TESTIMONY OF

ALAN BINDER, PHD

LUNAR RESEARCH INSTITUTE DIRECTOR,
LUNAR EXPLORATION INC. CEO &
LUNAR PROSPECTOR PRINCIPAL INVESTIGATOR

UNITED STATES HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE

HEARING

NASA'S MARS PROGRAM AFTER THE YOUNG REPORT: PART II

JUNE 20, 2000

Mr. Chairman and Members of the Committee, I am pleased to have the opportunity to appear before you today to discuss the ramifications of the recent Mars Mission failures and the contrasting successes in the Discovery Program on the Faster, Better, Cheaper approach to space exploration missions. As the Principal Investigator of the highly successful Lunar Prospector Mission, the 3rd mission in the Faster, Better, Cheaper Discovery Program and the 1st to be peer reviewed and competitively selected, I am both deeply concerned about - and strongly disagree with - the main conclusions presented in both the *YOUNG REPORT* and Tony Spear's *NASA FASTER, BETTER, CHEAPER TASK FORCE FINAL REPORT*. In contrast to the recommendations in these reports that call for more money, more NASA oversight, and more management to "insure" that failures do not occur, I decisively demonstrated with Lunar Prospector that inexpensive missions can be successfully defined, developed, and flown with an absolute minimum of both management and NASA oversight if they are managed by an experienced and fulltime Principal Investigator who is supported by a small staff of experienced and competent scientists and engineers. If the Young and Spear recommendations are followed, I firmly believe that we will have started down the slippery path back to the old, expensive, slow way of exploring space. If the Lunar Prospector model is followed and if we return to the Faster, Better, Cheaper concept as originally defined by Mr. Goldin at the beginning of the Discovery Program, I believe that we will achieve both a high rate of success, and a maximum return on investment in the exploration of the Moon and planets.

Before I discuss my experience with Lunar Prospector and the recommendations I have for conducting Faster, Better, Cheaper missions, I would like make the following general comments:

1) Having more money, more management, and more NASA oversight does not insure mission success as witnessed by the failure of the $800 million Mars Observer, the incorrectly finished mirror on the $3 billion Hubble Telescope, the stuck antenna on the $1.3 billion Galileo spacecraft, and other failed or compromised missions of the past.
2) The failures of the Faster, Better, Cheaper Mars Climate Observer and the Mars Polar Lander, as well as the WIRE and Lewis Faster, Better, Cheaper missions, were not caused by hardware problems; they were caused by poor management (as witnessed by the failure to only use the Metric System in the case of the Mars Climate Observer and to properly test in the case of the Mars Polar Lander). After some 40 years of experience, the components used to build spacecraft are highly reliable and will perform as expected if the definition, design, construction, and testing of the missions and spacecraft are properly and competently managed.
3) In contrast to the failures of the Faster, Better, Cheaper Mars Missions and the WIRE and Lewis missions, the four Discovery Program Missions thus far completed (Pathfinder and Lunar Prospector) or well underway (NEAR and

Stardust) have been highly successful. Thus any recommendations derived from an investigation of the Mars failures should be considered in light of the contrasting successes in the Discovery Program, as I will do using Lunar Prospector as the example shortly.

4) Regarding the Discovery Program: As originally conceived and defined by Mr. Goldin, the missions of the Faster, Better, Cheaper Discovery Program were to cost, on average, 30% to 50% of the $250 million cap, they were to have limited science objectives, and they were to be lead by their Principal Investigators who were to be "solely responsible to NASA for the success" of their missions. With the exception of Lunar Prospector, and despite Mr. Goldin's directives, the costs of all seven of the other full Discovery Missions selected by NASA's Code S are at or near the cost cap, the mission objectives have become more complex and the role of the Principal Investigator has been increasingly limited - while that of the NASA Program Manager has increased. Thus even in the Discovery Program, there is a creeping and disturbing tendency of returning to "business as usual".

In contrast to the recommendations of the Young and Spear reports, and in light of the above four points, I would like to use my experience as the Principal Investigator of the Lunar Prospector mission to substantiate how I believe Faster, Better, Cheaper Missions can be successfully managed and conducted.

First it is important to note that Lunar Prospector was developed as a private effort, completely outside of the NASA hierarchy and hence completely unencumbered by it. Six year before I proposed Lunar Prospector as a Discovery Program Mission, my colleagues and I in Houston, TX, together with the Space Studies Institute in Princeton, NJ and several Chapters of the National Space Society, developed Lunar Prospector as a private effort to demonstrate that small, inexpensive spacecraft with limited payloads could make major contributions to the exploration of the Moon and planets. When the first Discovery AO was released in the late summer of 1994, the Lunar Prospector payload, spacecraft and mission were well defined and validated at the Phase B level, its cost (including launch) was just $63 million and its Phase C/D development time was just 22 months. As such, Lunar Prospector was the ideal mission to prove the Faster, Better, Cheaper concept and was selected by the evaluation team to proceed directly to flight (the only Discovery mission to do so). While the NASA Code S goal for Lunar Prospector was primarily to obtain lunar data, my primary goal was to prove that Faster, Better, Cheaper worked. With this in mind, I would like to make the following points:

1) As was intended in the original definition of the management of a Discovery Mission, as the Principal Investigator, I was contractually and directly in charge of the program (not a NASA or a Lockheed manager) and directly responsible to NASA for its success. I was not only the Principal Investigator, but also the Mission Director and so I was responsible for - and actively participated in - all

aspects of every phase (definition, design, construction, test and flight) of the mission.

2) The management structure of the program was two-tiered: The Lockheed Martin Project Manager and I directly managed our engineering and support staff of some 35 people and worked intimately with them on every aspects of the spacecraft on a daily basis. There was one responsible engineer for each subsystem of the spacecraft. Every staff member knew exactly what his or her task was and who was in charge. Simultaneously, I frequently interfaced with my Co-Investigators, who were developing the science instruments at their home institutions, to insure that all science instrument issues were properly addressed. Finally, the NASA/Ames Research Center provided the required limited NASA oversight and acted as my contact with NASA Headquarters.
3) Program reviews were contractually limited. On the Spacecraft side, we had just four semiformal reviews – a Technical Design Review before we started construction (Phase C/D), a Test Readiness Review, a Pre-Ship Review prior to shipping the spacecraft to Cape Canaveral, and a Launch Site Readiness Review prior to launch. In addition, after the Lewis failure, NASA imposed a two-day review of the Lunar Prospector spacecraft on the project. Finally we had a Mission Operations Readiness Review before launch.
4) As was consistent with the original directive that the average total cost of Discovery Missions should only be 30% to 50% of the cost cap, Lunar Prospector's total cost was just $63 million (not including an extra $2 million for the 7 month extended mission) or 25% of the cap, and the mission was developed and flown within its original budget. The budget breakdown is: Spacecraft - $20 million, 5 Science Instruments - $4 million, Launch Vehicle - $29 million, 12 months of Nominal Mission Operations - $6 million, and Lockheed Martin Fees – $4 million
5) The Phase C/D construction of Lunar Prospector was completed on schedule in 22 months, well below the 3-year cap imposed by the Discovery Program.
6) Lunar Prospector was a simple, single-string spacecraft with no on-board computer (I controlled Lunar Prospector from the ground, sending one command at a time), constructed from reliable, flight-proven hardware. Similarly, the science instruments were all based of flight proven hardware and concepts.
7) Testing was extensive – I "flew only what was tested and tested everything that flew". Also my Operations Team and I helped conduct the testing, thereby gaining operational experience with the spacecraft before it was ever launched.
8) My small Operations Team and I also trained extensively before launch on a computer model of the spacecraft, during which we validated all of the operational and emergency procedures.
9) I flew an essentially flawless 12-month nominal mission (a 100+/-20 km altitude polar orbit) and a 7–month extended mission (a 30+/-15 km altitude polar orbit) without any failures or mishaps.

10) Finally, the global mapping data sets obtained greatly exceed those we originally proposed to NASA by a factor of a least 3 in resolution and at least a factor of 3 in quality.

In summary, the Lunar Prospector mission was the least expensive NASA lunar or planetary mission ever flown, one of the most reliable and productive, and certainly the most cost effective. Given its scientific and programmatic successes, I believe that Lunar Prospector fully validated the Faster, Better, Cheaper concept and should serve as a model for all Faster, Better, Cheaper Missions.

Given my success with Lunar Prospector, I disagree with the major recommendations of the Young and Spear Reports. Rather than spending more money and time on the missions and having more management and more reviews, the Lunar Prospector experience has shown that inexpensive missions will have a very high probability of success if the following recommendations are followed:

1) The mission should be defined and managed by a full-time, experienced Principal Investigator with the full authority and responsibility to conduct all phases of the mission. He or she must be fully responsible for its success.
2) The mission objectives, payload, spacecraft and mission profile must be kept as simple as possible. They, as well as the budget, must be validated and frozen before Phase C/D. NASA must not be allowed to impose new requirements or change the requirements on the program once Phase C/D has started.
2) The staff must have a sufficient number of experienced, senior engineers to insure that the lessons learned from the past are not ignored or forgotten.
3) A two-tiered management structure must be used so the Principal Investigator and his (small) management staff can work intimately with the engineering and science staff during all phases of the program.
4) Reviews must be limited in scope and number to avoid wasting program time and money. In general, since reviewers cannot delve deeply enough into the fine technical details of the hardware or mission to discover any fatal flaws the system may contain, missions fail despite having frequent and numerous reviews. It is better to have a full-time, independent, experienced, quality control engineer working on the project than to have numerous reviews. Major reviews at critical junctions in the mission development (like those listed in point 3 in the previous section) do serve a useful function if the review team is the same for all reviews so the review team is familiar with all aspects of the program.
5) The flight hardware, software and instruments must be developed using flight proven items and concepts – inexpensive missions can not be used to develop new types of hardware or software.
6) Finally, in order to insure absolute continuity and "no loss of information" during the entire project: The team that defines the mission must define the hardware; the team that defines the hardware must build the hardware; the team that builds the hardware must test the hardware; and the team that tests the hardware must fly the hardware.