new; we knew that that is what it was for all along. Fifteen years ago, when the Bush I space exploration initiative came out and they were looking at long duration space missions, they were the ones (we sometimes forget) who initiated Shuttle-Mir and we worked with the Russians to get that extended duration time for the life sciences research on Mir. It was a new and very inexpensive way of doing things and it ended up being very successful. The Russians had long-term experience in space and we were working with them to gain that experience ourselves and to add some of our medical expertise to

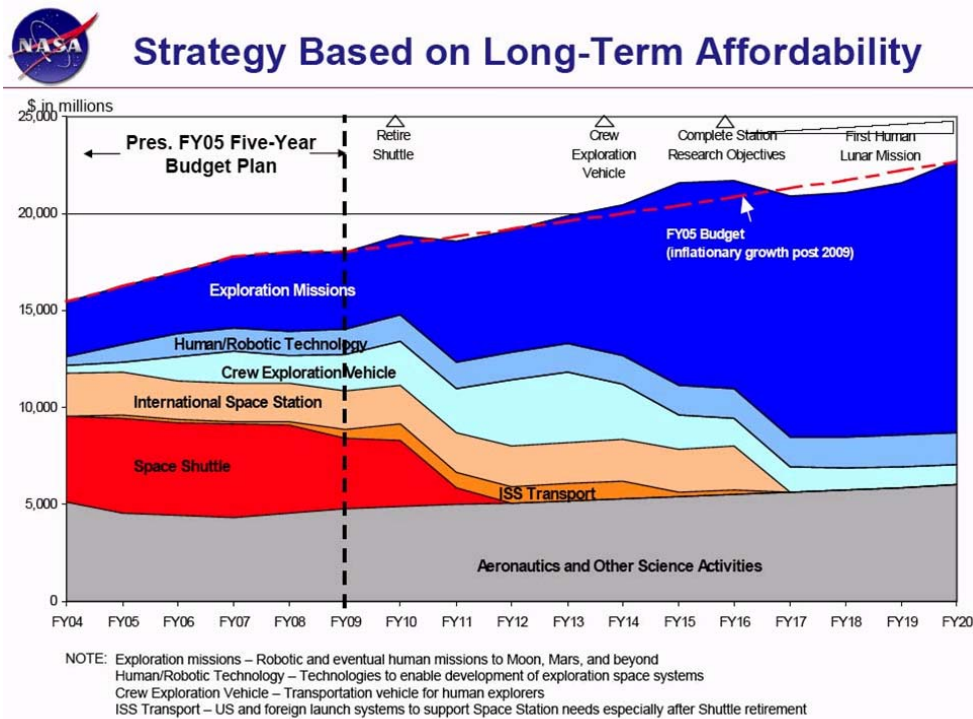
their experience. So I don't think this is anything new and I hope it "takes" this time.

The last point I want to make about this chart is that even though some of it is rebundling and there is not a lot of new money, it is still going to be extremely difficult to get this through not only Congress, but future administrations. We don't know what is going to happen in this election, but this is much longer term than a four-year plan. One of the main differences between fifteen years ago and now is the fact that NASA has accepted, encouraged and adopted this initiative. That was not the case fifteen years ago. We also asked for someone to head NASA who is politically savvy and connected with the administration and has the ear of the president, and we now have that. I think that that is very beneficial. Again, we have to be careful to keep it bipartisan and that is probably a new challenge, because this is a campaign year, which last time it was not. For that reason, it was probably not the best time to announce the initiative, but we will take it.



NASA's New Timeline
Figure 2

Figure 2 is another NASA chart called the “layer cake” chart. As you can see, the budget is now dominated by the space shuttle and the international space station. As these programs phase out, the budget will then be dominated by exploration, and that is something that we as a community have to accept. We have been given assurances that aeronautics and earth sciences will remain stable and certainly I hope that that is going to be the case, because earth sciences and aeronautics are two elements that the public most benefits from, that they connect with, and that provide the most value to society. Those are important aspects of what our nation does in space.



10
 NASA Budget Authority – FY 2004-2005 by Major Categories
 Figure 3

Figure 3 shows the major categories of the budget and how they are going to change over the next five years. The take-away from this chart is, as I have stated, that the Crew Exploration Vehicle (CEV) or Project Constellation is probably the first new program and will ramp up here, as the shuttle and station are ramping down over and beyond the next five years. We also have to recognize there will be a hiatus between the space shuttle going off line and the CEV coming on line. Having gone over and trained

a little bit on the Soyuz, I think it is a wonderful thing to use the Soyuz in the interim; I am not at all concerned about it, as I have been saying for years. We were always going to have to do it; it is not anything new, but it is wonderful that we are finally acknowledging it. Obviously we are using it now and it has worked very well for us.

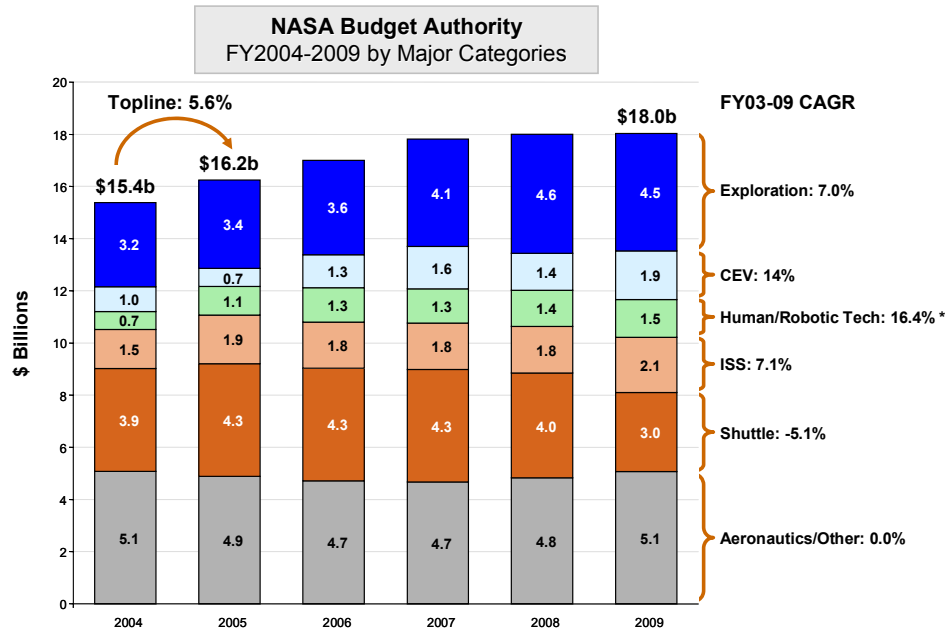


Figure 4

Figure 4 shows an analysis of how this works. Many people are saying, “this doesn’t have much new money, so is it real?” The CEV, again, is the most significant new competitive program that NASA will have out there under this new initiative.

We tracked a budget of the comparative elements of Apollo, keeping in mind that we are not developing a Saturn-5 this time; we are using an EELV (Figure 5). The budget for the command and service module elements of Apollo is the red line and the blue is the planned outline of the budget for the CEV. NASA is funding this to the extent that we funded the development of equivalent elements of Apollo. The difference is we stopped flying the Apollo soon after it came on line, so the budget dropped off very quickly. We do not anticipate that happening here.

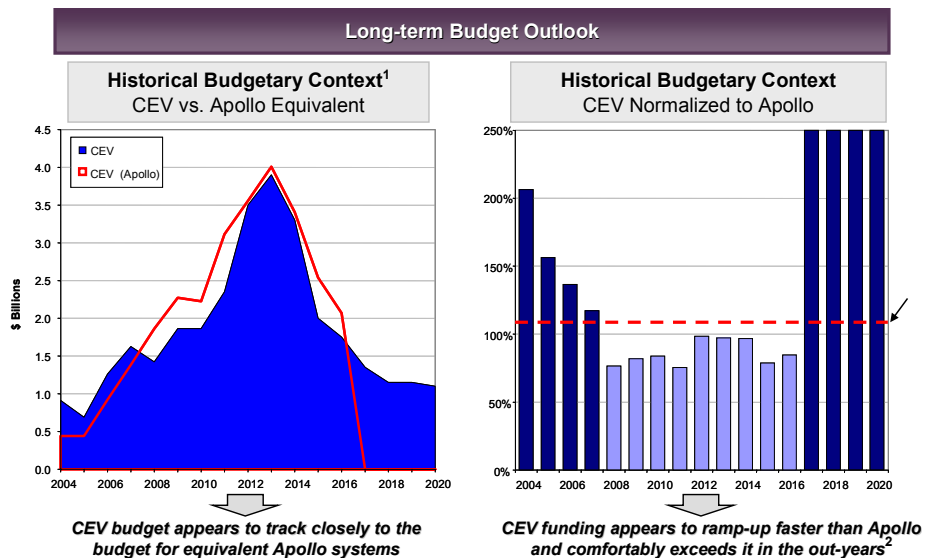


Figure 5

I will close with the statement that this has to be a sustained, bipartisan effort. I appreciate the opportunity to let you know my perspective on it and look forward to your questions. Thank you.

Stewart Nozette: I will try to be brief. I have the obvious disclaimer that these are my own views so if there are any people of the press in the audience, don't call Jan Walker at DARPA saying, "What is Nozette saying about what DARPA is doing?"

I will allude to some technology contributions that we have made and have been working on with the folks at NASA. We have a couple of joint activities going on and I will describe those. I think they have been described publicly before, but these are officially my own views, not any agency position or policy.

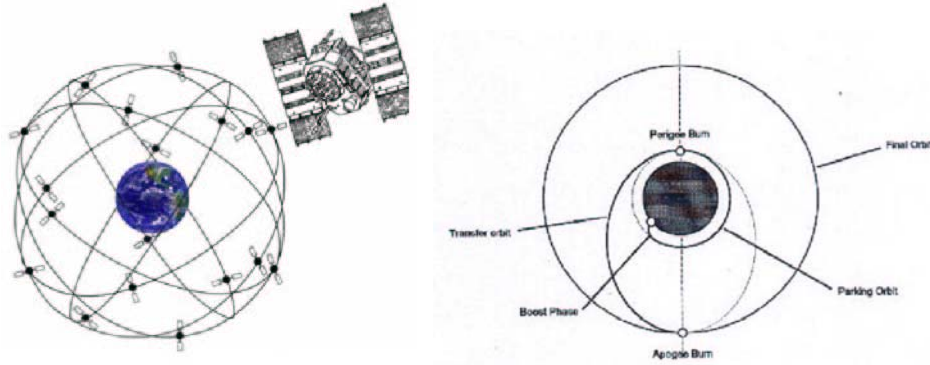
I want to give some of my perspective on the history, based on my previous background working for President Bush 41. This policy basically puts NASA in the lead in what we call the "cis-lunar missions." It has peaceful scientific exploratory goals and we want to garner international partners. I think that's a good thing. For my Marshall Institute brief here, I am throwing out some of what I call strategic goals – I don't want to say military, I want to say strategic – that are in the overall national interest. And as I already said, that is important for the long-term sustainability of this initiative. One of the longest-term projects that we had as a country

was fighting the Cold War, which lasted over forty years. That was a strategic goal for both Republicans and Democrats. NASA had a role there, because historically you could argue that Apollo was in fact a strategic venture, though it was carried out by a civilian agency. There is potentially new competition here, such as China. I am not saying we are fighting battles in space with China, I am saying that they are long-term strategic partners/rivals to the United States and that is a factor that we at least have to highlight.

What's different now from 1989? The '89 Bush I space exploration initiative was perceived as a failure by the body politic. Actually it was not a total failure; we did what we could and we made some significant progress with it. This is a perceptual issue that I would like to clarify. Going back to '75, when I first started getting involved in this business, numerous studies have been conducted on using lunar resources. Specifically, everyone agreed that we have to survey lunar resources before we talk about returning to the moon. There was a gap in the Apollo data, particularly about the polar regions. The original SEI plan was for low-cost robotic resource Prospectors. SEI in fact produced Clementine; we had to find a novel way to get it done and that helped do Lunar Prospectors. So I would argue the first phase of SEI that was laid out in the Bush 41 effort was in fact accomplished, and the results surprised us all. We were pretty skeptical that there would be polar volatiles, but the data from both those missions suggests there are. That really was the Holy Grail and in many ways it enables technology to do further exploration and learn how to use off-planet resources. We have to confirm that these volatiles are there, but this is suggested by multiple data sets and I will get to that later.

The other thing that is different from 1989 was that in '89 there was institutional NASA resistance to exploration. I think it was perceived as a threat to the shuttle and the space station. After I left the Space Council, I worked for General Stafford for a year with Paul Spudis and others and one of their conclusions was that the space station, as an intermediate step to moon and Mars, was arguable. This was right at the beginning of the space station's alternate cycles, as opposed to the end, and so I don't think the NASA institution really embraced this. After the Columbia shuttle tragedy and others, NASA and the body politic felt this system was potentially getting long in the tooth and that it would not last forever. What's next? What are we going to do with humans in space? We really have to think about this and we have to make a commitment that we are going to continue this enterprise. I think this particular initiative will garner the institutional NASA support to make it a long-term commitment.

Now potentially we have other strategic entities who are interested in this area and we have potentially a strategic goal. One of my concerns in looking at some of the plans is that we cannot just have a lunar touch-and-go. It is important to establish a long-term presence, of course, as others may establish their presence and have a strategic impact on us, and I will get to that.



High-Orbit, Multi Plane Invulnerability?
Figure 6

After the Rumsfeld Commission, there has been a lot of talk about the vulnerability of space assets. For example, the GPS constellation was always perceived to be invulnerable because it would be very difficult to attack from the ground because of the orbital geometry. We assume this is the best defense. Well, it is possible to find a hidden path. Back at Hughes, we demonstrated that we can use the lunar gravity to do many orbital gymnastics that would be prohibitive if we tried to do them directly (Figure 6). The ability to work in cis-lunar space provides a backdoor to get back to low earth orbit (LEO), middle earth orbit (MEO) and geosynchronous earth orbit (GEO), which is very unobservable. Our space surveillance systems today don't look for things flying around the moon. So if someone has a capability to work out there, this basically puts all our systems in a different plane of vulnerability. We are not saying "weaponize lunar space," we are saying "understand, survey and have a presence."

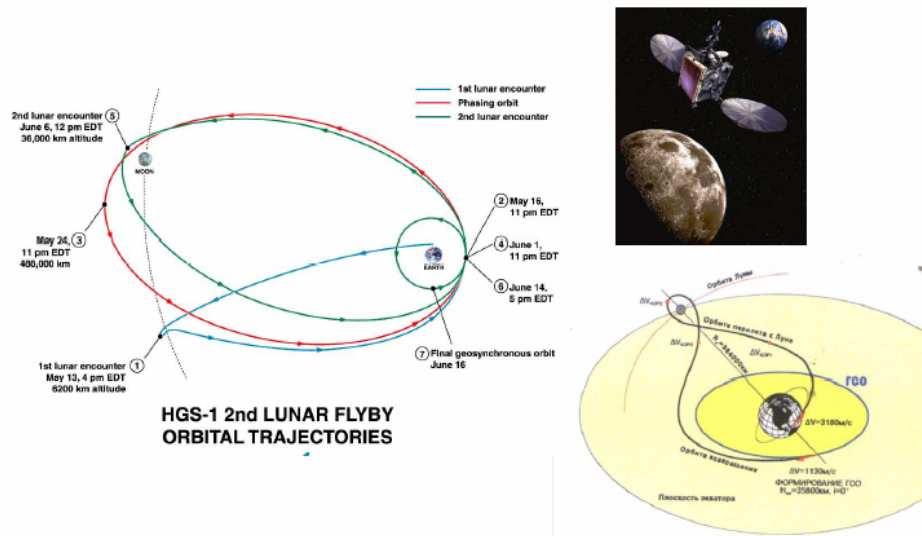


Figure 7

This was done in 1998, actually by a private entity (Hughes). Figure 7 shows the first commercial use of the moon, using it as a gravitational mass to carry out a rescue of a spacecraft that was left in a bad orbit by a launch anomaly. We were actually able to use lunar gravity to pull the plane down to GEO and get some use out of the spacecraft. This was all done as a commercial entity.

GEO is the pay zone in space. What is the real commercial industry today? Commercial/military/intelligence gathering are what's up there now. This is no different from the Apollo era. It's not widely realized that energetically, in terms of rocketry, GEO is in fact slightly more difficult to get to than a lunar orbit. If you look back to 1972 and the Apollo program, we launched two Saturn 5s, Apollo 16 and 17, which put about sixty metric tons into low lunar orbit. Today the GEO common industry does that, though they don't do it in such big chunks. That's about twelve GEO-birds, six Ariane or five ELV launches. We have a commercial cargo industry that can support this level of program and this potentially is a good thing for the GEO industry. I am just referring to a shuttle-derived vehicle; I think that is certainly a one-point solution that could develop heavy lift capability. For a lunar program, we need two to four shuttle-derived vehicles a year and some number of GEO launches that the commercial industry could provide. That seems very doable to me, in terms of the projected NASA budget. And these could be global, national, or international.

Navigation/Communications

- **Enabling Technology for Stressing Communications /Navigation**
- **Technology**
 - **High-Gain Radio Link**
 - **Laser Communications (TBD)**
- **Demonstration of Complex Spacecraft Operations and Control Through Alternative Paths**

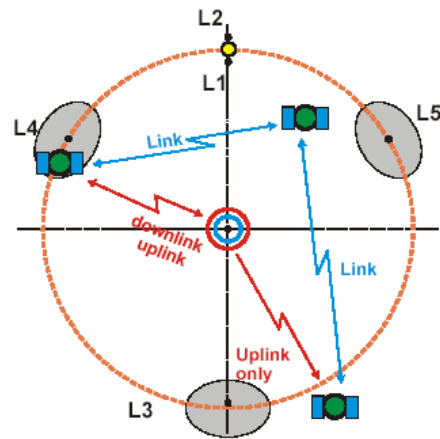


Figure 8

Another thing that is interesting is the GEO-communications industry (Figure 8). With all the launch vehicles and spacecraft, you get a geosynchronous transfer orbit (GTO), not to LEO. Once you are at GTO, you are very close to getting into cis-lunar space and you have the option to use low thrust as well as high thrust systems. There are all kinds of interesting things that can be done. If we are going to operate in these regions, we also have to expand our navigation and communications capabilities. We may want to look at expanding GPS-like capabilities out there with some micro satellites, and this could be part of a program to enable an expanded presence, as well as optical observation. Again, this is fairly low-cost.

Once you have a beyond-GEO high ground, you look back at what Rumsfeld pointed out in 2001 in the Rumsfeld Commission Report (Figure 9). These are all the things you want to be able to do, such as have communications and operations. I would point out here that there is a lot of discussion in policy circles about “the weaponization of space” and threats to assets. One could argue hypothetically that the ability to preposition assets in cis-lunar space that would go to GEO would in fact achieve a survivability objective without weaponizing or having guard satellites, because you would have distance, distance and time. So this is again a strategic

thought; this isn't policy or anything but this comes up when you start talking about a cis-lunar program.

National Security Beyond GEO “The High Ground”

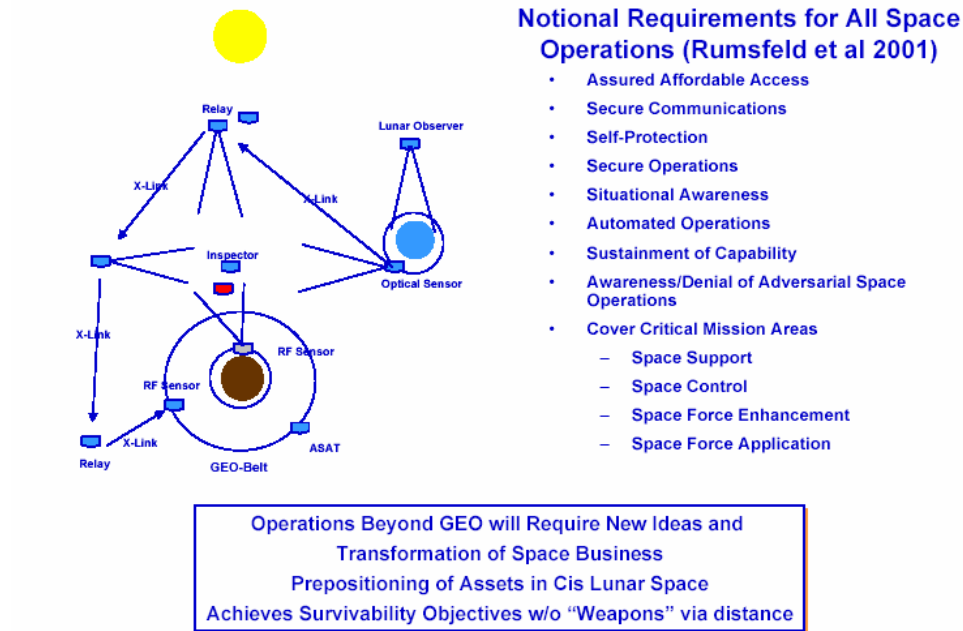


Figure 9

One of the things a program like this will do is encourage people to get into the space business, and it's unclassified. It opens up the opportunity for graduate students and Air Force officers to take part in this. One of the things I remember about the Clementine is we launched a Titan-II at Vandenberg in sixteen months. The commanding general there was Lance Lord; he was a one-star, who is now head of Space Command. He was very impressed with the performance. I talked to all the workers and everybody said, "Well, you know we have been dreaming of space for our whole lives, we children of Apollo. We always wanted to do something like this, going to the moon, and this isn't just another weather satellite or something else." So they really put the extra effort into it. The United States never got to the moon by everybody working 9 to 4:30. It really required the extra full measure of devotion to achieve this. I also want to emphasize that the more motivated and better people that get into the space business are, the better the performance will be, not just on the NASA side, but on the DoD side to execute the programs.

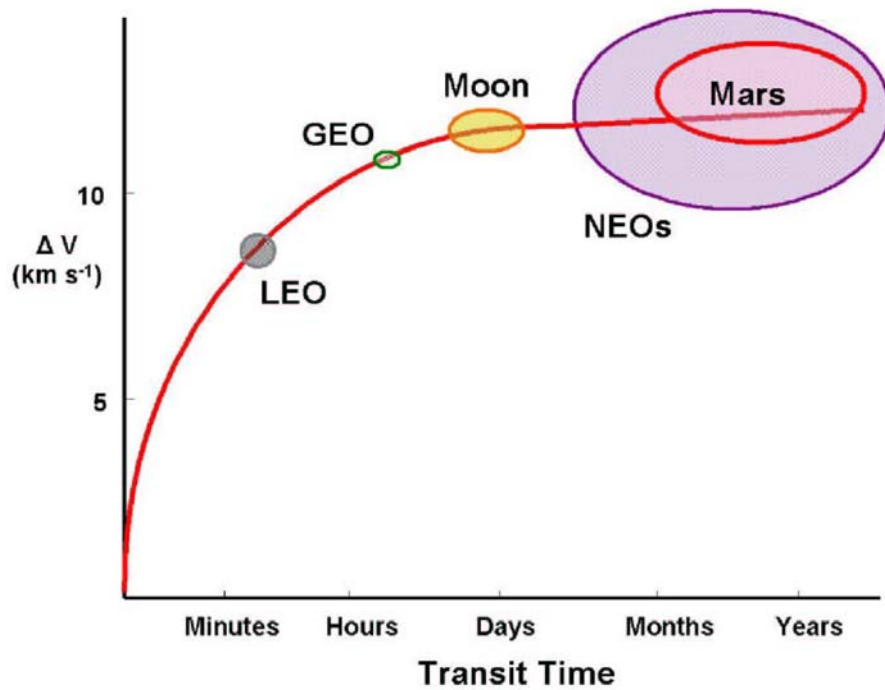


Figure 10

There has been articles in the press by people like Alex Roland and Greg Easterbrook which say, “It’s impossible to use more resources.” This gets back to the energetics and the physics of the problem. The high orbit GEO, where our pay zone is, is very close energetically to the moon, as you can see from this chart (Figure 10).

It is interesting to consider what that means for the rocketry. Figure 11 shows two boosters, two big heavy lift vehicles, which put several metric tons in geosynchronous orbit. The little lunar module basically almost does the same thing. For the scale of operations, it is very instructive to wander over to the National Air and Space Museum, take a look at that lunar module and compare it to one of these. These are systems that can put the same class of payload in the same place.



Figure 11

It has also been claimed that mining on the moon is impossible. If you actually consider the scale, such as a football field sized area, you could actually mine down to a foot, which is not a very big area. A fairly modest sized piece of equipment, something that looks like a little digger that you would see around a construction site, could excavate that area and turn the excavated material into some useful mass. It would take twenty Saturn 5s to take that equivalent mass to the moon, which suggests this is a revolutionary concept which enables a lot of this to go forward.

If we can actually learn to make stuff there, we will start with pretty simple stuff, such as bricks and roads. I argue that we could do something that the Romans could do, basic forgery, pots, things like that, and maybe get the technology up to the 19th century. We are talking about something that is close by, and that is the other thing the moon offers. Can we actually design systems that would manufacture parts of themselves? This is what Von Neumann called the concept of self-replicating automata. I am not saying we have a self-replicating machine that you drop there, but you could bootstrap the process so that what you build goes into further capability to build more, and that leads to a geometric expansion. You will never

really see that from the space station. Every molecule in that space station has to be lifted off the earth, and when you come back ten years later, it is still the same. With the lunar base, when you come back ten years later, it will have grown from a hundred tons to maybe fifty thousand tons. That's a big difference and brings in many new disciplines into the space business, such as engineering, construction, mining, and chemical engineering. It is really a revolution in how we do space logistics. But it is not traditional aerospace and so this is a new area that needs to be explored.

None of this comes for free; we will need energy and this gets back to why prospecting is important: we need to find the lowest energy/highest grade ore. We have done some studies with the Colorado School of Mines on this. This shows why it was important to find a high concentration of ice, because this is a net present value, an economic model. The percentage of ice in the soil has a big impact on the economics of this, because it relates back to the energy which affects the weight and things like that.

The next stage is the pay zone. Clementine and Prospector both pointed out (and this was really not appreciated when we started the Bush 41 SEI) that there are actually areas of dark and light at the poles. What really struck us in Clementine, when we saw it for the first time, was that the South Pole had all this permanent shadow. So we did an ad-hoc experiment with the spacecraft, though it wasn't really designed to do this: we shined the communication system signal into the areas which were dark (and therefore where no energy was going), because we wanted to see if there was a signature that might look like ice. Sure enough, on one of the orbits we found a signal that looks like ice to radar, a little bit like a roadside reflector. We could only tell this because the spacecraft was moving in its orbit and it shined through that. Something that is static is much harder to see. This was known before; there have been ground-based observations done from Arecibo with ground-based radar, but it was only looking at one direction. Previous to this, people thought there were very suspicious areas that could contain ice, since there is evidence of ice on Mercury in permanently shadowed craters.

These are the best images we have right now. We combined the high-resolution Clementine image with the earth-based radar image and these suspicious areas hide a high polarization ratio. The red area (Figure 12) looks pretty suspicious.

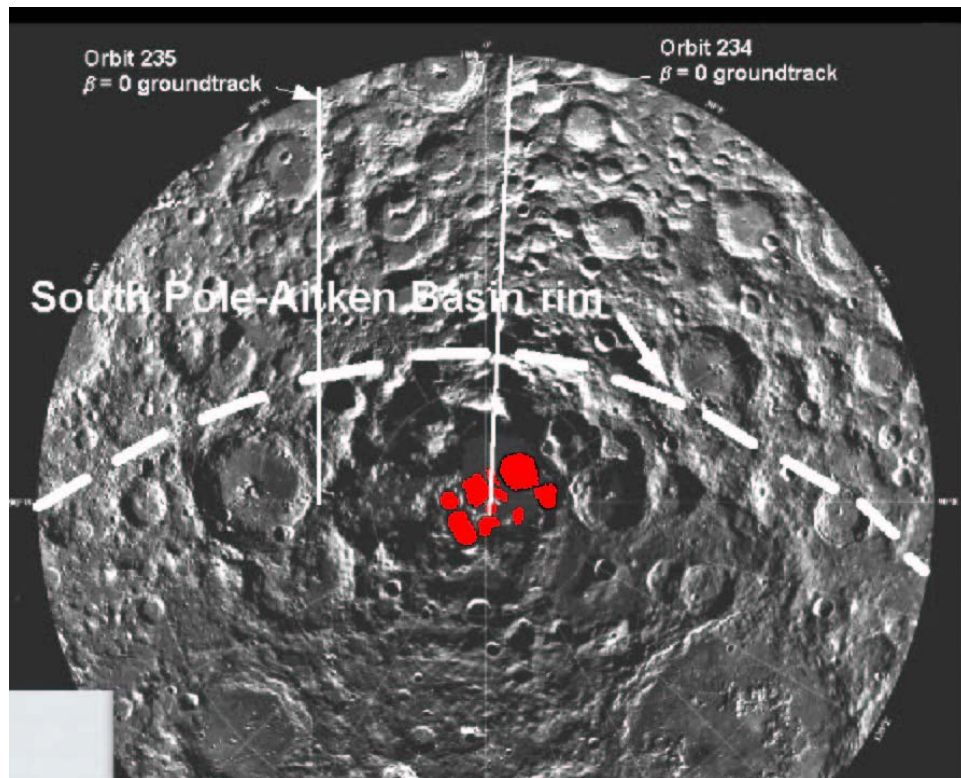


Figure 12

It is hard to do a bistatic measurement from the ground. They tried to do this with two sites. It's always said it's better to be lucky than good. One of the fortuitous things about why we saw something on Clementine was that the orbital track went right through that suspicious area. If it had been focused two kilometers on either side, we wouldn't have seen anything. So it suggests that the earth-based and space-based observations for this area aren't as divergent as people have suggested in some of the press statements.

Figure 13 came out recently from Arecibo. I always thought it was amusing to note where they put their arrow. They said the bigger craters didn't seem to have any evidence, but they put their arrow over the place that showed it! I always wondered about that.

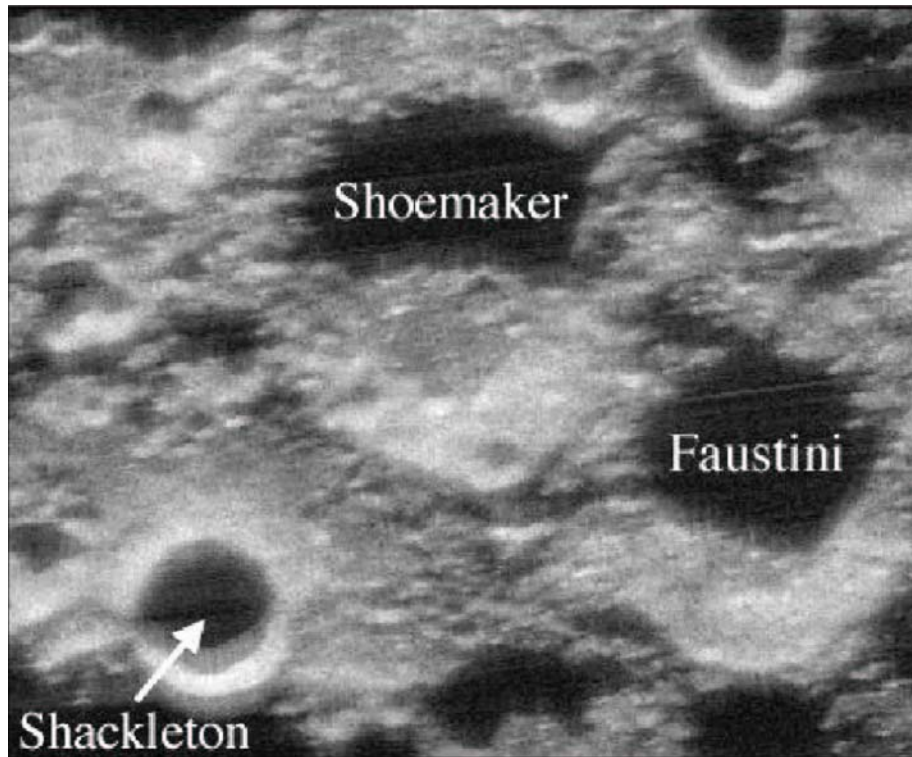


Figure 13

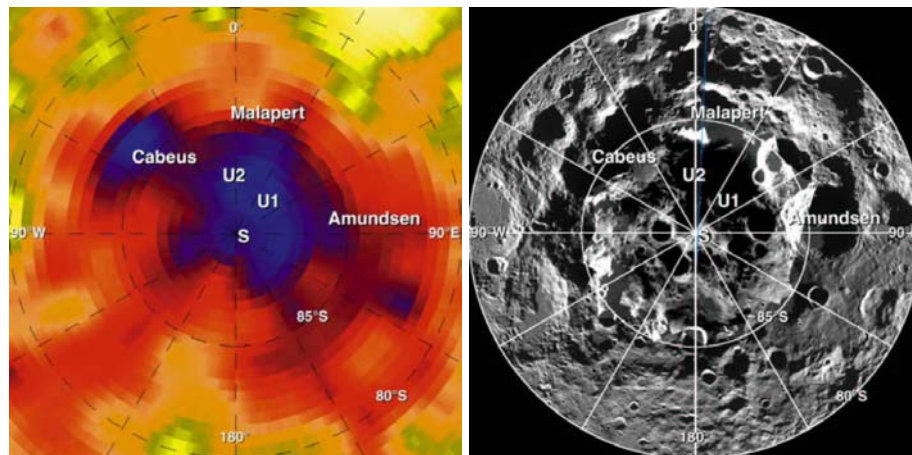


Figure 14

Figure 14 shows the Lunar Prospector data. It is not very high resolution, but it does show there is a correlation with the permanent shadow. The numbers are fairly consistent, so you have another line of evidence that is suggestive.

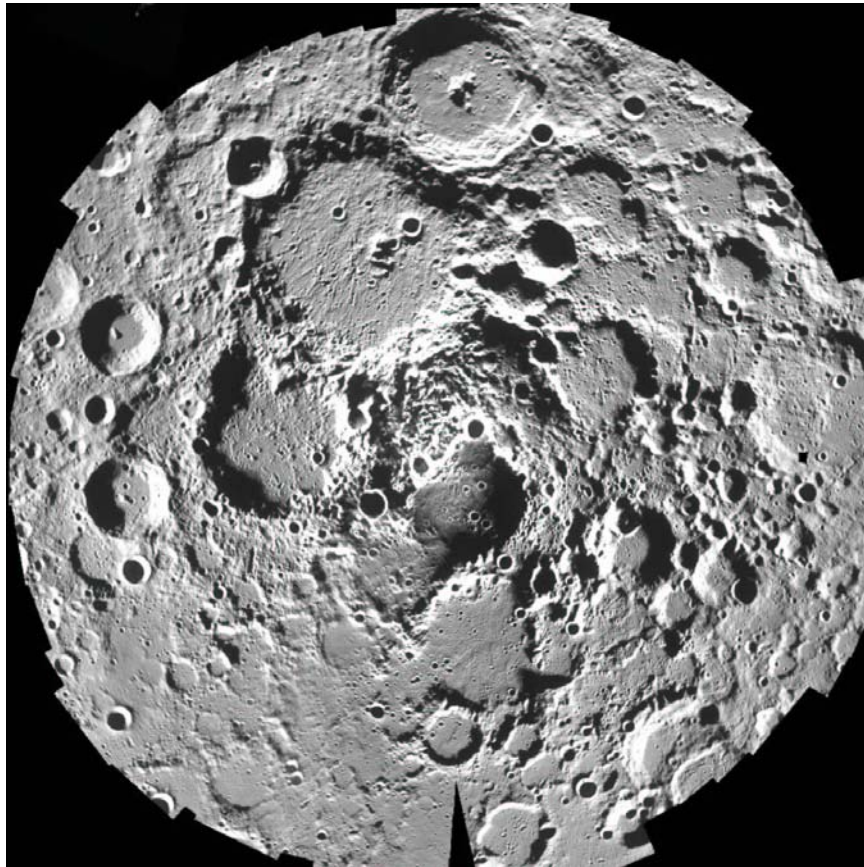


Figure 15

The Lunar Prospector investigators have shown that at the North Pole, the craters are smaller, but they get a good signature, so if it is associated with permanent dark, it is very difficult to explain with anything but a high concentration of hydrogen in the form of water ice (Figure 15). They can't really get another explanation that works. The signature also suggests that the ice is mixed in with the soil in tens of centimeters to meters.

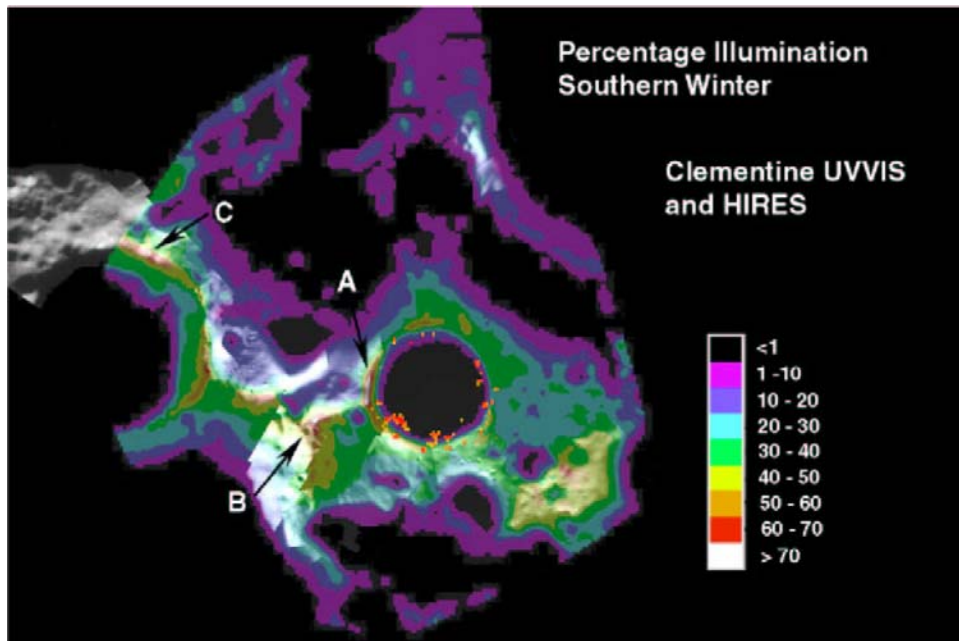


Figure 16

Another interesting thing is the three peaks of eternal light at points A, B and C on Figure 16. Remember, these little orange spots are suspect regions. Each one of those dots represents about ten hours. The yellow ones are sunlight, the black ones are dark. At one of the points, there is sunlight almost the whole lunar month, with about forty hours of eclipse. So that makes it a very attractive area; it will be easier to store energy for forty hours than for two weeks. Also one of these three points is always lit, which suggests that a power grid could be developed. This could all be done without nuclear power. So ultimately we are going to have to go back and do some more measurements and analysis, since we are really never going to see this from the earth. We are going to need higher resolution sensors.

Figure 17 shows something DARPA has been doing. We have been working on microtechnology applied to radar, actually it came out of the UAV program. So we think we could build some very light-weight radar systems.

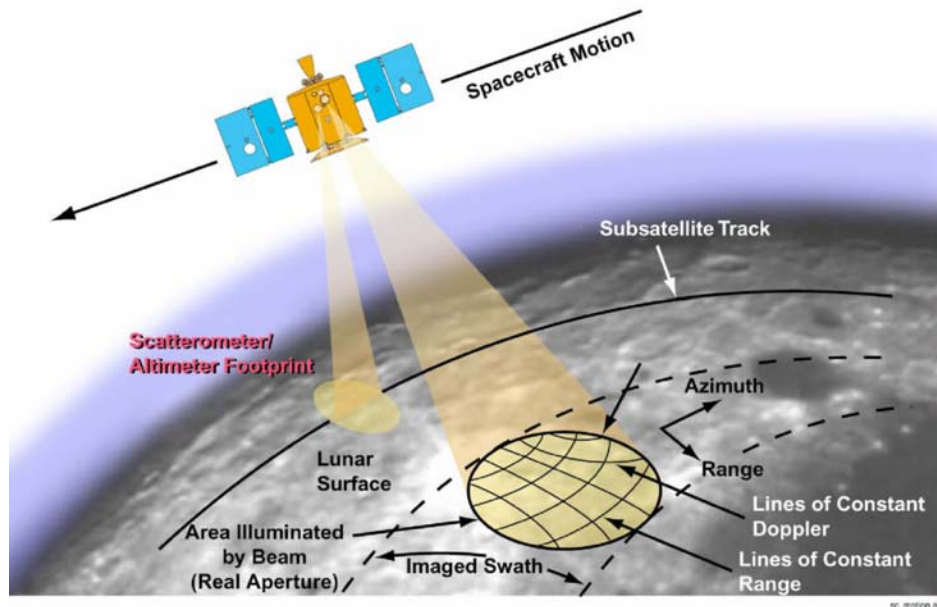


Figure 17

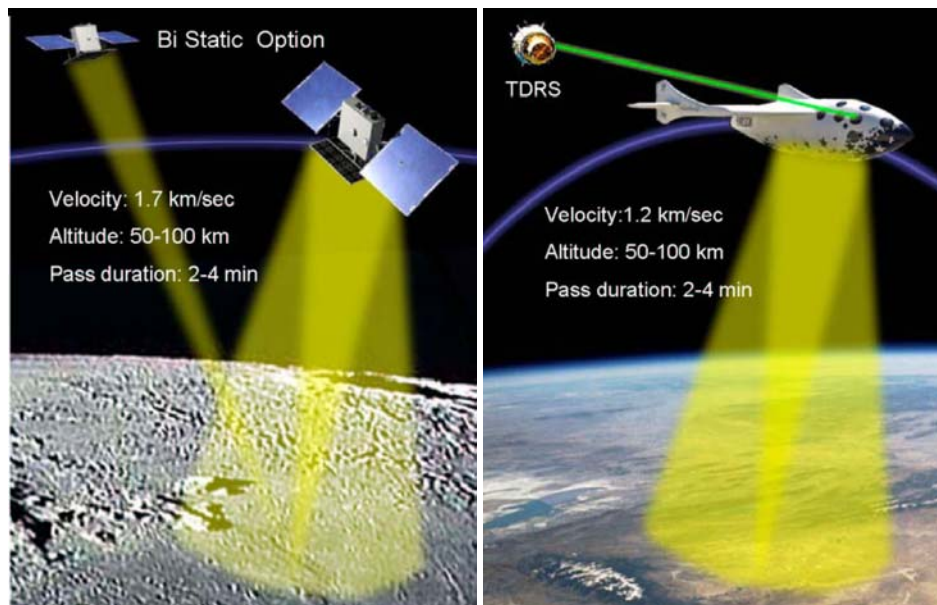


Figure 18

Figure 18 shows another thing we are doing with DARPA. We are working with Burt Rutan to demonstrate that we can use Spaceship 1 as a platform for experiments; it's like a manned reusable sounding rocket

which goes to the edge of space. Hopefully when he flies the X-PRIZE missions, we can put some telemetry experiments on there. He flies about 50 to 100 km, his velocity is very similar to that of a satellite in lunar orbit and the altitude, and he has plenty of area so we have looked at actually brass-boarding and testing radar systems for this. Ultimately we probably have to do it with two satellites around the moon to do this bistatic piece.

The other point I wanted to make was about commercial ventures. In the post-Apollo era, most of the commercial space technology has really come out of the military program, communications, navigation, imaging. Is there synergy? I think there is because of the relationship with GEO. I don't think GEO is going to go away, but it will require government leadership and technical risk reduction to make it possible. NASA hasn't really been a major player in this, but there are some things that they have done, such as TDRS, electro-propulsion, and advanced communication technology satellites. But it is not a big thing at NASA still.

What about the commercial national security uses? We have to learn how to operate in cis-lunar space and put a lot of mass there. One interesting capability would be the development of long-dwell imaging, beam-imaging systems. They are not practical today due to mass limitations. The time scales are commensurate and maybe over the next twenty to thirty years, we might have refueling possibilities. If we have heavy lift and space tug infrastructure, how about really transformational communications? Fifteen or thirty years is about two cycles of GEO bird replacement. How about getting a connection between lunar exploration and increased bandwidth through GEO? I might suggest to our countrymen a spin-off of 500 channels of HD satellite TV, compared to the ten or so today. That is something we could use to sell people on the value of this.

I think we can bootstrap this from existing capabilities, as Lori has mentioned. The ELVs, the shuttle-derived vehicles, and the commercial GEO industry can provide a lot of support hardware for this. The surface stuff is new, so if I had to argue from the NASA priorities, I would say that is where I would put a lot of the long-term R & D money.

So that is my basic pitch. Thanks.

Richard Buenneke: First of all, I would like to commend the Marshall Institute for having this event. In our system of government, the President can initiate a program, but Congress plays an important part of the process, too. So I think that it is good that we are up here on Capitol Hill today

to have this discussion with the broader community. It is encouraging to see that this is really a national debate, because we need a national vision. I don't have all the cool DARPA charts that Stu does, but I do have –

Nozette: They are my charts! I made them myself!

Buenneke: But I do share Stu's un-cool disclaimer that these are my personal views and not necessarily those of Aerospace or any of its customers in the U.S. Government. I will call this "Two Cheers and an Observation." You have already heard a couple of the cheers already, so I will go over them quickly.

The first cheer is that the vision does provide guidance for the President. We have already heard that this initiative has positive support from NASA's leadership, which was not the case under the President's father. It also responds to the call from many people -- space enthusiasts, the Congress, the Columbia Accident Investigation Board (CAIB) – to come up with a compelling vision with which our Nation can move forward. That is my first cheer.

My second cheer is that the President's initiative radically reforms human spaceflight programs. As Lori noted, we are starting to see that realization and all the pain and agony that may come along with it. At the same time, I liked the fact that Lori underlined the shuttle *must* be retired.

The CAIB had to resort to locutions like "it is not inherently unsafe." We have members of the Board here and other people who supported the CAIB, so I do not want to put words in their mouth, but I think there were real concerns about sustainability after the 2010 period. It also gets us out of the "cul-de-sac mentality," like suburban kids who can ride their bikes in the cul-de-sac, but can't go down to the end of the street or cross the street. We are now getting back out and venturing out, both as Americans and as, hopefully, the entire human race. Both the vision and the radical reforms are great, exciting things.

Coming from an organization of engineers, I have to say the "yes, but" on the issue of execution. This is why I cannot offer three cheers. The vision must be backed by a detailed implementation strategy that is adequately funded and we have to manage expectations. Mr. E. C. "Pete" Aldridge has made that point at the first public hearing of the President's Commission on Moon, Mars and Beyond. This is going to go across multiple Presidents, multiple Congresses and multiple generations, so we have to

make sure that expectations are appropriate. Much is said of spiral development and that is a good thing, certainly better than some of the other alternatives. But it is going to be challenging, as are the nuclear-powered applications in Project Prometheus or – if you want to go to Mars – perhaps direct nuclear-thermal propulsion.

COLUMBIA ACCIDENT INVESTIGATION BOARD

History – From Challenger to Columbia

Date for Shuttle replacement varied from 2000, to 2006, to 2012, to 2020 or beyond

Haphazard policy process resulted in a series of stillborn developmental programs

X-30 National Aerospace Plane – hypersonic single-stage-to-orbit (SSTO)

X-33, X-34 and VentureStar™ --rocket SSTO

Space Launch Initiative – lofted Orbital Space Plane

Since CAIB -- prospects for NASA-DoD National Aerospace Initiative uncertain with restructuring of NASA launch technology priorities



Figure 19

One of the things engineers try to do is take hard lessons, learn something from them, and apply them to the future so that we can move forward. This is true of accident investigations and other inquiries into technical failures. Figures 19 and 20 are derived from the Columbia Accident Investigation Board (CAIB).

The “front of the book,” if you will, in the CAIB report, is the forensic examination of what had happened. The “back of the book” deals with the “softer” social sciences surrounding the context of the accident: why the foam problem was not addressed during the mission and the pre-conditions that lead to the accident. In doing this part of the investigation, we had the A-Team of NASA historians, folks like Roger Launius and Howard McCurdy.

I think the most of the Board, with a couple notable exceptions like Professor John Logsdon, were not long-time NASA folks. As a result, they were probably more exasperated by the institutional causes of the accident than the space enthusiasts, because they were coming across it for the first time. As a result, the CAIB's final report notes the fact that the shuttle replacement dates oscillated back and forth with many mis-starts in a developing a shuttle replacement. The Board found both the oscillations and mis-starts were directly due to "haphazard policy process" – that is a direct quote from the report – as well as a failure of national leadership. This was over eight or nine Congresses and four Presidents of both parties, which provides some context for Mr. Aldridge's observation about the need for long-term support across multiple Presidents and Congresses.

As a result of the NASA restructuring after the Columbia investigation, there is a lot of uncertainty about the National Aerospace Initiative (NAI), which some were touting a year ago as the Great Answer for shuttle replacement. That's why my chart has a question mark on one of the NAI vehicle concepts and the other two are previous attempts at X-Vehicles that were subsequently "Xed" out.

The other disturbing thing that the CAIB found was the culture issue at NASA. NASA had become, in Howard McCurdy's words, "conventional" and had moved away from bold exploration visions. The engineers and the military folks on the CAIB were appalled to see that accidents would happen and nobody would learn and the casualties would continue. The sociologist Diane Vaughan, also a consultant to the board, calls this the "normalization of deviance." They found this culture anathema. It led to their doubts about the shuttle program, but also their call for a more long-term compelling vision to move forward with. So we hope that we will have that longer-term vision.

However, on the other side of the Potomac River where I work with DoD, we have learned some other hard lessons, as have some people on this side of the river at NASA in the non-manned space program. The gentleman who investigates most of these is retired Lockheed Martin COO Tom Young. In the first of series of investigations that I call the Young Trilogy, Mr. Young looked at the program failures that NASA had in the Mars '98 missions. He then led a meta-analysis of the failures and successes with the International Space Station. This included examining how the station had become an un-executable program and how the cost had ballooned in 2001. Most recently Mr. Young led a study, commissioned by Mr. Aldridge when he was still over at the Pentagon, on why all the national security

tional security space programs and acquisition were in such trouble. One result of these analyses is – this is my term, not his – the Young Box, which illustrates the dilemma that many space program managers face (Figure 17).

**Canonical Space Program Management Factors –
The “Young Box”**

Issues defined in a trilogy of studies led by A. Thomas Young
NASA Mars Program Independent Assessment Team (2000)
NASA International Space Station Management and Cost
Evaluation Task Force (2001)
Defense Science Board Task Force on Acquisition of National
Security Space Programs (2003)

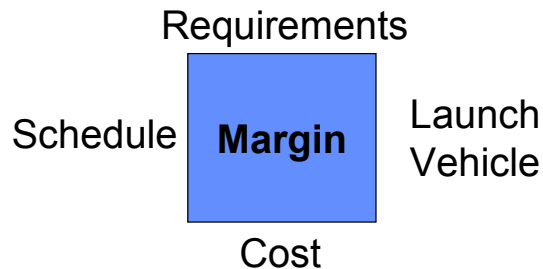


Figure 20

There are pressures on all four sides of this box, which are the requirements: what do you want this thing to do? There is the schedule: when do you want to do it? There is the cost: how much money do you have to do it with? And then there is a launch vehicle, which also translates into how big the payload is, or what is the upper limit you can have on the designated rocket. If your payload gets too heavy, the program has to move up onto another launch vehicle. That’s going to cost you a lot more money and the pressure is just going to increase on the other three sides. And in the middle, being squeezed on all sides, is this thing called “margin.” I would submit that this dilemma is faced across all government space programs. And, if we’re not careful, we are going to see this in spades as we move forward with the President’s vision.

These were all taken from Young’s Defense Science Board (DSB) report, which is available on the DSB website. This is the dilemma that we have seen, both on the national security side and in the Mars program, in the late 1990s. The recent successes with Mars Exploration Rovers Spirit

and Opportunity were the reforms that sought to restore margin to program managers.

In the programs with problems, there are some common problems defined in a trilogy of studies led by Thomas Young:

- Requirements which have very little flexibility and often “creep;”
- Unrealistic schedules due to unrealistic project plans. Sometimes there was also at the senior levels, a “kill the messenger” attitude. In these instances, senior acquisition officials replaced prudent managers who said they could not meet the schedule with folks who were considered more pliable. This happened in multiple agencies and programs across the space community.
- Little flexibility in launch vehicles;
- Insufficient understanding of cost. Young goes into this problem in great detail. Essentially it was gamesmanship in which a government agency would take a contract or price proposal and budget to that, rather than to what an independent cost estimate had said the project would cost. So the government would, in crude terms, “buy the lie” with a 100% cost overrun preordained from day one of the program.

When a more experienced or savvy program manager finds himself in this box and the sides are squeezing in on him, one thing he can do to keep his margin is to slip the schedule, and Young showed that the schedule kept slipping in the station program. The down side of that approach is that we have to keep paying money to keep people around, even if they are not working so fast, and the total project price balloons up. This is the dilemma that NASA faces on the space station program. But the parts that are done are more or less being done in a commendable fashion. That was one of Young’s conclusions.

When a program manager is not quite as experienced in this or does not want to be fired, he might say, “Yes ma’am, yes ma’am, three bags full” and take on increased risk. That results in higher probabilities of mission failure. Such a beleaguered program manager is more likely to do things like cut back on testing and evaluation downstream or cut back on systems engineering because they will use “total system performance responsibility” or some other sort of new management technique. Like any

sort of damnation, these changes often happen through many little incremental decisions; it is not done all at once. You see these practices in civil programs as well as on the national security side.

For national security in space, the U.S. cannot really say, “No, we are not going to have an early warning constellation for a couple of years.” Similarly, many advocates of civil space exploration feel America cannot have a long hiatus in human space flight, since this would lead to problems in sustaining political momentum and enthusiasm across those multiple Congresses and multiple Presidents.

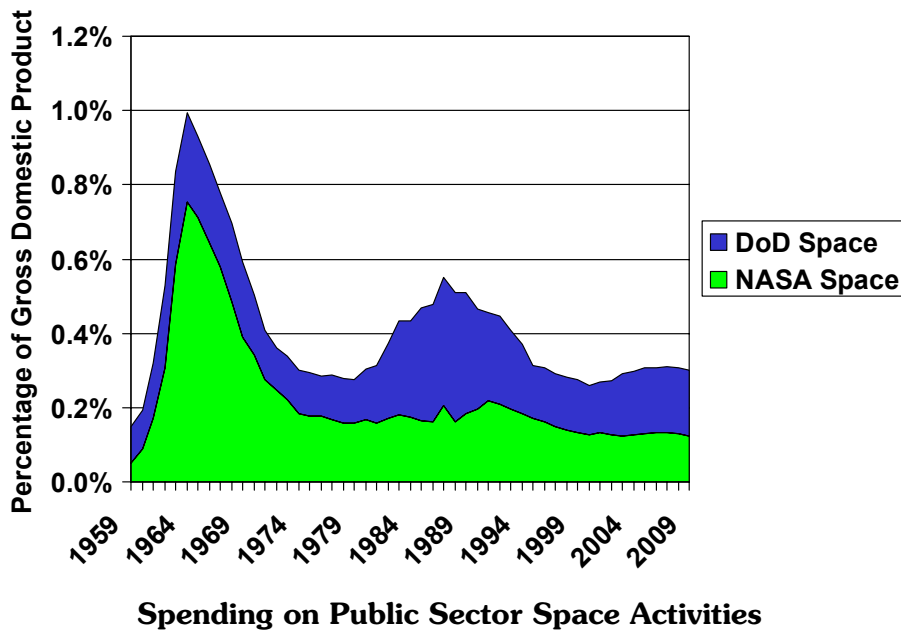


Figure 21

The last thing I will talk about is budget realities. Figure 21 shows U.S. public sector spending on space activities, measured as a percentage of the Gross Domestic Product (GDP). As you might expect, there was a big spike in the 1960s. Total spending has come way down and NASA spending (shown in green) has been low and has not gone up significantly. National security had a big buildup starting with Carter through Reagan and the George H.W. Bush administration, then came down and has really been tight. One of the reasons you see projected increases in the national security side in coming years is to make up for the problems that Tom Young noted. People were trying to do more with less and it really was unsustainable. Note that the NASA side does not go up significantly, or

even to the levels that we saw at the end of the George H.W. Bush administration.

As I said at the beginning of my remarks, the hard experience of the Columbia accident helped the larger cause of human exploration by bringing about the shuttle's retirement and providing the impetus for real reforms in NASA's human spaceflight enterprise. As Stu pointed out, rejuvenating the program, getting young folks in and getting them enthusiastic about space is part of the formula. It is great to see that Mr. Aldridge and his colleagues on the Moon-to-Mars and Beyond Commission are off to a good start. I think they are asking the right questions.

However, we still need independent cost estimates and program management systems engineering rigor up front and we should not think we can save on it later on. Last but not least, and hopefully the subject for future Marshall Institute symposiums, are some of these other issues that we touched on today, the role of the private sector, the role of the Department of Defense, and the role of our international partners in space exploration. So with that I will turn it over to Bob.

Robert Butterworth: To start with, I don't belong here. I don't have any slides and my opinions are pretty far off from what you've heard, so I warn you in advance. Down at the Shakespeare Theater at the Landsburgh they are doing *Henry IV, Part I* now and they have that great scene in there where Glenn Dower, the fellow from Wales, is puffing up his chest in front of Hotspur saying, "I can call spirits from the vasty deep!" trying to impress him. Hotspur says, "Why so can I! Why so can we all! But will they come?" My feeling is that what Lori is describing is President Bush calling those spirits from the vasty deep. The question I had from Jeff was, will they come? My answer is, no, not a chance.

I am sorry; I am really pretty negative about this. I have tried very hard to find something positive I can say and I did come up with two things. One is that there is not much money involved in this, at least not much new money. It looks to me like the amount of new money that comes into NASA within the FYDP is about less than the present value of a shuttle launch, so that is pretty good. Secondly, it is not an Apollo program, as we always hear: "We need to have a single focus in a coherent program to mobilize the resources of the agency" and all that sort of thing. But the problem with that is that it tends to starve out everything else and tends to scant science and technology development. In fact, the President's Science Advisory Council found that to be true in 1967 with the Apollo program

itself. They pointed out that a major unified program can be successful by arranging a concerted effort toward development, leading to immediate use of all technical results, but the basis for those results tends to be just the state of the art of the technology at the beginning of the program. So if you really wanted technology development and science development, you wanted a more balanced program, which is the direction that we had gone with NASA actually in recent years.

But to be more serious, is this a sustainable initiative? Is it something that will actually lead us into the future, into the good directions that, I quite agree with Stu and others, would be nice to have? And here we have a problem, because our analytic tools for judging what is going to happen tend to fail us, particularly when we deal with human space flight issues. The problems are that with human space flight, the costs are very real and they are very high. We have a lot of experience with the ways in which they can sneak up on us and demand support when other things demand our priorities. Often the benefits are quite vague and generally they are rather emotional. Human space flight programs are often attacked by both supporters, who want to do something more and more dramatic in many cases, and by opponents, who want to use robots or indeed get out of space itself. So human space flight programs tend to be particularly turbulent and prone to being knocked off course rather easily, and Dick's comments showed us ways in which that has happened in the past. In order to be sustainable, they tend to be tied to hardware programs that, they argue, have intrinsic benefits of their own, but the problem is that their intersection with so many other national concerns makes them depend exclusively and almost peculiarly on public policy and public debate.

That is about the only way that we can make decisions about human space flight, because our analytic tools don't let us do it in the same way that we do it with robotics and other kinds of programs. That kind of debate is generally held to be a good thing because it advances understanding, it helps us sharpen our perceptions, it helps us revalidate earlier priorities, and so on. Consequently, this current Moon-Mars initiative from the President should get good marks for stimulating the process. But in this case, I suspect the stimulation is likely to be faint and fleeting.

After all, we have seen it before. I do understand the differences between the SEI and the current initiative that have been pointed out this morning, but fundamentally it is the same program, at least in my view. In 1989 we had the SEI announced; in March of 1990, there was further guidance offered, which was that we needed a couple of miracles to make it

happen. Well, they didn't say miracles, they said "new approaches, innovative technologies with a potential for major cost, schedule, and performance improvements." That translated to "faster, better, cheaper" and I guess the question is, what is different now? Is there anything that gives us hope that this is going to be more sustainable today? Do we have lots more money involved? No, we have talked about that. Do we have great new breakthroughs in propulsion or launch technology? No, I don't think so. Do we have powerful new management organizations? Not in my experience at NASA headquarters, I am sorry. Do we have a stronger, more threatening international environment that is competing with us and driving us onward in the same way that we had the Cold War competition? No, I don't think so. What do we actually have? We have a few sentences that dust off a fifteen-year-old vision. But as *The Economist* wrote recently, ideas and visions are two a penny. Finding the best way to advance knowledge of the vast complexities of outer space, to boldly go where no man has gone before intellectually, rather than just physically – that is the real challenge, and that, I am afraid, we don't have with this.

So the discussion of this initiative at this time, even though I like the idea of public debate to form public policy on human space flight, should, I think, be short. I hope it dies quietly and quickly, or at least quickly. I hope I am not being too subtle about that, because not only will this dog not hunt, for many of the reasons that Dick had detailed in the second half of his presentation, but you probably don't want this dog hanging around in the yard. We don't need anything further that would feed perceptions of NASA as being a political sandbox with space programs that start and shift and stop and restart and delay, that de-scope and that disappear in response to episodic advocacy within the government. Unless we have something much more solid, the current initiative really promises to bring us turbulence, rather than new direction, to breed cynicism instead of new enthusiasm for the program, and may then threaten to discourage both recruitment and international partnering alike.

We didn't have to be here. Things could have been different by now. Fourteen years ago, the Marshall Institute study that Jeff talked about in the introduction, chaired by Fred Seitz and including Dr. Jastrow and others, reviewed the earlier President Bush's space exploration initiative and judged it, accurately, to be politically unrealistic. The study argued that the only reasonable expectations of progress were to be found in creating a mission-focused, autonomous, high-level agency outside of NASA. There were some other details, but that was the heart of the recommendation as I

saw it. That still sounds to me like a promising way to go and probably our only hope for really advancing this vision into reality.

Jeff Kueter: Well, that was quite a range of opinion. I knew Bob would wake everybody up as we began to have a lull from lunch. We have time for questions and answers.

Questions and Answers

Question: You mentioned earth sciences and aeronautics will remain stable, but according to your chart, the budget trend is going down in 2009. It's not stable, so definitely the aeronautical and other activities will be affected.

Garver: I agree. Even NASA, I think, is acknowledging it will be slightly affected. They are saying some of the reduction is because we had been in a buildup area, especially with earth sciences and aeronautics, and we are at a point when we would have been leveling off and maybe dropping down. They are arguing that it is not only going to be stable but increase over the long term, but it is absolutely a correct observation to be concerned. My point was that they said it would be stable and we really need to hold them to that, because ultimately those are big pieces of NASA which are not included in this vision. A lot has been said about whether or not NASA intends to go farther down than they have admitted so far. That's a good question.

Question: I have one more: where does NASA expect that money to come from?

Garver: It is very much reprogramming of their existing budget, tying in the things they are already doing, the James Webb space telescope, the whole origins program, the Mars exploration program are all part of that. They are now saying that is all exploration initiative focus money. Not \$165 billion of *new* money; in fact there is only \$1 billion of new money for the next five years

Question: I have a question for Lori and a follow-on for Bob, which ties in. In 1996 the President issued a space policy that actually X-ed out any mention of moon or Mars exploration. Since maybe you were in government back then, can you explain the reason behind that 1996 policy, and given that policy, is Bob recommending that to go back to that policy or exit from the space station as well?

Garver: That is a good point. I was not in government yet, I went about the time that was coming out. Unfortunately space has become somewhat political and things are a backlash from the predecessor organizations and that new policy was the Clinton administration's first response to the first Bush administration's space policy and I think an acknowledgement, as Stu pointed out, that that policy had failed. There was a very strong focus on bringing the Russians into the space station at that time and continuing the shuttle and the space station. I don't have any particular insights into the cutting out of humans back to the moon and Mars, beyond that was not their focus at that time.

It has been said that the White house at that time did not allow NASA to talk about going back to the moon or Mars, and that is absolutely not the case. If you go back and read the NASA administrator's speeches over those years, he talked about the first steps on Mars and how you looked up and there was a woman behind the astronaut's mask. Everybody has acknowledged that is ultimately where the space program will go, maybe not even the program, but where humanity eventually will go, whether it is commercial or a government-run entity. It is not something that was shut down during the Clinton Administration, even if the policy itself was not to do that at that time.

Butterworth: I don't know what to do with the human space flight part. That was the point I was trying to make about our analytic tools. Everything that I have worked with on the national security side says that robots and instruments and tele-operations and so on do a better job for us. But there is still the human space flight and I understand there are reasons for doing that that people have. The only way I know to make programs formed out of that is rather than have things be decided quietly and then sprung on people in the State of the Union, is to have fairly broad public debate and discussion to see what is in fact going to be sustainable, how much people do want to do. To do that there needs to be a serious proposition on the table, not something that says we can go ahead and do something we couldn't do fourteen years ago for a buck-ninety-five.

Buenneke: I won't press Bob on that, but I attended the hearings that the House Science Committee conducted last summer and fall. Over and over again and the members were saying, "We need a vision from the White House!"

Butterworth: Two a penny, two a penny! Look, no offense to you or anyone else, but what is this vision doing for you? You know, you and Glenn Dower go have a good time. But you need troops in the field.

Question: For the private industry's sake, any ideas how people will make any money on this initiative?

Garver: Ultimately there will be winners and losers from this initiative, if it succeeds. The truth is, I have shied away a bit from giving my predictions. I am not that optimistic either; we are just a month and a week into it and already I am seeing industry on all sides of this. I am not seeing the groundswell that I would have hoped certainly would have followed such an announcement. If it does succeed, the private sector stands to gain a great deal by this infrastructure evolving from just a couple of low-earth orbit shuttle station programs to ultimately an infrastructure that takes us back to the moon. I believe, as Stu really pointed out, that this encompasses all types of activities in cis-lunar space and that would be the real excitement. Plus it will involve many, many more people than just this government-only program does right now.

Nozette: I'll make a short comment. I have been thrashing around, trying to answer that question. That's one of the aspects of a government activity. We are saying that we will not have an immediate profit issue, but over the next fifteen to thirty years, if we did this the right way, we can. I disagree with what I heard earlier, I think this can be bootstrapped within a reasonable projection of what NASA and the DoD are going to spend in space. The real hard part of the problem, as alluded to, is that you're going to have to make some choices. But if you take the amount of bandwidth that went through GEO in 1972 and look where it is today, you say, well, people aren't going to give up their orbital slots, there is still going to be a GEO market. You say, okay thirty years from now, that's ten times the bandwidth. So if you look at the value of that now, even if we have all kinds of competition with fiber optics and all that, we are still talking about big numbers, in terms of revenue.

I had an interesting discussion with somebody at NASA about this about a year ago. I said ultimately you couldn't have wealth creation without extractive industry. If you get to some place like the moon that has stuff to extract, by definition you are going to start to generate new wealth and new opportunity and I think the kind of companies that can get involved with that are not necessarily the traditional government contractors; they may have lines of business in real commercials. There is direct payoff

and then there's probably technical spin-off which, okay, you're really going to generate some new wealth. That is really the perception that I have seen and I really didn't see that in the whole Mars push and that was why I thought the lunar question was more germane to that. Even if we could improve the performance of the telecommunications industry and put the U.S. back in front, there are only so many orbital slots and everybody has to cram more bandwidth through them, you're going to find some benefits, one would think. I don't think that connection has been articulated as well, but that is why I call it the pay zone in my picture.

Kueter: Stu, do you want to elaborate a little more on the bootstrapping element of it? Your point on bootstrapping seems to challenge some of things that Bob said.

Nozette: It's really just the perception. You say, Okay, I have so much money for space. I have got a \$15 billion a year NASA budget that is going up, the shuttle is going down, the station is going down. There is a wedge, so how do I most efficiently use that wedge to get a foothold with the technology -- and I disagree, there are some interesting breakthrough technologies. It's not a revolutionary technology; as I said, it is something the Romans probably could have done, it's just in a very alien environment that leads to a geometric increase in the amount of mass and the amount of things that can be done. It opens up possibilities that weren't there and that was what we alluded to when we wrote those policy statements back in 1990.

I think people like Zubrin ran with that and said, Okay, well, we really could do this differently. It's not the traditional aerospace state of practice; it's going to have to be invented, it's going to have to be developed. But we are not talking about big dollars. If you make the right priorities, it can be done. As I said, you launch the equivalent of enough to start this right now; we can buy it from Sea Launch or from Ariane. It's getting the right technology to be able to multiply that geometrically. That's really the real question. You also have to take the longer-term view of this; the first people who came here and started cutting trees, it took a while to get independence. But it's a different mindset than what we have traditionally seen and that's the challenge for the management. I think you can apply the technology the right way. That was really the argument that led to creating Clementine. We had the argument we could shrink the weight of something that could do more work so we could put it on a smaller launch vehicle, so therefore we could do something that we couldn't have done before. It's the same with any new technology.

Question: What has been presented as a space exploration program really is a human space exploration program. I wonder if it couldn't be looked at as follows: you start with space exploration, you define a number of scientific objectives of what it is you want to accomplish, it could be seeking any remnants of life on Mars, etc. and then consider that there are different methods of going about it. Some of the methods might require human involvement and others can be done by robotics. And especially when you have a long timeline, this is unlike Apollo program which was all done in the space of ten years, where you have a long timeline involving decades, the methods are going to have to change. Robotics will be cheaper, easier, more efficient and I would think in time perhaps humans may be less important or maybe more costly when you consider what would happen if there is an accident and so forth. So what I would like to ask the proponents is why not step back from the human aspect of the program and consider that as an option to be utilized as needed in order to achieve certain objectives.

Nozette: Can I comment on that? I think that's a very good point. And I think that we have an institutional challenge with this. I fully agree. That's another thing that is very interesting that the lunar situation, there's a lot of it can be operated from the ground, a lot of it can be done robotically. In the military it's a very common situation where you can have the robotic or other type of systems very commensurate and working together with the troops. NASA is bifurcated into two different cultures, so what has to happen is the keys to the robotic kingdom effectively have to be handed over to those that want to use that. It is not what National Academy says we ought to do for robotic systems, it's what supports or interfaces with the human. And there are going to be many places, and this is again why I think it can be done very affordably, many of these things can be done with unmanned or robotic systems and the humans go when and where they need to go. But they are working together. So in a sense, the human program put requirements on the unmanned program and that's going to be a different cultural mindset. But that's going to be a very big challenge in the management sense to do this. The other thing that NASA hasn't done, and you know it's not their fault; it's that they had this one big vehicle. When you have a program like this, you have the opportunity for different classes of things and the spiral – I wouldn't want to use that word – but the qualification of those systems for humans can be done reliably, so we have much less risk and that's really the way we would do it in any rational development plan. Now can we screw it up? Absolutely. It is a challenge, I agree.

Garver: I would argue that that was in fact the previous policy. If you look especially at the Office of Space Science, you had some fundamental questions that they were trying to answer, like life in the universe. We have discovered that in fact you really don't need humans for a very, very long time if your absolute objective is scientific. I believe that people want to go into space *not* to answer those scientific questions. Bush has said it is written into the code of our DNA. There are wonderful quotes about why we must explore, as people. This is going to be a very difficult question for NASA because you have the whole scientific entities and all of their peer-reviewed research focused on answering those questions, and now they are saying the robotic. It's a 180° turn. It's now going to be focused on how you get humans there. That is going to be a tough one to sort out.

Nozette: We went through that sort of, in the first Bush 41. That's why we got the name Clementine, it was a very deliberate one and we wanted a very practical mining allusion; our goal was to answer those questions.

Question: I hope NASA doesn't make the mistake it made with the shuttle. Back in my earlier life, I was in NASA and I was the project scientist in the polar orbiting weather satellites. We were forced to develop the polar orbiting satellite, which would be dual compatible so that once the shuttle came on board, NOAA would have to use it in order to put satellites up. It made no sense for two reasons: one, it increased the cost to NOAA and they objected vehemently, and the other is, why use a human to put up a satellite that you can do much more easily without. I can understand the point if you say there is a desire perhaps beyond science to want to put a man there, but don't force it to then do the things that it really can't do as well as robotics can do

Nozette: There are other problems. You're going to have to solve radiation. If we are going to put humans on the moon, they are going to have to make a living to operate there. It's really about wealth creation, about strategic value, and the science that supports that or comes along. That's a different cultural approach than what we currently have. It's the reorientation towards that, you can leverage the entire robotics industry today, I think you can leverage a lot of capability that shows you can do this affordably, I think it's a challenge to the creativity of the people to do it.

Bueneke: The other thing I will point out about this Aldridge commission is that Mr. Aldridge is the only "astronaut" on it. He didn't actually fly in space, but he was in an astronaut-training program for a mission that was canceled after the Challenger accident. . But Mr. Aldridge was also the

person who basically got the ELV line started up again and reversed the previous – and in retrospect, highly mistaken -- policy of placing all U.S. payloads on the shuttle. But if you look at the rest of the commission, it includes four scientists, a retired four-star general who is an engineer, a couple folks who are more politically oriented, and the Chairman of Hewlett-Packard. You do not have anybody named “Neil” or “Buzz” on the panel. You can judge that how you wish, but you don’t have any astronauts on the Commission. I think that’s sending a message.

Question: For Bob, with the reality check, or your particular reality: as Lori said, many organizations and individuals have been looking for this vision. You said the dog won’t hunt and you may not even want the dog in your yard. Are you saying that if the things on the list you provided were met, a different kind of organization, a new technology, then that is the time? Because it would beg the question, if not now, when? You’re apparently saying the time isn’t right now.

Butterworth: I didn’t mean to say that the time wasn’t right; I just meant that this particular initiative wasn’t worth very much. 1990 would have been right if people had implemented what the Marshall guys had proposed at that time, because that provided some real substance and sustainability to a program. Maybe I am just perverted because I started my government career in program analysis and evaluation in the Pentagon and our rule there was “policy without funds is just poetry.” We don’t have a serious program here.

Question: I would like to make a comment as one of two authors who spent the last nine months sitting in the back of the room as this policy was formulated. I am not speaking for the Bush administration either, but I must tell you having watched – and like sausage, sometimes you don’t want to watch things being made – having watched these guys struggle with this, I think they would be appalled to hear Bob and this discussion. Let me tell you why.

I have no clue as to whether this will be successfully implemented and I agree with Lori’s concerns about all the issues and politics. But from what we saw, every single issue was vetted and debated and I will use the term (and we will use it in the book) agonized over, and here they can’t win! What did we hear fifteen years ago? Give us a hundred billion dollars and we’ll go to Mars. And the people said, oh, you’re never going to get a hundred billion dollars. So what did these guys do? They invent a program that’s a little bit of new money and a lot of old money and now people

don't believe that! Then they say, "You're flying the space shuttle and you can't afford to do anything." So what did they do? And this was the hardest thing that they did – they are giving up the space shuttle. Then critics say, "You've got the space station, it's going to cost you billions." They are giving up the space station. They are reinventing NASA. You're Sean O'Keefe, on the first day on your job, you have a four billion dollar cost overrun facing you. You have a bifurcated Congress, you have a nation which, I hate to remind this audience, is at war. We are at war and at any time we can get ourselves blown to kingdom come. We are at two wars. We now occupy another country, whose government we have to create. Now I don't think it's unreasonable to say, give these guys a little slack! Because what they have done in the unlikely environment with a President of the United States who said to me, and we interviewed the President for this book, that he was interested in space. You know what made him interested in space? February 1, 2003. Seven people paid for this with their lives. So I would hope we would at least be receptive.

Let's see what Bob is saying: Not enough money. Too many cultural problems. It's not a real program. I can tell you that I saw every conceivable thing from the space elevator to a replacement of the shuttle talked about, and the President said – and these were his words – "You have to redo your reputation but you cannot break the bank to do it." War. Deficits. Political divisions like you've never seen before. This is a President who stepped before the country and was not going to roll this out at the State of the Union and was not going to roll this out at Kitty Hawk, because he wanted this to get its own focus. Now he can't win, because people say, "he didn't announce it at Kitty Hawk, so he's not serious. He didn't say it at the State of the Union; he talked about steroid use." No matter what this guy does, he can't win! So what did they do? In the environment in which we live, they came up with a plan. And ladies and gentlemen, let me tell you something: the train has left the station. If this industry and this community cannot support this initiative, you know what will happen. It will fail and we will never get another one again. You had better – Bob, you want to get out of the manned space business, that is exactly what will happen. So this is a democracy and you do have a choice. Do you want to play or not? Because we don't have to do this. We don't have to be using thirty-year-old spacecraft which people risk their lives to fly every time they go up. But if we are going to sit here and whine and complain, "Oh, we ought to have this, we ought to have that," you know what is going to happen at the end of the day? Nothing. And that's what is going to happen. These guys struggled with these issues, they tried to walk down the middle of a minefield, and they came up with a policy which has

problems, rollout wasn't good, you have political issues, Lori's absolutely right. This is it. You are not going to redo this. The commission is not about redoing the plan; it's about how you make the plan work. If we don't support this initiative, you can tinker around the margins, there are elements – I have sat in a meeting in which the argument was about getting rid of human space flight, just having robotics and the President didn't want that. So they are trying to fuse robotics and humans together, which has never been done before. So what is the criticism going to be, you ought to have more humans and less robotics, more robotics and less humans. This initiative is the future of the country's space program and the people of the country ought to decide this year, in this environment whether or not it is important to them or not.

Kueter: Just a couple of points that I'd like to make so this event isn't mischaracterized, the purpose of it was not to throw stones at what the President said. I think if you read the press release that Bob Jastrow and I wrote on the fifteenth of January, we strongly support what the President is calling for. The purpose of this meeting today is to begin to discuss how you accomplish such a task, and confronting some of the issues, such as those Bob raised. These are things that the implementers of this policy will have to grapple with as they move forward. I don't really characterize what you hear today as "whining," but rather an open discussion of the problems and challenges that we face as we go ahead.

Buenneke: I'd like to make a comment on that. I don't know if I elucidated this well enough in my presentation, but DoD had a pretty bad pile of lemons in 1986 and after several strings of ELV failures in the 1990s. But it figured out a way to make lemonade, to make an advance. That's what is going to happen here. It took a lot of creativity and a lot of hard work, but we found enough money to move and say, what are the absolutely critical things we have to do next? And DoD was able to do it. It's the same case here. I think this is actually better than that. It's going to take a quite a bit of work; there is enough resources to make a step, to make two steps, to make three steps on this and it may open up things we didn't know.

When the first President Bush announced his Space Exploration Initiative in 1989, we didn't know what we do now about the moon. If we had known it, we would have had a different approach. This is going to be a slog, I agree, but you have to take the steps and whatever resources we can get. We have to be very creative. We have to leverage U.S. solutions with international contributions. We have to involve the commercial sector.. You're right, if you don't advance it now, you're not going to go there, be-

cause political entropy is going to overtake the shuttle and the station. They are going to be gone, one way or another.

Butterworth: Once you're in Baghdad, do you have a plan?

Nozette: There's learning along the way. There's a lot of history on things like that, in the Reconstruction of the South and in the Occupation of Japan. I think we have to look at that and say, we were able to make progress. And I think we can make more progress now because actually it is a much better environment. The administrator is much more cognizant that he has to solve these problems, but it is going to take some people with fairly thick skin to figure out some creative ways to go about it. Because the alternative is, as you say, it's bad, it is turning away. And I disagree, I think you do have an international flavor; over the next fifteen or thirty years, the Chinese, the Indians, others will be doing this. And they will be doing it from a large labor pool, so what will you do when they can take out all our GEO satellites in a way we can't see? Oops! What are you going to do when they are on the moon, doing this stuff? And they are looking at it as a strategic objective, you know it's probably a fifteen or thirty year strategic objective. So we have the opportunity here, I think the way it came out from the current administration was exactly the right way; they could have gone many different ways. I think there's a huge challenge in implementation and it's going to be a lot about the people that are going to be doing it.

Question: I just have a question on the international aspect of this policy. I haven't heard a lot about how the direction of international space programs from other countries are affecting this plan. I'd like to see if any of the other panelists have any ideas whether or not they were consulted and, seeing that this is an international endeavor for the benefit of humankind, how much the direction the other countries are moving in has affected the future of this program

Garver: My view is that the administration really did this on their own, as is appropriate. It is a U.S.-led program and they contacted the heads of agencies of the other countries literally hours before the announcement. What is telling to me is that I've been told that the response was overwhelmingly positive from everyone they called. They recognized that they didn't need to have been part of the discussion, they recognized that this was U.S. led, they want to participate at the right time, and they look forward to it. Given our history on international space station, that is extremely welcome news. I was thrilled because we had many challenges

when I was at NASA and we brought in the Russians on the space station with the international partners. Space is global and the fact that the NASA leadership has, by and large, stepped up to what we need to do, as truthfully have the Russians and others over the years, has helped us all. There is just nothing but goodwill from what I can see from the international space agencies on this program.

Buenneke: I will also be realistic, though; the European Commission just put out their first considered response in a communiqué that said, “Yes, this is a great thing and we are looking forward to participating. But we are still going to build Galileo [satellite navigation system], we are still going to do GMES [Global Monitoring for Environment and Security]. We are also looking at expanding other security-related activities in space.” So national and continental interests remain in this process. The civil space program has always been where international cooperation happens, but I think we will see those other interests, as Stu noted, with the Chinese and other countries.

Butterworth: I think it’s on a case-by-case basis, I think there is a lot of potential with India, with the U.K. and with Canada.

Buenneke: Well, hopefully, Canada is also part of NORAD; I’d like them to look up there at GEO and see that stuff sneaking up on us too.

Nozette: They have a big mining industry in Canada. They do remote robotic mining and so they have many possibilities. Some of the birthing space powers have some very interesting capabilities, as do our Russian colleagues, and I think it has to be done. Remember, we did international stuff with SEI; we did stuff with the Russians, we did stuff with the French, so it should be doable.

Question: It seems to me all of these reasons for the initiative are rational, but it seems to me that selling it to the American people as a logical, rational thing inherently seems shortsighted. My only criticism or question is why this program hasn’t been communicated or sold more effectively to the public on what the essential reason for it is: it is an irrational impulse to explore. I think you can knock this down a bump here to logical, rational reasons but the romance of space isn’t being communicated. Tom Hanks found out with Apollo 13 there is an audience for the romance of space. The only question I have, is, is this being done for purely logical, rational reasons or is something deeper underlying this?

Garver: Specifically on the communications aspects, we probably have some of the same criticisms. NASA has long claimed that they cannot be their own proponents to the public and they cannot advertise. I have argued the Army does advertise through its recruiting end; certainly there is some room for that. But there is an effort: NASA and some of the space associations and companies are getting together to try to do this. It should have been done already. It's one of my criticisms, and probably Frank's, too, but I think you will see it and you're absolutely right, we need to take this to the public. The Aldridge Committee town hall meetings are good for that. As many people have said, this is the public's space program, and absolutely, it's where Bob is coming from, he would agree, we need to do our best for them.

Kueter: My only comment on that would be that bits of the answer to that question seem to have come out in the course of this conversation. It is only a month and a week since the announcement and it is quite clear that there's a lot more to come as this initiative begins to be fleshed out and certainly the hearings this summer in the Congress and the deliberations there will keep this issue on the front burner. I want to thank you all for coming.

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