SPACE STUDIES BULLETIN
VOLUME 14, ISSUE 3 July-September 2003

This is my first column as the Chair of the Space Studies Board, and I approach it with some trepidation. My immediate predecessor, John McElroy, turned these columns into an art form, in which, based on his vast experience, he exhibited profound thought and imparted great wisdom. I do not expect to rise to this standard, but hopefully I will be able to comment on the issues that concern me and that will guide the actions of the Board.

Those of us who have long been involved with America's civilian space program are truly troubled these days by its uncertain direction and focus. One can argue that the space and Earth science programs of NASA are, as they always have been, awash in opportunities. The Sun and its influence on Earth, Earth itself, the solar system, and the universe beyond are truly fascinating places, and the technology exists, and is being further developed, to explore and understand their behavior and evolution. The science programs of NASA support a broad array of exciting missions and research efforts, but there is always more to do than resources permit.

The situation with the human side of space exploration is different. We have no destination other than low-Earth orbit, and now with the Shuttle fleet grounded, that is temporarily inaccessible via American launch vehicles. The International Space Station is of limited capability and has an ill-defined mission. Is it to prepare humans for future exploration, and if so, to where? Is it to solve some fundamental science problem, and if so, what and is this the most cost effective way to do so?

The space science programs of NASA are well funded relative to many science disciplines. This has always made sense when space science is undertaken as part of a vibrant, broader, civilian space program. But if that broader space program is not well defined, and supported, how vulnerable does space science become?

NASA has suffered a major failure with the loss of Columbia. There are two possible responses: If there is a major national goal to be achieved with human space flight, deviation from pursuit of the goal is not an option. Problems will be solved and progress will resume. Or will it be that failures will be avoided simply by taking no risk and that paralysis will result? And will that paralysis extend to the robotic program as well?

NASA's infrastructure has remained basically unchanged, and in some cases inadequately maintained, since the days of Apollo. The university community that has participated in and supported the space program for decades is in many ways a shadow of its former self. The human capital on which the space program depends is aging. If the nation were to find a reason to embark on a great new space adventure could we even accomplish it, or would a new team have to be assembled and trained, as in the beginning days of the space program?

There is a clear need for a national debate on America's future in space: Why are we doing it; what are our goals? If we cannot articulate our goals, and achieve consensus that they are in the nation's interest to pursue, how can decisions be made on funding for NASA, or on NASA's priorities? Is NASA's mission simply to exist as a legacy of times when space was important? Or is there an important role for NASA in the world of today?

There is also a clear need for a national debate on the investment the nation is prepared to make in space and whether this investment is consistent with the agreed-upon goals. Often forgotten is the fact that President Kennedy's 1961 speech that contained the clarion call to place a man on the moon and return him safely to Earth before the decade was out, included a detailed discussion of the funds and the commitment necessary for success.

We started such a national debate after the Challenger accident in 1986 and for a while recommitted ourselves to a vigorous space program. The NASA budget grew substantially within a few years after Challenger, and all programs, including science and human exploration, benefited. In 1990 the Augustine Report of the Advisory Committee on the Future of the U.S. Space Program charted a vigorous space program to be funded by a 10% annual growth in the NASA budget. But then the economy soured and the Administration changed. The 1990s were a period of no growth in NASA funding. A series of arguable economies were then undertaken to preserve the appearance of a vigorous program within an inadequate budget. The result was cost overruns, mission failures, and weakened morale among the NASA workforce.

It is my sincere hope that the Space Studies Board can help foster and participate in a national debate on the future of the U.S. civilian space program. To that end we will continue the Board's examination of

national space policy at our November meeting in California. We will consult with other knowledgeable individuals and hope that they, along with the Board, will articulate what should be the principal purposes, goals, and priorities of the U.S. civilian space program. We will then transmit these ideas to a broader audience, with the hope that NASA, the Administration, the Congress, and the American public, can collectively reach agreement on the civilian space program this nation wants and deserves, and is prepared to support.

It is also my hope that the Board, through its committees and studies, will focus on the major issues before us. This is not a time for minor issues. There is a need to help chart the overall strategies of certain science disciplines and to offer sound advice on approaches that NASA is pursuing to ensure a vibrant space science and applications program. We hope to be able to undertaken several major, new studies along such lines within the next few months.

The coming years of my tenure as Chair of the Space Studies Board will be exciting, and I trust what we accomplish will prove helpful to preserve and enhance the greatest of all adventures, the use of our minds and our nation's wealth to extend the bounds of human knowledge into the vastness of space.

SPACE STUDIES BULLETIN
VOLUME 14, ISSUE 4 October-December 2003

As we enter the New Year, it is a time for reflection on what has past and anticipation of what is to come. This is certainly the case for the nation's space program. Last year witnessed the tragic loss of Columbia and its crew, and as would be expected, that forced us to face the reality that our human space flight program has no clearly defined goals, for which we can ask our astronauts, some of best of this and other nations, to risk their lives. The Administration is widely reported to be analyzing and debating what the goals for human space flight should be and what they are prepared to invest in. At the time of the writing of this column, these goals have not yet been revealed, but it is with anticipation that I sincerely hope that they will be deliberate but far-reaching, worthy of a great nation that recognizes the evitable march of this civilization into space.

The Space Studies Board has been determined to participate in the national debate on the future of the space program and to help represent the science community in these discussions. To that end, we, with the support of the Aeronautics and Space Engineering Board, held a Workshop on National Space Policy in conjunction with our November meeting. We invited distinguished representatives of the broader science community and of industry, former military and government officials, historians, and behavioral scientists. We had some of the most stimulating discussions in which I have ever participated. The collective wisdom and experience led to profound and well-articulated thought.

The report of the workshop will be available shortly, and it captures the important points made and the discussions that led up to them. I will not preempt the report here, other than to share my own personal impressions of what proved to be remarkable resonance on what we should be doing in space.

There was general agreement that space science, defined in the broad sense of both Earth and space science, was in good shape. The universe is a most interesting place, and we currently have the technology to observe and study it in detail, as well as to investigate our Earth from space and to explore robotically the far-reaches of our solar system. The only issue is resources. There are more exciting and important things to do than resources permit.

The more problematic issue is the human spaceflight program, which lacks focus and direction; it lacks a destination. The purpose of human spaceflight should be to explore, and you cannot do that by endlessly circling the Earth. It is time to go somewhere. The workshop participants did not deal with whether it should be the moon or Mars or somewhere else, but only that we begin to extend the human presence out of low-Earth orbit, to explore space and use the opportunities it affords us.

During the Cold War the civilian space program was a demonstration of U.S. technological prowess. Such demonstrations are no longer needed, since many others are available. However, the civilian space program can be a demonstration of U.S. good will in which we use our technological prowess to explore space on behalf of humankind. It would be better still if we use our prowess in space together with other nations, since exploring space on behalf of humankind can be perceived as yet another form of U.S. arrogance.

The workshop participants were political realists, who could not advocate an Apollo-type dash to somewhere, with its requirement of vastly increasing funding; the nation's resources are not available for that. The participants did lament that the NASA budget was allowed to decline in a time when federal budget surpluses were available, and growth should have been possible. But reality must be accepted, and what should be possible is a long-term goal, which requires only a modest increase in space funding, but most importantly, sustained funding. It can be difficult to maintain interest and support for a long-term goal, and so it is essential that there are a regular series of near-term milestones and successes. After all, the National Institutes of Health have a long-term goal of curing disease and enjoy great support for their many near-term successes.

Having set the goal for human spaceflight, it will then be possible to deal with the Shuttle and the Space Station. The Shuttle is a dead-end program; the Station has no clearly defined mission. With a goal, it should be possible to define an exit strategy for the Shuttle, a context for its replacement, and a mission for Space Station. Indeed, all decisions about NASA's assets, whether it is the Field Centers, the launch capabilities, the workforce, etc., become simpler if there is a defined goal to achieve. But it is important that the goal determines the needed assets, not that the available assets define the goal.

Perhaps most important for me from the workshop was the widespread sentiment that exploration is a form of science. If NASA would pursue its human spaceflight program as exploration, optimizing the use of humans and robots, whether it is robot-assisted humans or human-assisted robots, then the science

community, at least as represented by the workshop, would be enthusiastic participants. Many of us are veterans of the wars between the human and robotic sides of the space program. The former was perceived as stealing from the latter; the latter was perceived as not being supportive of the former. In the workshop there was optimism that a human spaceflight program pursuing exploration and therefore legitimate science, properly conducted, would bring a constructive harmony to the space community.

The report of the workshop will be available shortly, and we will circulate it widely. Perhaps the Administration has already drawn the same conclusions as we did, which will be embodied in a new space policy. If not, I hope they will listen to the wisdom of our participants. It is a pivotal time in the space program. We have the unique opportunity to recognize our lack of direction and to define a promising future. Space has always been a Presidential matter. I sincerely hope that President Bush is prepared to set a new national space policy, which Congress can endorse and support, and around which the entire space community can dedicate their careers to pursuing on behalf of the nation and the world.

SPACE STUDIES BULLETIN
VOLUME 15, ISSUE 1 January-March 2004

At the time of writing the last column for the Quarterly Newsletter, we were waiting with anticipation the President's announcement of a new national space policy. The National Research Council had held a workshop on space policy in conjunction with the November 2003 meeting of the Space Studies Board, and we were anxious to see whether our concepts for new directions for the nation's space program and the President's new vision were at all compatible.

As it turned out, we almost could have written the new national space policy. The new vision for space, as we hoped it would be, directs NASA to explore – humans and robotic spacecraft working in synergy to explore our solar system and beyond. To conduct this effort, not as a race, but as a systematic long-term journey that will in time move our civilization into the solar system and beyond, understand the broader universe in which we live, and realize its opportunities.

The enthusiasm for the new exploration initiative, however, became tempered somewhat, when, as I will argue, an unnecessary event occurred.

The FY2005 budget proposed for NASA by the President provides for a substantial increase, all the more remarkable considering that funding for domestic spending is severely limited. Space and Earth science as a whole grow in this budget even beyond the remarkable increases that were planned. However, NASA has chosen to divide space science into two groups: The first is judged to be essential for the exploration initiative – the Solar System Exploration program, the Search for Astronomical Origins program, and focused research on the Space Station, such as biomedical science, that supports the initiative. The second group is judged non-essential and labeled with the unfortunate title, "other science", which includes the Sun-Earth-Connections program, the Structure and Evolution of the Universe program, Earth Science, and some research on Space Station, such as fundamental physics, not in support of the initiative. Funds from the second category have been diverted to the first, particularly in the out years. It is important to note that unlike previous battles, this is not a case where funds have been diverted from science to human spaceflight, but rather where the science program has been prioritized to the benefit of some and the detriment of others.

I am less troubled by the loss of funding for the "other science" than I am about the categorization. It has not been uncommon in the history of the space science program to have to redirect funds, on a temporary basis, to satisfy a near-term priority. During my tenure as Associate Administrator it was necessary to raid mercilessly the then Solar-Terrestrial Division to fund the initial repair of the Hubble Space Telescope. When funding in the early 1990s did not materialize as expected, it was necessary to cancel the CRAF comet mission to save the Cassini mission to Saturn. Such things happen. But never before has NASA decreed by policy that some science disciplines are permanently judged to be more important than others.

It is particularly troubling because the categorizations appear misguided. It is hard to imagine a discipline that will be more relevant to human exploration of the solar system than Sun-Earth-Connections [SEC]. The radiation hazards are formidable and will need to be forecasted using the fundamental science this program is pursuing. To be accurate, NASA did spare the SEC Living with a Star [LWS] program from cuts but did not appreciate that LWS will succeed only if the Explorer program, the Solar-Terrestrial Probes program, and the operating missions, all of which were seriously cut, are performing their required tasks.

It also doesn't make sense to decide that the Search for Astronomical Origins program is *in*, but the Structure and Evolution of the Universe is *out*. It is as if we are dividing up the exploration initiative by wavelength. Infrared and visible light astronomy, which searches for inhabitable sites in the universe, is *in*, but x-ray and gamma ray astronomy, which looks at the more violent parts of the universe, is *out*.

And then there is Earth science, which has a mandate, all its own, separate from exploration. We live on this planet Earth. Surely, it must be important to us, with a resulting budgetary priority, to learn the future of this planet and what we as humans are doing to it.

The issue with Space Station research, in which research in support of the initiative, such as biomedical science, is emphasized to the detriment of other disciplines, is somewhat trickier. There has long been a debate on what research makes sense on Space Station, and indeed, the NRC workshop in November very clearly called for focusing Space Station research on preparing humans to live and work in space. On this point, we would argue that NASA is moving in the right direction, but there are certainly scientists who are addressing critical physical science questions that relate to technologies

needed for exploration and others whose research will be disadvantaged who are less comfortable with this position.

I think it is important that NASA more carefully evaluates the unnecessary demarcation between "other science" and the science disciplines that are judged essential for exploration, and the resulting budgetary penalties. They should do so, not only because it is the right and logical thing to do, but also it is in the interest of providing support for the new initiative. Many of us are veterans of the wars that were fought when NASA proposed the Shuttle and the Space Station, and much of the science community objected to its expected drain on resources. The exploration initiative is a much different and more positive situation. The space science community in general is enthusiastic, but some of us object to being left out.

It is important also to note that the new exploration initiative is not going to be a passing fancy, unique to the current administration. A brave thing has happened. NASA has publicly stated that the human spaceflight program pre-initiative – Shuttle and Space Station – was not worth it without a longer range purpose. All those claims about spin-offs and discoveries that were going to benefit people on Earth, justifying the expense, were unfounded. There is no putting the Genie back in the bottle. We will never go back to simply circling the Earth with humans, looking for a reason to do so. As long as there is a human spaceflight program, it will need to be based on exploration, leaving low-Earth orbit. All of space and Earth science is important in a NASA that has this mandate, and we need to insist that we are defined as such and supported.

SPACE STUDIES BULLETIN
VOLUME 15, ISSUE 2 April-June 2004

When I first became Chair of the Space Studies Board a year ago, and discovered that one of my tasks was to be a columnist for the quarterly newsletter, I wondered whether there would be enough fresh material each quarter. Clearly, with the many changes in the direction and structure of NASA this past year, lack of material has not been a problem. This quarter, the grist for my column mill is, of course, the Report of the President's Commission on Implementation of United States Space Exploration Policy [the so-called Aldridge report] and the restructuring of NASA headquarters that followed immediately.

When President Bush announced the new space exploration vision for NASA on January 14, he also chartered a commission, chaired by Pete Aldridge, to determine findings and make recommendations on how best to implement the new vision. The study lasted only 120 days and resulted in a most interesting report issued in June. Much of the report dealt with industrial policy, about which I will not comment. My focus is on the recommendations on science, and here I found much about which to be encouraged.

One of the most troubling issues with NASA's initial response to the new space vision was how science was dealt with in the FY2005 NASA budget submitted to Congress in February [See last quarter's column]. Space science was divided into two very distinct parts: science that was judged to be in support of the exploration initiative – mainly the Solar System Exploration program, the Search for Astronomical Origins program, and focused research on Space Station – and all other science, which was labeled with the ignominious title of Other Science and lumped together with Aeronautics, which has not done particularly well in NASA in recent times.

The Aldridge report has a far more comprehensive and balanced definition of the science that should be undertaken in a NASA pursuing a vibrant exploration initiative. The National Science Research Agenda, on page 38 of the report, includes all or nearly all of what we would agree are the important scientific thrusts to be pursued in space. To be sure, there are scientists who could quibble that their discipline wasn't properly described or emphasized, or are troubled by the one reference in the report that argues that science disciplines that hamper the implementation of the vision should be transferred to another government agency or organization that could capably implement them. I choose to read the Aldridge report in a most positive sense, that the commission recognized the importance of all space science for exploring the universe, and I am not threatened by concerns over transfers to other agencies, since almost all of what we do can only be accomplished by NASA. Indeed, I am particularly heartened by the last sentence in Section IV on science, where the report states that a "discovery driven program argues for supporting a sensible and affordable mix of space-based fundamental research that extends from dark energy to solar system science, because the history of discovery has shown that one never knows where the next transformative breakthrough will occur".

It remains to be seen of course which vision for science NASA will follow, but here too there is reason for optimism. Shortly after the release of the Aldridge report, NASA responded to an Aldridge recommendation by announcing a long-discussed reorganization of NASA headquarters. Again from the point of view of science, the principal effect will be to merge the Office of Space Science and the Office of Earth Science into a single Science Mission Directorate and to fold the Office of Biological and Physical Research into the Exploration Systems Mission Directorate. [There are four Directorates: Exploration Systems, Space Operations, Science, and Aeronautics Research]. The merger of Biological and Physical Sciences into Exploration Systems codifies the intent of the exploration vision to focus the research on Space Station towards preparing humans and developing technology for long-duration space travel. However, this reorganization can also be expected to be detrimental to other more fundamental research that was to be pursued on Station, and this will need further worry. The merger of Space and Earth Science should provide an opportunity to pursue the Aldridge Commission's agenda for science, a balanced and multi-discipline approach.

During the history of the space program, NASA has tried many different organizations for science. In the late 1970s there was an Office of Space Science, which included what we now call Solar System Exploration, the various astrophysical divisions, and Sun-Earth Connections, and an Office of Applications, which was mainly Earth Science. In the early 1980s these were merged into the Office of Space Science and Applications, which persisted until 1993, including my tenure as Associate Administrator. In 1993, the three separate offices were established. I have always felt that having as much of science together as possible is helpful. In any federal agency, clout and importance depends on

the size of your budget, and we should be pleased that the new Science Directorate has a combined budget in excess of $6 billion.

In all of the vetting of the new organization that NASA has provided to the chairs of the various advisory committees and other senior scientists, we have been assured that NASA does plan to use the new organization to follow the more balanced science agenda of the Aldridge Commission. The proof will be in actions. The FY2005 budget, which oddly divided science, has already been submitted. The FY2006 budget, which will appear next February, should have all space and Earth science together, and the priorities should reflect a balanced program, pursuing a broad science agenda, which both supports the exploration initiative and leads to fundamental discoveries, and which follows priorities set by the science community.

The Aldridge report is equally clear that the scientific community, principally through the National Academy of Sciences, should have major input into exploration architectures, the setting of science priorities, and how machines and humans, used separately and in combination, can maximize scientific returns. The thorough engagement of the scientific community would be a most positive development. One of the principal hopes from last November's NRC Workshop on Space Policy was that an exploration initiative, properly conducted, would end the long-standing dichotomy between robotic science and human space flight; that it is possible to synergistically explore the solar system and the universe beyond, together. The way to make that happen is to thoroughly engage the scientific community in all of NASA's programs. And of course, there is the extra benefit that a thoroughly engaged science community is a dedicated stakeholder, who will prove very useful in sustaining the exploration initiative in the long term.

Finally, I would like to comment on the personnel changes that accompanied the reorganization of NASA headquarters: Ed Weiler and Chris Scolese to go from Associate Administrator and Deputy Associate Administrator to Director and Deputy Director of the Goddard Space Flight Center, and Al Diaz from Director of Goddard to the new Associate Administrator for the Science Directorate and Ghassem Asrar, who was the Associate Administrator for Earth Science, to the Deputy Associate Administrator. First, Ed and Chris have done an outstanding job in running the Office of Space Science, and I wish them equal success in managing Goddard, which will face many opportunities and challenges. The fate of space and Earth science in NASA now lies with Al and Ghassem, and here I am also quite optimistic.

I have heard some grumpiness in the science community that Al is not a card-carrying scientist, and that this will hamper his ability to mange the science program. Al was the Deputy Associate Administrator when I was Associate Administrator, and I found him a most capable steward of science. I also know from personal experience that being Associate Administrator does not depend heavily on your scientific abilities, but much more so on your management and political skills, and here I have every expectation that Al will be most successful. And I also expect that, as every successful Associate Administrator before him, Al will build a bond with the broader scientific community, which will help guide, strengthen and support the NASA science program.

SPACE STUDIES BULLETIN
VOLUME 15, ISSUE 3 July-September 2004

The current saga of the space program continues, with almost every month bringing a new twist. Let's review the sequence of events.

On January 14, 2004, President Bush announced a new vision for the Nation's space program. After several decades without such a vision, the National Aeronautics and Space Administration (NASA) was directed to extend the human presence back to the Moon, then to Mars and beyond, with humans and robots working in synergy. From the perspective of the Space Studies Board, the new vision has much to cheer about. In general terms, it closely resembles the direction for the space program called for in the report of the *Workshop on National Space Policy*, sponsored jointly last November by the Space Studies Board and the Aeronautics and Space Engineering Board.

Shortly after the announcement of the new space vision, NASA released its proposed budget for FY 2005 and interpreted certain disciplines of space research to be more relevant for exploration than others, with the funding for the latter reduced, particularly in the out years. This was definitely not compatible with the workshop report, which had argued for continuing a vigorous and balanced science program.

In June, the President's Commission on Implementation of United States Space Exploration Policy (the so-called Aldridge Commission) reported out with a variety of sweeping recommendations, especially on industrial policy. From the perspective of space science, it defined a much broader science program in pursuit of exploration than NASA did in its proposed FY2005 budget. Indeed, the notional science program presented in the Aldridge Report covers essentially all of the science disciplines that NASA has been pursuing, including the disciplines initially disadvantaged by NASA, such as Earth science and parts of Sun-Earth Connections and astrophysics.

Shortly after the release of the Aldridge Report, and partly in response to it, NASA began a comprehensive transformation designed to streamline its organization and change its culture. At NASA Headquarters, space and Earth science were merged again. This provides an opportunity to have a more balanced science program, which NASA has pledged to pursue.

As part of the reorganization, Charles Elachi (who also serves as Director of JPL) was appointed Director of Advanced Planning for NASA, and he has undertaken a comprehensive strategic planning effort. A set of roadmapping activities is being organized, with each roadmap covering a specific technical or scientific goal for NASA. In the case of the science goals, all of NASA's science disciplines are to be included. Where available, the decadal strategies of the Space Studies Board are to serve as the starting point for the science roadmaps, and the Board will have an opportunity to review and advise on the outcome of the roadmaps. This could be one of the most important exercises ever undertaken by NASA and, if successful, should result in a space program with balance across the disciplines, founded on technical reality, and with broad community support.

Then the Congress acted on the FY2005 budget. The House acted first and was severely limited by inadequate funding allocated for the entire VA-HUD-Independent Agencies appropriations bill. All the major independent agencies were cut 2 percent from the FY2004 appropriation, which is equivalent to a billion dollar cut to the proposed FY2005 budget for NASA. The Senate was able to be more supportive than the House. NASA is to be funded in the Senate bill at $15.6 billion, up by $200 million from FY2004, but still less than the President's request. However, the return-to-flight of the Shuttle and the repair of the Hubble Space Station are to receive an additional $800 million in emergency funding, with the result that the Senate's FY2005 appropriation proposal for NASA will exceed the President's request. The matter now goes to a conference between the House and the Senate, which is unlikely to occur before the election. It is to be hoped that the Senate version will prevail.

The Senate also provided detailed direction in the report that accompanied the appropriations bill specifying how NASA is to spend its funds. One item particularly heartening to science is recognition in the report of the need for a strong, balanced science program, based on the scientific strategies developed by the National Academy of Sciences. The Space Studies Board is asked "to conduct a thorough review of the science that NASA is proposing and to develop a strategy by which all of NASA's science disciplines, including Earth science, space science, and life and microgravity science, can make adequate progress towards their established goals, as well as providing scientific research in support of the new policy".

From the perspective of science, then, there is a recurring theme throughout the events of the last few months. The apparent mismatch in the implementation of the new space exploration vision, in which

certain disciplines of science were judged more or less relevant, was not the result of the science program being too broad, but rather the exploration program was defined too narrowly. Human space flight has limited destinations in the foreseeable future–the Moon and Mars. The robotic science program has unlimited destinations–direct exploration of the objects of our solar system, vicarious exploration of the objects of the broader universe, and exploration with very tangible relevance, i.e. the study of our home planet Earth from the vantage of space. All space science is a form of exploration, and all space exploration is a form of science. There is no mismatch, but rather profound synergy, with a bold definition for exploration.

It has also become increasingly evident that a broad and comprehensive science program will be important for sustaining the exploration initiative. Funding will be constrained, as shown by the recent Congressional actions, and human space flight limited, in the near future, to only those activities we now conduct, i.e. the shuttle and the International Space Station. Exciting, robotic science missions, revealing the wonders of the universe, will serve as a continual reminder that the future of our civilization lies in space.

In the coming months we will continue to advocate the bold definition of exploration, conducted via a broad and comprehensive science program, which has long been the position of the Space Studies Board. The November meeting of the Space Studies Board will be devoted in large part to developing the strategic context for all of NASA's science disciplines, as called for in the Senate language, and to provide input into the roadmapping activities being undertaken by NASA. Indeed, the strategic planning exercises being initiated by Charles Elachi are consistent with the request of the Senate to create balance across the science programs, allowing each to make adequate progress towards their established goals.

And like the rest of America, we will await the outcome of the Presidential election, with particular interest for what policy changes, if any, are to befall the space program, and with profound hope that no matter what, the best of the new space policy will survive and be supported.

SPACE STUDIES BULLETIN
VOLUME 15, ISSUE 4 October-December 2004

One year ago, President Bush announced a new space policy – that NASA was to implement a sustained and affordable human and robotic program to explore the solar system and beyond. This was a good thing. The human space flight program had lacked clear goals for decades, and now it has a clear charter to leave low-Earth orbit.

In the ensuing months, NASA has received much advice on how to implement the new exploration vision, particularly from the President's Commission on Implementation of United States Space Exploration Policy, the so-called Aldridge Commission named after its chair. The Space Studies Board and other advisory committees have also weighed in on what needs to happen for this to be an effective effort.

Congress, in the final assembly of the omnibus FY2005 appropriation bill, found all the money that it felt the Nation can afford to pursue the exploration vision. At the same time, Congress granted NASA unprecedented license to rearrange its funding and directed NASA both to implement the exploration vision and to cover the additional funding needs of the return-to-flight of the Shuttle and the servicing of the Hubble Space Telescope.

President Bush was reelected with a perceived mandate to pursue the Administration's policies, and thus continuity of the vision to explore space is expected. Sean O'Keefe, who can be credited with doing what no Administrator since James Webb has accomplished – getting clear direction for human space flight – resigned and will need to be replaced.

We are thus at a pivotal moment in the space program. NASA has all the funds that are likely to be available, all the advice on what to do, and all the authority that it needs. The Administration has a mandate. What NASA does with its advice and its authority, and whether the Administration provides required leadership to NASA and budgetary follow-through, will determine whether the exploration vision is stillborn or proceeds with alacrity to send our civilization forth into space.

The policy debate last year was unusual in my experience. Unlike the debates over Shuttle and Space Station, when most of the science community objected to NASA's efforts and hoped only to be insulated from them, this time many in the science community were prepared to be more supportive. The community requires only that NASA not mess up – and the opportunities to mess up are clearly there.

Scientists most object to illogic. It was illogical to say that we are prepared to risk sending humans to the Moon and Mars but not to repair the Hubble Space Telescope, which is a task we have done several times before. It has been similarly illogical to define exploration, as some would appear to interpret the President's vision, as a narrow concept in which humans or the search for life must be involved.

The central theme of the new space policy is that NASA is to go forth and explore the universe. Scientists would argue that they have been undertaking such exploration since the inception of the space program, with ever more capable robotic spacecraft, to observe and study from our home planet Earth to the most distant galaxies. Scientists have looked with a certain pity on their human space flight colleagues who have been bound to low-Earth orbit, and now welcome them, and the unique contributions they bring, on the bolder journey. But human presence, or the presence or possibility of life, does not by itself define what is worthy to explore. The universe is too vast and far too interesting for that narrow definition.

We have a tendency at times to make the rationale for our space policies too complicated. NASA needs to accept two simple premises: It has the responsibility to transform our understanding of the universe in which we live, including the Earth, through exploration and to turn us into a true space faring civilization. The targets for exploration are the ones that have the most impact – the most likelihood for discovery, for advancing understanding and knowledge, for true breakthroughs that excite us as a forward looking civilization. The important issue is impact – the choice of the means, whether through robots or humans, separately or in concert, should fit the task. The human species will go forth into space and we do need to start now. There will be research and discoveries that make this possible. NASA then has an obligation to build a space program that both transforms us through exploration in the broadest sense and which moves our civilization along on the inevitable journey into space.

There are some who would define the argument as science versus exploration. This is mistaken. Science is a form of exploration and exploration, when done properly, is a form of science. They can be indistinguishable and inseparable. We should not confuse the goal, which is to explore, with the means, which is robotic and/or through the presence of humans.

The real argument is between NASA's future and its past. More than one-third of the NASA budget, in excess of $6 billion per year, is now spent on the Space Shuttle and the International Space Station (ISS). The ISS has a limited role in NASA's future, qualifying humans and technology for long duration space flight. It would be hard to argue that its final configuration is optimally designed for this purpose. The Shuttle has only one purpose – to finish the ISS [unless it is allowed to service Hubble]. Think about how much progress can be made when that $6 billion can be applied to new work on the exploration initiative. It has never been more important for NASA to exercise strict budgetary discipline and support only the minimum use of Shuttle and the ISS so that NASA can move beyond its past and get on with its future.

There will be decisions made in the next few weeks that will determine our future – how are the FY2005 funds to be spent; what will the President propose for NASA in FY2006; who will be the next Administrator? Let us hope that they are very wise decisions. It is a pivotal moment, which can and hopefully will lead to a space program with clear and defined purpose, and profound impact, worthy of the vast discoveries that lie before us.

SPACE STUDIES BULLETIN
VOLUME 16, ISSUE 1 January-March 2005

We are now in budget season. The President has submitted a FY2006 budget for NASA, and now it is up to Congress to actually appropriate the funds. Some of our worse fears about science in NASA have not been realized in the President's budget; a healthy share of the agency budget is devoted to science. However, that is only the macroscopic view. When we look in more detail there is the potential for serious damage to the future of science in NASA and for that matter to the agency as a whole.

Science in the NASA budget appears in two places: in the Science Mission Directorate (SMD), which includes all space and Earth science, and in the Exploration Systems Mission Directorate (ESMD), which includes all microgravity and life sciences. The comments here are directed at SMD, for which more detailed information is available. The microgravity and life sciences efforts appear to be evermore focused on support for long-term human exploration, but the full impact of these reductions in scope is still unclear.

SMD is to be funded in FY2006 at $5.476 billion, which represents 33 percent of the overall NASA budget of $16.456 billion. The SMD budget is approximately level-funded from FY2005. It is slated to grow to $6.798 billion by FY2010, which relative to the projected overall budget for NASA in that year, represents about 38 percent.

Comparisons with previous budgets for science are somewhat difficult to make due to reorganizations and changes in accounting for launch costs and civil service salaries. Throughout much of NASA's history, science considered its fair share of the NASA budget to be 20 percent. In the late 1990s and early 2000s, the percentage for science did grow. However, this was an era when human space flight lacked a defendable purpose, and so science was able to demand and receive a larger share. By historical measures, then, SMD now appears to be allocated a healthy share of the overall NASA budget, and with human space flight now having clear goals, the percentage for science is highly unlikely to become a much larger share of NASA than the projected growth to 38 percent.

It would, of course, have been desirable for the NASA budget as a whole to grow at a more rapid pace since then, even at a fixed percentage, the science budget would also experience more rapid growth. Unfortunately, with limits on domestic discretionary spending, NASA is growing at only a few percent per year. In fact in FY2006, the NASA budget increases by $0.5 billion less than was projected just a year ago.

In evaluating the FY2006 budget for SMD the most important comparison is with expectations. In the FY2004 budget for NASA, which predates the Vision for Space Exploration, space and Earth science were projected to have combined budgets of $6.550 billion in FY2006, compared with $5.476 in the actual FY2006 request. Even after accounting for the transfer of the Prometheus nuclear technology program from SMD to ESMD, SMD would have to have a larger share of the NASA budget than is now possible to support the FY2006 program that was expected in FY2004, plus the new initiatives for the Moon and Mars.

Most of the growth that was projected in FY2004 was in space science; Earth science was projected to have a declining budget. In many ways, Ed Weiler, the former Associate Administrator for Space Science, was too successful. He sold programs that required a growth in funding for science that is not now attainable.

A similar situation happened to science in the early 1990s. There were three major new starts: AXAF (now Chandra X-ray Observatory) in 1989; the CRAF/Cassini comet science and Saturn exploration mission pair in 1990; and the major Earth Observing System program in 1991. To accomplish these programs the budget for space and Earth science needed to increase at greater than 10 percent per year throughout the 1990s. Such an assumption was not unreasonable at the time; e.g. the 1990 Presidential Advisory Committee on the Future of the U.S. Space Program, chaired by Norm Augustine, assumed that the overall agency budget would grow at 10 percent per year.

However, the growth in the science budget and in the overall agency budget in the early 1990s did not occur. The response of NASA leadership at that time was to make surgical cuts to missions and to protect the base of small missions, Research & Analysis (R&A) grant funding, and Mission Operations & Data Analysis (MO&DA). AXAF was descoped; CRAF was cancelled; and EOS was subjected to a major downsizing. The only new missions added to the budget were relatively small missions such as the Discovery program for solar system exploration.

In FY2006, NASA leadership appears to be taking a different tactic. They are making every attempt to preserve the space science missions in development. There appears to be some concern that the cancellation or serious delay of space science missions under development will be seen as having been caused by the exploration initiative, which would be a challenge to its political support.

With the budget for science limited by the growth in the overall NASA budget, missions in development protected from cuts, and new lunar and Mars missions added, there are limited places to go for relief. Consequently, operating missions are being cut; e.g. MO&DA funding for missions such as Voyager and Ulysses are to be eliminated in FY2006. Small R&A grants for theory, modeling, data analysis, and technology development are seriously threatened, as evidenced by the recent cancellation of some expected proposal solicitations.

There is a fundamental question here. Is NASA's job to do science or simply to fly new missions? The two goals are not necessarily compatible. Within limited funds the science program may be better optimized by getting the maximum benefit from ongoing and irreplaceable missions, such as Voyager and Ulysses, than by undertaking new adventures. Science is conducted through the R&A and MO&DA programs, and the value of the investment in missions can be realized only if the accompanying programs necessary for their success are healthy.

There is also a practical issue here: there is no flexibility in the proposed NASA science budget. Congress will inevitably earmark the budget for several hundred million dollars. There needs to be a plan for how to absorb the earmarks without hurting the foundation of the program, the R&A program.

Finally, it is very much not in NASA's long-term interest to cut its base, the supporting MO&DA and R&A programs. These are the programs that support the training of the next generation of scientists and engineers at universities.[1] The workforce problem facing NASA is potentially crippling. It will take an entire new generation of scientists and engineers, perhaps 50,000-75,000 new participants, to execute the President's vision for space exploration. They will be trained in the nation's universities, supported by the R&A and MO&DA programs. To cut here is to strangle the pipeline of students on whom the future of NASA will depend.

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[1] The roles and importance of research and data analysis programs are discussed in detail in the 1998 SSB report, Supporting Research and Data Analysis in NASA's Science Programs: Engines for Innovation and Synthesis.

SPACE STUDIES BULLETIN
VOLUME 16, ISSUE 2 April-June 2005

Each of the columns that I have written to date has dealt with an issue of immediate concern to the space program, usually triggered by some recent event that altered the purpose of the space program, or the balance among its various aspects, or its leadership. We are presently at a brief lull in the action. At the Subcommittee level, Congress has passed appropriations for NASA that are essentially equal to the President's request, although there are some concerns and differences in the details. The new NASA Administrator, Mike Griffin, has made statements that are very supportive of science, particularly with regard to the breadth and balance of science that is to be pursued. However, the statements will become reality only when the FY2007 budget is developed this fall. There are rumors of many leadership changes in NASA, which will have a profound effect on science, but these will have to await the 12th of August, which is when the new Administrator can make such changes.

It seems appropriate then to use this column to discuss an issue of long-term importance to the space program. Indeed it is among the most significant issues for determining our future success: the workforce. Where will the space program obtain the workforce to execute the ambitious goals we have, and how and where will they be trained?

The fact that the future workforce is an important issue should not be a surprise. The civilian space program began with a bang in the early 1960's. Starting from essentially nothing in the late 1950's, an American workforce of over 400,000 was assembled at the peak of the Apollo program in the mid-1960s. Students were encouraged to pursue careers in space. Those of us who were in high school when Sputnik was launched were both fascinated by the opportunities of space and drawn by a national imperative to serve our country by pursuing careers in space. After Apollo, however, the funding for civilian space declined, and it has remained at an essentially constant level since the early 1970's. Those of us who got in early have enjoyed successful careers, and during our prime there was relatively little need to replace us. Now we are getting old. Whether all of us are as bold as we were in our youth, or as bold as we will need to be to execute our future in space, is questionable. And while there is no mandatory retirement in the U.S., mortality eventually catches up with all of us.

We will probably not send humans to Mars for 30 years. Certainly the first generations of space scientists and engineers will be gone by then, and also so will many who are now in the prime of their careers. There is no plan to sprint to Mars as in Apollo, but it is not hard to imagine that on this 30-year time horizon, we will need 50,000 to 75,000 new scientists and engineers that we currently do not have.

It would be nice to think that someone in the NASA leadership is worrying about the workforce issue and doing something positive to ensure that the required workforce will be available. Unfortunately, that does not seem to be the case, as is evidenced by the fact that so many recent actions have been detrimental to creating the required workforce. I am not suggesting that these actions are malicious, only shortsighted; it is the law of unintended consequences at work.

Unless we are expecting to have the workforce trained overseas, the research universities of the United States must provide the needed scientists and engineers. At the graduate level, this training must involve participation in forefront research. Even at the undergraduate level, the training should involve hands-on experience with actual space projects. The most pressing future need will be for engineers and scientists who are able to develop hardware, and thus their training will be meaningful only if the faculty of their university is also involved in the development of space hardware.

Regrettably, almost every recent procurement action by NASA has been detrimental to university participation in hardware programs. For example consider the following:

- It has become increasing costly to develop a competitive proposal for participation in a NASA flight mission, and the costs are beyond the resources available to universities. They have no bid-and-proposal budgets and no profit that can be applied, and proposal preparation is not an allowable overhead expense.
- Many NASA missions, particularly the smaller ones, are selected as a complete mission with a single PI who can, in principle, come from a university. However, with the exception of a few powerhouse universities, most academic research groups do not have the infrastructure to manage an entire mission. These groups are then dependent on having partners at other universities, industry or in NASA centers to participate. It is not the NASA procurement process that determines their selection, only the alliances they can build.
- In the past, the development time for space instrumentation was longer and allowed for

development of new technology. Universities used these longer missions to replenish their technology base and to update their infrastructure. Now missions have a limited development time and a highly constrained budget, with the consequence that effectively no new technology can be introduced. Where then do universities develop new technologies to remain competitive? There are some programs for developing new technologies, but they are limited.

- NASA is currently imposing management requirements on how flight hardware is to be developed, with the belief that this will result in fewer failures. Many of these new processes run counter to the way university groups have learned to develop hardware, and have enjoyed considerable success in doing so. Even worse, the technical evaluation of proposals by NASA can penalize universities, in the belief that they are not able to execute NASA management processes. The result is a competitive disadvantage for universities compared to NASA centers and other national laboratories.
- Universities have their own aging problem. The distinguished faculty members who established competitive experimental groups are retiring and need to be replaced by younger faculty. Yet in today's competitive environment, it is very difficult for a young faculty member to be selected for flight hardware or to have anything to show for the effort when it is time to seek tenure.
- Balloon and sounding rocket programs have long been the mainstay of university research and graduate training. These programs are now inadequately funded for this task.

It is not surprising then that the number of university space research groups capable of building space hardware is dwindling. A professor can produce only so many graduate students. If the number of active groups is limited, the production of graduate students is limited, and the pipeline will be inadequate to meet the national need.

NASA does have an education program. However, it has focused primarily on K-12 education. This is fun stuff. It is good for NASA's image. It may even increase the number of students who will pursue careers in science and engineering. It is unlikely, however, to do anything to ensure the required workforce for space. The numbers required to pursue space exploration might seem large, ~75,000, but they are still small compared with the nation's output of scientists and engineers. The question, then, is not how many students pursue careers in science and engineering but rather how many will devote their careers to space. There is no national imperative this time. Even a vigorous human exploration program to Mars will not capture the national attention as Apollo did. Once again, it will be the universities that have the important role. They can lure students who have already decided on careers in science and engineering into the excitement of space, especially by offering research opportunities for undergraduates.

At the beginning of the space program, NASA recognized the need for a strong university involvement. The agency encouraged university participation through research and technology grants and significant hardware opportunities. The result was an impressive infrastructure that trained the current workforce, developed innovative technology, and performed outstanding research. That infrastructure is currently being allowed to decay. Yet there is a pressing need now to rejuvenate the workforce. Our future will depend on.

Let us hope that some enlightened NASA leadership will recognize that the principal impediment to success in space is the lack of a trained workforce and that they move aggressively to ensure that it will be available. And let us hope that the agency's leadership will attack this problem in a coordinated way, recognizing that there are many aspects—from the health of the university infrastructure to NASA procurement practices—that must be addressed.

SPACE STUDIES BULLETIN
VOLUME 16, ISSUE 3 July-September 2005

This column is being written as Joe Alexander's retirement date from the position of Director of the Space Studies Board is fast approaching. Joe has been both the dynamic leader and the wise counselor behind all the Board's activities these past seven years. The Board is stronger and more influential than at any time in its recent past; the space program we serve is far better for all Joe's efforts. It has been my great pleasure to work with Joe during my two years as Chair, as it was when we worked together in NASA. I will miss his guidance and trust we can keep him involved in SSB activities, if not directly involved in the leadership.

Joe's retirement comes at a crucial time for the space program, because, perhaps more than any other recent time, NASA is very much in need of good advice. There is good news. The NASA administrator, Mike Griffin, consistently says that he will provide space and Earth science (the Science Mission Directorate, SMD) with a fair share of the NASA budget, presumably roughly equal to the 33 percent that science now enjoys. However, there is bad news as well. The science program that we have planned and hoped for does not fit in that fair share. We are in need then of wise counsel for how to deal with this situation.

Certain of the planned missions, such as the James Webb Space Telescope (JWST), appear to have serious projected cost growth. Missions within the Living with a Star (LWS) program, such as the ongoing Solar Dynamics Observatory development or the upcoming Radiation Belt Mapper mission, are projected to cost much more than when LWS was conceived. The projected cost overruns appear to be endemic throughout much of SMD. Is this requirements-creep, a consequence of premature commitment to high-risk technology, or faulty management? Regardless, we can't execute the science program we anticipated with the funds available.

The problem was evident in the recent NASA strategic roadmapping exercise for science. Each roadmap was expected to be faithful to the NRC decadal strategy for its discipline (when a decadal strategy was available). When the Space Studies Board conducted its review of these roadmaps,[1] it was clear that the sum of all the programs in the science roadmaps greatly exceeds any reasonable budget for science.

The question is what to do. How does NASA make the hard decisions about what stays and what goes, or what is delayed? What is to be the balance among the science disciplines? What is to be the balance among small, medium, and large programs? These decisions are of course ultimately for Mary Cleave, the Associate Administrator for SMD, and the rest of the senior administration of NASA and for the Congress. However, all would be wise to have input from the science community on how to construct the optimum program for the funds available.

The NRC decadal strategies are the foundation on which we plan our future. Today, however, they do not provide sufficient advice by themselves. They were constructed with a set of assumptions about the cost of missions that has not proved to be valid. JWST is the highest priority in the recent astronomy and astrophysics decadal survey,[2] but nowhere was it envisioned that cost overruns in this program would be allowed to squeeze and delay other important astrophysics missions such as those devoted to the study of dark energy and dark matter.

We could imagine an exercise in which NASA decides how much funding is likely to be available for each of the four main science disciplines: astronomy and astrophysics, solar system exploration, sun-Earth connections, and Earth science. The community could then be asked for input on how to create an exciting, balanced program within each discipline. How such advice would be input is less clear. The internal advisory committees of NASA, chartered under the Federal Advisory Committees Act, do not exist at the moment. Although the NASA Advisory Committee is expected to be reconstituted shortly, it is less clear whether the mission directorate advisory committees such as the Earth and Space Science Advisory Committee will return. The Space Studies Board could take on this task. We have the membership needed to do so. Historically, we have dealt more with strategy than implementation. However, the task of fitting the previously planned program into a limited budget falls somewhere between strategy and implementation.

However the advice is obtained, it is important that it be considered. The science community, which is made up largely of current and past academics, likes process. We are realists; we can accept bad news and limiting constraints. This acceptance, however, is contingent on our having input into the decisions. Not making the decisions – that's the Government's job – but insisting that our reasoned positions are

heard and considered before the inevitable hard decisions are made. NASA would be wise to ensure that there is a process in place whereby the science community can have organized input into the creation of the exciting science program the nation deserves, and that the resulting program serves the broad aims of the various science disciplines for which NASA is responsible.

The science community, and indeed the broader aerospace community, also needs to help NASA find better processes for controlling mission costs. The problem we are facing is driven mainly by the increases in projected mission costs. We thought the program we were planning would fit in the NASA science budget, and now it does not. Have we simply discovered reality? Have the true costs been revealed? Or is there something endemically wrong with how we are executing programs, which if fixed we would get more science for the dollar?

NASA has become very risk averse, particularly for its large, strategic missions. The policy of avoiding risk has resulted in extensive management oversight, which appears to be compounded by full-cost accounting at centers, which seems to have resulted in even more NASA personnel assigned to project management. And they are not necessarily experienced personnel at that. It would be a worthwhile exercise to ask whether all of this oversight, and the inherent costs, are worth it. Is the risk really reduced? There is also the cost and trauma of mixing engineering cultures. Not everyone manages as NASA now wants to do, and yet there are successes out here, in universities and in industry, which should not be discounted.

The good news is we have a NASA Administrator who is willing to give space and Earth Science its fair share of the NASA budget, and not put constraints on science. We do not have to respond to heavy-handed policy overlays, in which only science that directly relates to the Exploration Vision is favored. Rather, we can have a balanced science program, in which each of the disciplines can expect to make reasonable progress towards its established goals. But we have to live within our means. We have to construct a science program that fits within our budget share and execute it smartly. And this is a job for all of us— NASA and the science community—collectively creating an exciting future.

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1 *Review of Goals and Plans for NASA's Space and Earth Sciences*, National Academy Press, Washington, D.C, 2005.
2*Astronomy and Astrophysics in the New Millennium*, National Academy Press, Washington, D.C., 2001.

SPACE STUDIES BULLETIN
VOLUME 16, ISSUE 4 October-December 2005

This is a time for anticipation. The President's FY2007 budget request for NASA should have been settled by now between NASA and OMB, but the outcome and the profound implications for the future of the space program will not be known until early February. It is no secret that NASA will not receive the funding that is required to pursue all the tasks assigned to it. The issues are how this funding will be distributed; where will the funding be adequate for progress; and where are there to be setbacks and damage?

NASA's Administrator, Mike Griffin, has embraced a broad spectrum of goals for NASA. This is a welcome change from a year ago when NASA invoked a prioritization that focused on a very narrow interpretation of the Vision for Exploration outlined by President Bush in his speech of January 14, 2004. NASA indeed has many goals. Its task is nothing short of exploring the universe, extending the human presence into the solar system, and fully utilizing the opportunities of space for humankind.

Mike Griffin also has introduced the concept of balance in the NASA program, a term that was previously banned from the NASA lexicon. We can conceive of balance between human space exploration and robotic science and also balance among the disciplines within the science directorate. This is balance in the sense of optimization, not entitlement. For NASA's many tasks, the issue is how to optimize the available resources so that reasonable progress can be made across the board.

One wonders, however, whether there is an adequate appreciation in NASA and OMB, and in the Congress, concerning how many different goals of NASA there are—progress in human exploration and progress in science; short-term tactics and long-term strategy—that need to be optimized. Or whether optimization is in fact even possible within the highly constrained overall resources.

Administrator Griffin has said consistently that science will not be asked to pay for human exploration of space. This statement requires some translation. The Science Mission Directorate (SMD), which includes Earth and space science, has so far not been asked to pay for human exploration. However, life and microgravity sciences, which reside in the Exploration Systems Mission Directorate, have seen their program scaled back drastically, presumably to provide, in part, the limited resources that are needed to begin the development of the Crew Exploration Vehicle. NASA has a stated goal, which is understandable, to achieve some traction in the next few years towards the President's directive to return to the Moon, and the funds need to come from somewhere. However, there is a trade-off to be made here. No one doubts that a vibrant research program in life and microgravity sciences will be necessary to achieve the long-term goal of extending the human presence into the solar system. The long-term strategic necessity is being traded off against the near-term requirement for money.

Griffin has not said that SMD will be excused from helping to pay for the return to flight of the Shuttle and the completion of the International Space Station (ISS). In fact, in a letter to OMB [posted on the internet], he offered to cap the SMD budget at the FY2006 level for five years, thereby freeing up funds for the continuing assembly of the ISS with the Space Shuttle until the Shuttle's retirement in 2010. It is unusual to have insight into the budget negotiations between NASA and OMB, and whether this was a ploy that ultimately will not result in a drastic cut for science will not be known until the FY2007 budget is released. However, the magnitude of this potential cut is staggering. It would effectively eliminate $4 billion from the planned SMD program over the next five years. One could argue that SMD should never have expected to achieve the planned growth since it would have resulted in an Earth and space science program that was funded at 38 percent of the NASA budget, compared to the current 33 percent. It will be more reasonable, however, if SMD is allowed to grow in proportion to the overall NASA budget, maintaining its current fair share.

Mary Cleave, the Associate Administrator for SMD, has consistently said that each of the four science disciplines in SMD—astrophysics, heliophysics, solar system exploration, and Earth science—will be treated fairly and asked to solve their own problems within their funding allotments. One wonders, however, how the distribution among the disciplines is to be done? It cannot be based on the allocations made during the initial excesses of the exploration vision, since this greatly favored Mars exploration at the expense of other important science programs; indeed, one of the first acts of Mike Griffin was to rebalance the science program at the expense of the growth in robotic exploration of Mars. The distribution also cannot be based on the pre-exploration vision budget, because at that time Earth science had been in a systematic decline and did not have its reasonable share of the science budget. It's a tough call. One can hope that when the distribution is made NASA will be able to articulate a

defendable and acceptable logic.

There is also a question of balance within each science discipline of SMD; between the sizes of flight missions; and among flight programs, Research & Analysis (R&A) and Mission Operations and Data Analysis (MO&DA). NASA likes its big, spectacular programs, its strategic missions, e.g., the upcoming James Webb Space Telescope. In times of limited funding, however, it is questionable whether emphasis on the extravaganzas is the optimum choice. Rather, a balanced program of small, medium, and an occasional large flight program, founded on vibrant R&A and MO&DA programs, is more likely to yield the maximum science for the funding available, which after all should be the goal. This is an issue that demands close cooperation between NASA and the concerned science community to produce the optimum science program. There may be pain in these decisions, but no less than the future of each of the science disciplines is at stake.

We can also ask about the balance between the cost of flight programs and their capabilities. One of the most alarming and discouraging trends in space programs worldwide is the growing disparity between what flight programs were expected to cost and what they actually end up costing. Under these circumstances, it is impossible to plan and optimize the science program. Is the disparity because NASA and industry are simply incompetent estimators or driven to low-balling the estimates to sell the initial program? Is it that we can no longer manage programs effectively? Have we become so risk adverse that we are more concerned with process than with smart, effective engineering? Whatever the reason, this is a problem that needs to be solved if we are to have a future. Ironically, the programs for which cost overruns are minimized are Principal-Investigator class missions, such as the Explorer and Discovery programs, since these are capped to start with and, if needed, are usually descoped to remain within the cap. These are the programs that NASA is threatening to de-emphasize the larger strategic missions.

There is a question also about the balance between NASA centers and the broader space science community, residing mainly in the nation's research universities. NASA is concerned about its workforce; it has excess capacity and underutilized staff at its centers. If the consequence of this concern were to be to continue to gather more scientific research into NASA centers, at the expense of the university researchers, it would be a serious mistake. The scientific talent of the nation in space research does not reside principally at NASA centers. There are only two members of the National Academy of Sciences active at a NASA center compared with more than 100 who would list space research among their primary activities at the nation's universities. NASA centers do have enormous capabilities in engineering and management, as measured by their many members of the National Academy of Engineering. In the beginning of the space program, NASA proactively marshaled the scientific talent residing in universities and depended upon it for technical innovation, instrument development, data analysis, and theoretical advances. It was wise then, and it would be wise again to emphasize this resource.

When balancing present needs, and the tactical decisions required supporting them against long-term strategic requirements, the issue of the future workforce cannot be avoided. The nation's aerospace workforce is aging and needs to be replenished; the growing restrictions imposed by the International Traffic in Arms Regulations (ITAR) regulations are requiring that the future workforce be comprised of U.S. citizens, presumably educated in U.S. universities. Effective engineering and scientific education requires hands-on experience with real space projects. Among our most important issues of balance, then, is the need to worry about the health of the university research community, which will provide this hands-on education and generate the required workforce.

The numbers of issues that need to be optimized in the NASA budget are many—more even than we have discussed here. One hopes that somewhere in the NASA administration there are individuals who worry about each and every one of these issues and that collectively they have produced an optimized budget that, within the available resources, is the best that can be achieved. And that they are able to articulate and defend the choices they made. We'll have to see in a few weeks.

SPACE STUDIES BULLETIN
VOLUME 17, ISSUE 1 January-March 2006

There can be no more important subject for this quarter's column than the FY2007 budget request for NASA. From my experience, I cannot recall a budget request that has resulted in more consternation and outcry from the science community than this one.

The consternation results in part from a confrontation with reality. The science budget of NASA has grown more rapidly than the agency's budget as a whole since the mid-1990s. This is unsustainable. However, what is a surprise and a disappointment is how abrupt and draconian has been the downward adjustment to science. The budget for the Science Mission Directorate (SMD) is to experience a growth in FY2007 of 1.5% compared to the agency's overall budget growth of 3.2%. SMD's projected budget is to grow only at 1% per year for the next four years, compared with the total NASA budget rising at roughly 2-3%. These figures are much lower than what had been projected in last year's budget. The result is to remove $3.1 billion from the runout of the SMD budget. The projected growth in SMD was not a funding wedge for programs yet to be determined, but rather real programs, supporting the careers and aspirations of real scientists and engineers. One cannot remove $3.1 billion of content without major disruptions. The disruptions are proportionally larger in the life and microgravity sciences programs, which are funded through the Exploration Systems Mission Directorate, and which are to experience a near 70% reduction in content.

In fairness to NASA, there are no good choices for cuts in the FY2007 budget. The agency does not have sufficient funds to pursue its many missions, and it is a question only of whom to disappoint. The agency's bottom-line funding is inadequate. Most space experts considered it inadequate when the President directed NASA in 2004 to pursue an aggressive program of returning humans to the Moon and going on to Mars—the Vision for Space Exploration—while still maintaining its near-term commitments to complete the International Space Station (ISS) and maintain a vigorous science and aeronautics program. It became more inadequate when the Administration did not request the budget for NASA that it projected at the time of that announcement. It became still more inadequate when the costs for flying the Shuttle to complete the ISS proved to be understated. The choices then were to disappoint the international partners on the ISS program by reneging on our commitments to complete the ISS, or disappoint the scientific community by removing the planned growth in its budget in order to fund the completion of the ISS. Or NASA could delay the development of the Crew Exploration Vehicle (CEV) destined to replace the Shuttle, resulting in a longer gap in the United States' ability to launch humans into space, with the corollary consequences for the NASA and industrial workforce that needs to retain the knowledge acquired over decades of how to build and operate human spaceflight systems. Or NASA could disappoint the life and microgravity scientists by taking their funding to develop the CEV. In an overall agency budget that is this constrained, there are no good choices.

Budget reductions are not abstract concepts. They result in individuals being fired and career aspirations being disrupted. The choices that NASA has made for reductions in the planned growth of SMD have the unfortunate consequence of negatively impacting a large number of space and Earth scientists, and graduate students who aspire to join their ranks. The small flight missions of NASA, e.g., the Explorers and Earth System Science Pathfinders, were reduced in the FY2005 budget, at the time of the announcement of the Vision for Space Exploration. They are reduced further in the FY2007 budget request, and a new target for reductions is found—the basic grants program in Research & Analysis (R&A)—which is the lifeblood of the space and Earth science communities. The R&A program is to be reduced 15%, retroactively to FY2006, with selected programs such as astrobiology reduced by 50%. It would be difficult to find reductions that impact more space scientists, particularly those in the university community. The outcry that has resulted was predictable.

There is a well-established pipeline for human capital and technology in the space and Earth sciences that runs through R&A and small flight missions. R&A supports the training of graduate students, young investigators, the analysis and interpretation of data from ongoing missions, theoretical studies, the planning for future missions, and the development of new technology prior to its use in flight hardware. The cuts in R&A, beginning in FY2006 and then in subsequent years, disrupt this pipeline, in some fields irrevocably. More than that, the cuts send a chilling message of uncertainty to the young about the opportunities and the promise of the future.

Large technology corporations have long recognized that their cumbersome bureaucracies do not promote innovation. The best of the large technology corporations form alliances with small businesses,

which retain the agility and the drive for innovation. The partnerships can be highly effective, with the small business innovating and the large corporation turning the innovation into effective products. Why has this lesson been lost on NASA, or for that matter the Federal government? Universities are the small-business equivalents for the space and Earth sciences. They have highly innovative researchers; they retain their agility. The innovative role of universities has been a central, driving feature of the space and Earth sciences since the inception of the space age. Yet so many recent actions by NASA have driven the university community out of participation in the development of technology for space. NASA is justifiably proud of the fact that its flagship missions support research at universities. This, however, is data analysis and theory. It is not technology development. It is shortsighted and counter to successful corporate strategies for NASA not to avail itself of the technology innovation available in universities through vigorously funded, small missions and R&A programs.

The funding reductions in small missions and R&A have caused disproportional damage to the space and Earth science communities. The converse is also true. Fixing these reductions and ameliorating the damage requires relatively little funding. A 1% change to the overall NASA budget, ~$160 million, applied to the R&A and small missions programs of SMD, and allowing SMD to increase in proportion to the agency's overall budget in the out-years, would go a long way to restoring the pipeline of human capital and technology essential for the future.

The funding reductions in life and microgravity sciences are more drastic and more difficult to restore. Every statement made about the consequences of the reductions in R&A and small missions in SMD is amplified for the life and microgravity sciences. By NASA's own count, the reductions in the grants program in these fields have resulted in laying off more than 500 postdoctoral fellows and graduate and undergraduate students. That is a whole generation of scientists whose expertise is needed to lay down the foundation of knowledge required for NASA's success in implementing the President's Vision.

The FY2007 budget request for NASA has been proposed by the President, and now is in the hands of the Congress. It is to be hoped, even within the constraints now present on the Federal budget, that it will be possible to provide NASA with the funding that is required to accomplish its many missions of national importance. And that it will be possible to undo the disproportional damage that has been done to those programs that are fundamental to our future in space.

SPACE STUDIES BULLETIN
VOLUME 17, ISSUE 2 April-June 2006

We are just beginning the human exploration program to return to the Moon—the Vision for Space Exploration that President Bush announced in January 2004. Few if any firm technical decisions have been made. It is, however, the time when critical decisions need to be made as to what are the goals and the strategy for this important endeavor. It will not be possible to evaluate and to agree upon the various competing technical approaches without first knowing what we plan to accomplish and why we are doing it.

There are some who would argue we are going to the Moon because it is national policy, as directed by the President, and now authorized by Congress in the 2005 Authorization Act for NASA. However, this President has only two and a half years remaining in his term. Those of us who believe it is the right path for human exploration, to go forth into the solar system, would like this initiative to continue through multiple Presidential and Congressional terms for generations to come. The foundation for the program needs to be sound, understood, and more widely appreciated and endorsed for such long-term stability.

There are some who believe that the motivations for human return to the Moon are obvious. We explore; it's who we are. In effect, we explore because we are explorers. We need to remember, however, that we have been to the Moon before, with Apollo. We had a clear goal to go and to return safely. But it was not a goal that could sustain the program, and Apollo ended. Having accomplished the task of reaching and returning from the Moon, we were unable to defend our continuing presence there, or the further human exploration of the solar system, against other competing national interests of that time.

From the perspective of science, the process for developing a strategy for what we want to do on the Moon is easy. One of the great successes of the Earth and space science program has been the synergistic relationship that has developed over decades between the Space Studies Board (SSB) and NASA to develop strategies and the community consensus required to execute these strategies. The decadal planning process, initiated by the astrophysicists and now practiced by all Earth and space science disciplines, has ensured the quality of NASA science and generated community ownership and support for the program, which has been necessary for its funding and its success. The SSB, at the request of NASA, has chartered a National Research Council (NRC) study on lunar science to be conducted during the initial phases of robotic and human exploration of the Moon. The SSB is also assisting with planning for life and physical science to be done on the Moon in order to continue human exploration on and beyond the Moon. The NRC studies of lunar science are major efforts and should yield the desired result—of a sound strategy for science we would like to achieve, and can achieve, at least in the near term.

It is very important that the NRC process be allowed to proceed in an orderly way. We do not want to repeat the early history of the Shuttle and the Space Station programs. In those cases, NASA set forth to justify the infrastructure it intended to build by promoting the opportunities it opened up for science, and arranged a series of internal studies and workshops to rationalize the inevitable. This time, we have a unique opportunity in the history of the space program to first define the science we want to do and then to encourage and help formulate the infrastructure that will be required. Proceeding in this way, we can balance the science to be done on and from the Moon against NASA's many other science goals. Only with such balance can we expect a consensus to develop in the science community that will support this effort for the long term.

It is singularly important that balance among the science activities of NASA be maintained. NASA has been willing to spend only a certain limited fraction of its budget on science. The number has varied over the years, and some could argue it is currently at a historical high, but nonetheless it is limited. Funds for science on and from the Moon will thus come from other science, unless the NASA overall budget rises, which at present seems unlikely. The largest threat to the stability and support for science in NASA would be the development of disciplinary warfare over limited funds. If science on and from the Moon is to receive broad community support, it will be because this science is conducted in a balanced science program.

The question arises, however, as to who is establishing the goals and strategy by which the human exploration program to the Moon can satisfy broader national interests than science. This could be an appropriate role for the NASA Advisory Council, which, through deliberations or commissioned studies, could determine the criteria for success that meet broad national goals. Strong arguments are needed to defend the program against inevitable questions about whether it will serve the economic wellbeing of the nation, improve our national security, and ensure the preeminence of the United States in space beyond

low Earth orbit. Can this program serve to unite disparate nations of the world in an effort on behalf of humankind? Will the program lead to substantial improvements in our space infrastructure for many other applications? Will the program inspire our youth to study science and math and help assure a technologically literate workforce? In the longer term, will the inhabitants of the resource limited Earth require the broader resources of the solar system?

In my judgment, we are not expending enough effort now to establish the necessary firm foundation for pursuing the goals and strategy for returning humans to the Moon. The underpinnings are not adequate to sustain public and political support for this program. We will need to do better if the sustainability and the success we desire are to be realized. We also cannot say when success is achieved without knowing what success is to be.

SPACE STUDIES BULLETIN
VOLUME 17, ISSUE 3 July-September 2006

There is consternation these days between the National Aeronautics and Space Administration (NASA) and its external science community. In August, three senior science advisors were dismissed from the NASA Advisory Council (NAC). In the aftermath, the Administrator of NASA, Mike Griffin, through correspondence with the NAC and its science subcommittees and through a major speech at the Goddard Space Flight Center, clarified how NASA will manage its science program, and the role of the science community.

Quoting from the Goddard speech, "members of the external scientific community are suppliers to NASA, not customers." The role of the science community is defined in this way to avoid what is perceived as an inherent conflict of interest that results when the scientific community is a purveyor of products to the government, while at the same time being the primary source of advice as to which products the government should purchase. Accordingly, the formal internal advisory structure for science in NASA has been abolished, except for the NAC, whose function is to advise the NASA Administrator. The Associate Administrator for science, and her division directors, no longer have an independent, internal advisory structure.

During the near 50-year history of NASA, two very distinct management cultures have evolved. The human space flight management culture is a pure engineering culture in which NASA sets requirements. The only external community is aerospace industry, and they are not empowered to do anything other than supply NASA with services as requested. The science management culture is very different. Here there is a dedicated external-to-NASA community of scientists who feel obligated to engage with NASA on the execution of the science program to ensure its success and quality.

In the current construct for managing science in NASA, the human space flight engineering culture is being imposed on the science program. The external science community is to have the same role in NASA as the aerospace industry. This is a radical departure from the past and, in fact, a departure from the way in which other quality science programs in the Federal government—with engaged, external communities—are managed.

Science is done by scientists, most of whom, in the case of space science, do not work directly for NASA. The scientists perform their tasks, as do other scientists, by devising observations and experiments, by analyzing and interpreting the resulting data, and through supporting theoretical studies and modeling. NASA provides the space hardware from which the observations and experimental measurements are made. This is an essential role, but by itself it is not science. To define it otherwise would be to conclude that the manufacturer of laboratory equipment is doing science, as opposed to the scientists who are making discoveries with the equipment.

Since it is NASA's role to provide the scientists with the equipment required to make their observations, in that real sense, the scientists are indeed the customers of NASA. It is thus quite reasonable for scientists to have a direct say in how they want NASA to perform on their behalf. It is backwards to argue that scientists are suppliers to NASA. It is NASA who is the supplier and the science community who is the customer.

In the current model for managing science in NASA, the external science community is to be involved directly only through the National Research Council (NRC), which has the responsibility to set long-range strategic plans. After that, NASA, and particularly senior NASA managers, take over. To carry the laboratory equipment analogy further, that is like a scientist deciding on a field of research to pursue and then turning further decisions over to the laboratory equipment manufacturer. In this model, quality science is unlikely.

NASA is, of course, also the supplier of funds to scientists to perform their science, which is where a conflict of interest can arise. It could be argued equally well that NASA has a conflict of interest. The agency is both the supplier of funds to its customers—the scientists—and the supplier of the tools necessary for them to do their work. Thus, NASA could fund the science— or, in particular, the technical approach to science—that it, arguing only with itself, deems appropriate.

To manage the conflicts of interest, both for the science community and for NASA, a set of self-governance procedures has evolved over the decades. The NRC has set recommended science priorities; it has weighed the value of one mission candidate against another and one program against another, within general funding constraints provided by NASA. Then a series of internal advisory committees at all levels in the NASA science program provided advice on how best to implement various missions and programs.

And then there of course has been the peer review process; research grants and space instruments are chosen with members of the external science community participating in the evaluation.

The participation of the science community in the management of NASA's programs and flight missions has been of great value. It has introduced a constructive tension that pushes the program to excel. This constructive tension was noted as a strength of the science program in the NRC Workshop on National Space Policy Science1, held before the announcement of the Vision for Space Exploration in January 2004. In fact, it was recommended that the human space flight program, to the extent possible, emulate this strength of the science program.

Of course, NASA, acting for the President and with the consent or direction of Congress, has the final say in the initiation of a program or in any selection, as is required by law. The question, however, is to whom is NASA accountable. In the current model, science in NASA is accountable only to the Administrator and through him to the President and the Congress. In the previous, scientist-participation model, NASA also accepted accountability to the science community, to act on their behalf in a collective effort to ensure a science program of excellence.

Probably all, and certainly most, past NASA Associate Administrators for science were encouraged or permitted to manage the science program of NASA on behalf of the nation's science community defined in the broadest sense. They were required, on behalf of the President and Congress, to administer the funds correctly, and to ensure that the program was one of quality and substance that served the needs of the nation. The demonstrable success of NASA's science program is testimony to the wisdom of this approach.

During the interval I was Associate Administrator (1987- 1993) the science budget of NASA initially increased dramatically, tracing the growth in the overall budget of NASA following the Challenger accident. However, in the early 1990s the rate of growth leveled off suddenly and somewhat unexpectedly. The situation then is similar to today, with the additional overlay that human spaceflight, with the Vision for Space Exploration, now has a clear claim on its fair share of the NASA budget. The change in funding expectation for science that occurred in the early 1990s was weathered with little difficulty in large part because the science program was a collective effort of NASA and its science community. The consternation that is prevalent in the science community today over the changes imposed by NASA, is similarly the result of the science community's response to having been disenfranchised from participation in the management of space science.

By abolishing the comprehensive internal advisory structure for science, NASA apparently believes that the conflict of interest will be avoided. In fact, the opposite is more likely. Now scientists are free to act individually and use access to NASA managers to attempt to influence favorable decisions. When the advisory structure was in place, such attempts at influence occurred in the presence of other scientists, who may have articulated differing positions, with the result that the interests of the community as a whole were represented.

Supporters of the space program in Congress are complaining that members of the science community are lobbying them for their individual programs, at the expense of other agency programs or sometimes at the expense of other science programs. Such behavior is to be expected. NASA has indicated that it will take direction only from the President and Congress, and thus one of the main routes to influence the execution of the science program is through Congress. Indeed, with the internal science advisory structure eliminated, Congressional supporters should brace themselves for an onslaught of individual requests from scientists.

NASA is in the process of finding a successor for the current Associate Administrator for Science, Mary Cleave, who has announced her intention to retire from NASA in the spring. It is to be hoped that her replacement will be granted the tools and the authority required to succeed in managing one of the world's most successful science efforts. The current experiment in managing science in NASA should be brought to a close as soon as possible. If not, the long-term quality and productivity of science in NASA is at serious risk.

1National Research Council, *Issues and Opportunities Regarding the U.S. Space Program: A Summary Report of a Workshop on National Space Policy*, The National Academies Press, Washington, D.C., 2004.

SPACE STUDIES BULLETIN
VOLUME 17, ISSUE 4 October-December 2006

It is time again, at the beginning of a New Year, to pause and reflect on the year past, and to anticipate the year ahead. Our pause this year is almost a necessity since there is great uncertainty about the health and the near-term future of the space program. Congress went home without passing a FY2007 appropriations bill for NASA, the fiscal year we are now three months into. The new Congress is threatening to leave NASA at the FY2006 funding level. (See the Director's column for more details.) It is uncertain, then, whether the painful cuts to science, and particularly to the Research & Analysis program, will be redressed, or exasperated. It is unlikely that the Mikulski-Hutchison amendment to rescue NASA from wholly inadequate funding to accomplish its mission can succeed.

It is also too early for the President's FY2008 budget for NASA, due to be released in early February. We are entering into the last two years of the current Administration, which is preoccupied with the war in Iraq and the legacy of this President. NASA, which is attempting to make visible progress on the President's Vision for Space Exploration to the Moon and beyond, could prosper, or be caught in the downdraft of a diminished administration.

There is also uncertainty in the science leadership of NASA. Mary Cleave, the Associate Administrator for the Science Mission Directorship, has announced that she will retire in March, and, at least at the time of the writing of this column, her replacement has not been named. This individual will have profound influence on the future of space and Earth science, provided of course that he or she is granted the authority to lead.

We have new Congressional leadership, with the Democrats taking over the chairs of all Congressional committees. NASA has been fortunate to have bipartisan support and so its support should not diminish. However, there is a clear intent by the new leadership to hold the current Administration accountable for all its actions, and NASA should not expect to be an exception.

As we mull over last year, in our period of reflection, several highlights come to mind. NASA, to its credit, got the Shuttle flying regularly again, and made considerable progress on the completion of the International Space Station. Unfortunately, the mere act of bringing the Station closer to completion exposed the fact that the U.S. has few if any plans to use it, with many experiments having been canceled and many researchers driven from the field of life and physical sciences in microgravity.

There was the usual number of exciting scientific discoveries, showing the continual vibrancy of the space and Earth science program. Gratifying also was the awarding of the Nobel Prize in Physics to John Mather and George Smoot for their discoveries with the *COBE* mission. Not unnoticed was the fact that *COBE* was an Explorer mission, a program that has been decimated since the initiation of the Vision for Space Exploration.

NASA made progress in replacing the Shuttle by taking necessary steps to develop the Crew Exploration Vehicle, *Orion*, and its launch vehicle, *Ares*. NASA ended the year by announcing the results of a massive effort to collect ideas on what to do on the Moon, and concluded that a lunar base was appropriate. It is heartening to know that there is much to do on the Moon, but discouraging that most of it is beyond the financial resources that are likely to be available, or even beyond the career lifetimes of all but the youngest of scientists or engineers. Indeed, the cited reasons to go and the opportunities to pursue are so massive that it is hard to imagine that they could be used to set reasonable priorities. Surely, NASA is not repeating the mistakes of the early Space Station era in which too much was promised to too many.

And then there was the saga of the NASA internal advisory structure. The scientific community objected to the internal advisory structure imposed by the NASA Administrator, in which all advice is channeled through the NASA Advisory Council. Two members of the NAC were fired and another resigned rather than be fired, in large part for objecting to the new structure, and they were replaced. Setting aside all of the rhetoric and passion associated with this event and its aftermath, we can ask the simple question -- is the new structure functional. At the level of the Science Subcommittees, which interact with the division directors, it does appear to work for the simple reason that the division directors receive the advice directly. The Associate Administrator for Science, however, has no way to get advice or seek support from the community, since all her advice has to flow from NAC's Science Committee to the full NAC to the Administrator and back down. And along the way there are lawyers. In October, the NAC Science Committee actually passed a resolution of substance and forwarded it to the NAC, only to be told that its advice was tainted by a conflict of interest and therefore unacceptable. The Federal

Advisory Committee Act (FACA), which was used to declare the advice unacceptable, was passed in 1972. How strange that NASA functioned for all those years, with a vibrant internal advisory structure rendering advice at all levels of the science program, but now cannot.

The coming year portends to be a most interesting and important one. By the time this column appears, the NRC decadal survey for Earth science should be released. This is a long-awaited document. For more than a decade now the Earth science program has been atrophying, and in recent years it has been practically in freefall. The decadal survey is expected to be the roadmap out of the abyss. There is a growing national sentiment to move more aggressively on understanding the environment and to make wise policy decisions to protect our future. NASA has a major role here, but not the resources required. Will NASA be provided with the resources, or will the broader science program be asked to take one for the team again? Or will this opportunity to revitalize the Earth science program of NASA be lost?

One indication of whether Earth science in NASA will rebound will come from the upcoming Presidential election in 2008. It is early in the campaign, and there are only a few candidates openly declared, but many more likely. There is a sense that global climate change, and the anemic response of the current Administration, will be a campaign issue. Certainly not at the same level of concern as Iraq, but nonetheless, of much more visibility than ever before. NASA Earth science could do well in a belated response from the current Administration, and even more so in the next Administration, regardless of party.

And since we are speculating on the year ahead, why not speculate with optimism that someone in a leadership position will move aggressively to fix the things that are broken in space and Earth sciences. Perhaps we should make a list and pass it in to the new Associate Administrator. Space missions cost too much. Something has gone seriously wrong, worldwide, with the management of flight programs. We are not getting full value for the funds spent, which in times of limited funding is a serious grievance. The scientific infrastructure of the nation is atrophying. University research groups, particularly experimental groups, are in decline. The science at NASA centers is being diminished by bureaucratic overload and seemingly simple things like inadequate accounting. An agency that argues that its best days lie ahead when it leads the civilization into space is seemingly unconcerned with the workforce and the infrastructure necessary for its success. The handoff to the next generation must be a managed process; new technology must be nurtured. And above all, the excitement of scientific discovery must always be encouraged. We are often awash in discouraging news about the constraints that funding and politics impose on us and can lose sight of the excitement of the science. The role of leadership in NASA should be to insulate the science practioners from these problems and encourage their success.

The space and Earth science program effectively began with the International Geophysical Year in 1957, with Sputnik, the formation of NASA, a host of scientific discoveries, and the launching of a generation of inspired scientists. In July of 2007, the National Academies will begin a yearlong series of events marking the 50th anniversary of the IGY; the final event in July 2008 will mark the 50th anniversary of the establishment of the Space Science Board [now renamed the Space Studies Board]. These events are not to be a celebration of the distant past, but rather a celebration of the excitement of the present and the promise of the future as the wonders of space open before us.

SPACE STUDIES BULLETIN
VOLUME 18, ISSUE 1 January-March 2007

In January, the new Congress finally passed the budget for FY2007. The budget was based on the Continuing Resolution that had been in effect since last October, and so NASA was denied the increase over FY2006 that it had expected. In early February, the President proposed his budget for FY2008, and the screws on NASA tightened yet again.

The requested FY2008 budget for NASA is essentially what was promised to the agency in FY2007. In that sense the Administration is consistent. However, essentially none of the problems were solved that were identified in the FY2007 requested budget, and are now exacerbated with an enacted budget for FY2007 equal to the FY2006 budget. (In the newsletter articles that follow, the Chairs of several of the standing committees of the Space Studies Board and other Board members express their personal opinions on the impact of the FY2008 budget request on their disciplines.)

NASA has made it clear that its number one priority is to build the Ares rocket and its Orion spacecraft to replace the Shuttle and serve as the vehicle to return us to the Moon. Left to its own devices, NASA may well have raided other parts of the agency budget in FY2007 to maintain schedule. Congress, however, fenced off funding for science and aeronautics in the enacted FY2007 budget. The result is that Ares and Orion have a serious funding shortfall in FY2007 and the schedule cannot be maintained. The gap between the planned retirement of the Shuttle and operational flights of Ares and Orion is growing, causing a range of concerns to NASA, from an inability to re-supply the Space Station, to the retention of a skilled workforce.

NASA's single-minded focus on Ares and Orion is evident in its treatment of the life and physical sciences in microgravity (i.e., the users of the Space Station) and of lunar robotic missions. These programs, both within the Exploration Systems Mission Directorate, are not fenced from the needs of Ares and Orion. The community of researchers in microgravity science has been decimated to a degree unparalleled in the history of U.S. science. In most of the sub-disciplines of this field there has been an 80% reduction in the number of external research grants, with the resulting layoffs of countless students and postdoctoral fellows. Also, the lunar robotic program now appears to be reduced to just the Lunar Reconnaissance Orbiter.

There is a certain logic, I suppose, to insisting that without Ares and Orion there is no human spaceflight program, and no return to the Moon, and so they should get the highest priority. However, support for the return to the Moon depends on the public being interested and believing in the long-term possibilities and opportunities of human spaceflight. Ares and Orion are of interest to NASA centers and aerospace industry, not the public. The strength of NASA, in particular NASA science, has been a strong external research community that is dedicated to and that cares about NASA's success. If nothing interesting happens relative to the Moon until 2020, if there is no real activity in preparing for long-duration spaceflight, and if the program becomes inwardly focused into NASA Centers and their contractors, it will have no legs. A major strength of the Apollo program was that something exciting happened every few months. The public interest did not wane until success was achieved.

The single-minded focus on Ares and Orion is also evident in the resistance to any calls for increases in other portions of the NASA budget. The just-released NRC decadal survey for Earth science documented the missions that are required to answer the questions important to society on the future of Earth. Not surprisingly, it said more money is required. More surprisingly, it said a viable program could be constructed just by returning the Earth science budget of NASA to its FY2000 level. However modest this request, it has been labeled a brazen and unacceptable recommendation. One could be cynical here. Research into the causes and future of climate change has to be one of the most important undertakings that the government should support, and today, with the overwhelming public concern about global climate change, one of the easiest programs for which to seek funding. But the NASA budget is fixed. Increases in funding for Earth science could come at the expense of support for Ares and Orion, and so the decadal survey's request is being attacked.

The American Competitiveness Initiative (ACI) resulted in increases in funding for programs in fundamental science (e.g., the National Science Foundation and the Office of Science in the Department of Energy). These programs were among the few that saw increases beyond their FY2006 budget level in the enacted FY2007 budget. It is difficult, in fact impossible, to distinguish between the fundamental science conducted by NASA in its Science Mission Directorate (SMD) and the fundamental science conducted by the NSF or the DOE Office of Science. It is interesting to note that had the funding for

SMD been allowed to increase in the same proportion as the NSF, it would have followed the pattern of growth it enjoyed in the late 1990s and early 2000s. Instead, the growth for SMD was curtailed in FY2006, to pay for the Shuttle and the Space Station.

Limiting the growth of SMD resulted in reductions to basic research grants provided by the Research & Analysis funding. Not only was science at NASA not allowed to be part of the ACI—even though comparable tasks at other agencies are allowed—but the very parts of SMD that most contribute to American competitiveness were cut. And, as noted above, the fundamental research in life and physical science in microgravity was decimated.

NASA does not have enough funding to fulfill its many obligations. I am a big supporter of a human spaceflight program that is to move our civilization out into space; but not at the expense of everything else. And not with a priority that denies everything else its opportunity to play its proper role in the national agenda, and be supported in the budget to do so.

I spend time these days interacting with Congress. NASA has many supporters in Congress. The biggest frustration I hear is that the Administration does not ask for the funds that NASA requires. The appropriations process starts with an allocation to the subcommittees, one of which has NASA in its portfolio. If the allocation is inadequate, there is little the subcommittee can do to help NASA. Yet, the allocation is influenced strongly by the Administration's request. It would be so much better if the Administration just asked for the funds that NASA needs. It would even be better if they just asked for the funds that were promised to NASA when the Vision for Space Exploration was announced in 2004. The shortfall is now measured in billions of dollars, and that does not include the extra cost of the return to flight of the Shuttle, or any new initiatives such as in Earth science.

NASA officials frequently tell the science community that we should be happy—the funding for the Science Mission Directorate, as a percentage of the NASA budget, is at an all-time high. But that ignores the fact that funding for science was decoupled from being a fixed percentage of the NASA budget in the mid-1990s and allowed to grow in proportion to non-defense discretionary funding, whereas human spaceflight was not. Science was allowed to grow in proportion to what the nation was prepared to spend on science— not just on space—and now it is not. The Earth science community is supposed to be happy because it is only one of four science thrusts in the SMD portfolio and funded roughly at that percentage of the total SMD budget. But this ignores the fact that in 1992, when Earth science in NASA took on its role of providing essential information on global climate change, Earth science funding was close to 40% of the NASA science budget.

These historical arguments are interesting but irrelevant. The budget issue we must confront is not what we had, but what we need. Science in NASA has a job to do. We are to explore the universe and lay down the foundational knowledge for the human expansion into space. We are to determine the future of the Earth, so that sound policy decisions can be made to protect the future of our civilization. We are to contribute to the capability of the United States to compete in the world, whether it is through new knowledge, new technology, or a new workforce. There is no comfort in knowing that we have been proportionally abused in the NASA budget. We do not have the funds required to do our job, and we are not happy.

SPACE STUDIES BOARD NEWS
VOLUME 18, ISSUE 2 April-June 2007

When there is good news, we should rejoice in it. The new leadership of the Science Mission Directorate (SMD), under Alan Stern as Associate Administrator, has brought welcome changes. Alan has exhibited insight into the concerns and issues facing the science community, as well as energy, imagination, and enthusiasm in addressing them. If the NASA Administrator, Mike Griffin, intended with this appointment to begin healing the growing rift between NASA and its science community, he made an excellent choice.

There is, of course, more to repairing the past damage to science in NASA and its relations with its external community than simply choosing a new leader. The new leader needs the freedom to act to correct past problems and to seek new opportunities. It has never been more important for the NASA Administrator, as have previous ones, to say to his Associate Administrator for science, "Go forth in concert with your community and build the best possible science program." SMD needs to be set loose to seek its proper role in the national agenda, not constrained by what other parts of the agency can or cannot realize in the way of support.

Consider Earth science. The world is worrying about global climate change. It is occupying political discussions in both developed and developing nations. To be sure, NASA is not responsible for remedying global climate change. However, NASA is the repository of the technical expertise required to study and understand the human impact on the climate, and to provide the knowledge required to make sound policy decisions to protect our immediate future. Congress understands this role; each recent markup of the FY2008 NASA Appropriations bill recognized the inadequacy of NASA's current Earth science program and each contained substantial increases in funding. Let us hope that in the President's FY2009 budget request for NASA, which is currently in preparation, SMD—and NASA—are allowed to seek the funding required for a vigorous Earth science program that is sufficient to meet the clear and present societal need.

There is also a need for SMD to be able to control its program. There is widespread concern in the science community about the number of Center employees being assigned to oversee the development of instruments and missions that have external Principal Investigators (PIs). This trend appears to be driven in large part by full-cost accounting, which requires all Center employees to have a program to which they can charge their time. Experienced PIs find this increased oversight counterproductive. It is more likely to increase risk rather than diminish it, and it is certainly a contributing factor in the growth of the costs of projects, both at the Centers and at the PI institutions. SMD should be encouraged and given the authority to fix this problem and reverse the trend.

The other good news in which we should rejoice is the concern and attention that Congress has been paying to NASA particularly to science in NASA. There have been a number of hearings this year by both the appropriations and the authorizing subcommittees exposing the inadequate funding that NASA, as an agency, suffers under and the particular dilemmas faced by science. In the markups of the FY2008 appropriations bills, both the House and the Senate added some money to NASA, in spite of limited overall allocations, and each singled out science as having been cut too far and in need of additional funds.

I have wandered about the Congress on behalf of space for many decades now and have some perspective. The authorizing committees and their long-serving staff, including Dick Obermann, Ed Feddeman, Jean Toal Eisen, and Jeff Bingham, have always been some of the strongest supporters of NASA, including science in NASA. It has been a pleasure this year to witness the care and concern for NASA exhibited by the new Chair of the House Appropriations Subcommittee overseeing NASA, Congressman Mollohan, and subcommittee clerk, Michelle Burkett. It is always a pleasure to observe Senator Mikulski take the strategic view and recognize that only a major infusion of new funds can save NASA. We all wish her and her co-sponsors in the Mikulski-Hutchison-Shelby amendment success in their attempt to increase the FY2008 NASA budget by $1 billion.

One particularly important area where Congress is seeking to focus more attention on NASA is with legislation related to the American Competitiveness Initiative (ACI). The ACI has garnered considerable Congressional support as a means to improve the competitive position of the United States and, particularly, our technical workforce. The ACI, which has resulted in major increases in funding for the NSF and the DOE Office of Science, is based on the recommendations of a highly influential NRC report: *Rising Above the Gathering Storm*. The authors of this report apparently did not consider NASA as a

whole to have an essential role in U.S. competitiveness and did not include it in their recommendations. There are, however, parts of NASA that should undeniably be included in the ACI. An essential part of the SMD mission is to build a technical workforce by providing hands-on experiences. Moreover, there are science disciplines in NASA that have a direct impact on the economy, such as Earth science and the study of space weather. And all the science disciplines at NASA provide fundamental knowledge, as do the NSF and the DOE Office of Science.

We are entering that strange political time when the President has reduced influence and limited opportunities for initiatives. We await, and have uncertainties about, who will be the next President and what his/her policies will be for space. In such times, the Congress becomes ever more important: to provide new initiatives in spite of the uncertainties, and to retain our momentum to ever improve the space program.

SPACE STUDIES BOARD NEWS
VOLUME 18, ISSUE 3 July-September 2007

The 50th anniversary of the launch of Sputnik, on October 4, is a time of nostalgia for those of us who are old enough to remember it, and for all of us in the space community, whose lives and careers were strongly influenced by Sputnik and the ensuing space race between the United States and the Soviet Union. It is also a time to ponder the difference between the halcyon days of the early space age and today, and wonder where the excitement has gone.

President John F. Kennedy, in his speech to a Joint Session of Congress on May 25, 1961, calling for the United States to commit itself to sending a man to the Moon and returning him safely to Earth within the decade, also said, "every scientist, every engineer, every technician, contractor and civil servant must give his personal pledge that this nation will move forward with the full speed of freedom, in the exciting adventure of space." And so we did. At the peak of the Apollo program some 400,000 Americans, some 20,000 industrial firms of all sizes, and 4% of the Federal budget were engaged in the pursuit of the civilian space program. That program—complemented by the growth in the military space program—created the space infrastructure on which the nation now depends, generated new science disciplines, and created legions of scientists and engineers, who since have fueled our continuing economic growth and wellbeing.

The story became disheartening in the early 1970s, when the Apollo program was canceled, and we turned our human spaceflight ambitions only to the utilization of space in low-Earth-orbit. But we at least continued a vigorous space science program. NASA, of course, never lost the dream. Two months after Apollo-11, Vice President Agnew chaired a Space Task Group that presented three options for the long-term goals of the U.S. space program: (1) a full-up program, costing $8-10 billion per year [then year dollars], including a manned mission to Mars, a space station orbiting the Moon, and another larger space station in Earth orbit served by a shuttle; (2) an intermediate program costing less than $8 billion per year but including a Mars mission; and (3) a program of $4-5.7 billion per year for an orbiting space station serviced by a shuttle. President Nixon chose only part of (3), the shuttle, but it is interesting to note that all of NASA's ensuing actions have been to try to follow this seemingly obvious path into space – first a shuttle, then a space station, then back to the Moon, and on to Mars.

Many of us were thrilled when President George W. Bush announced his Vision for Space Exploration in January 2004, putting NASA back on the path to the human exploration of space. Presidents are, of course, important for a vibrant space program. Kennedy established the human spaceflight program; Nixon destroyed it; the first President Bush tried to reinvigorate human spaceflight, but his efforts generated little enthusiasm, even in NASA. The current President Bush had the best opportunity in a generation, but unfortunately his support for NASA seems to have been a fleeting gesture. Not once since the FY2005 budget for NASA, announced at the time the Vision was introduced, has the President requested the funding that was said to be necessary to execute the Vision, and, in fact, many have judged that the initial projections of the funding required were inadequate. And Congress so far has been unwilling to correct the inadequacies of the President's request. In fact, in FY2007, when most of the Government was funded at the FY2006 level, serious cuts in the President's request for NASA resulted. And so to follow its dream of returning to the Moon, while still continuing to fly the shuttle and complete the International Space Station, NASA has been forced to cannibalize much of the rest of its program.

Many of the articles that are now being written in newspapers and magazines in honor of the launch of Sputnik discuss NASA's plans to return to the Moon. This is good, but I suspect for many Americans it is the first time they have had any realization of the undertaking. The cannibalization of the rest of NASA's programs to support the return to the Moon while continuing the current human spaceflight program, has reduced to invisibility many of the programs that the public identifies with an active space program. We are not using the Space Station we are building, nor do we have any meaningful plans to do so; apparently, we can't afford it. We are not pursuing a vigorous Earth science program to provide important data on climate change—an issue of profound public interest—due to lack of funds. We have a robotic program to demonstrate that the Moon is exciting scientifically and has potential for utilization, but that is, at best, anemic. We can hardly claim that NASA is an engine of technology, since the return to the Moon on the cheap appears to require that we rely on direct derivatives of existing technologies. And so NASA is reduced

And so we wait. What will the next President's policies be for space? Will we have leadership that

results in a NASA that is relevant to our society, generates excitement, and is supported for doing so? While we ponder that possibility, perhaps we should also consider what has gone wrong with the current Vision, or its implementation, that has left us unable to regenerate the excitement or support.

NASA is currently executing the Vision for Space Exploration as a remake of the Apollo program. All of NASA's centers, many of which were established to do Apollo, are to be maintained. The concentration is on putting people on the Moon, using many of the technical concepts from Apollo, modernized but applied directly. This, however, is not the 1960s, and the relevance of this approach to the industrial needs of the nation, and to the needs of our society, do not appear to be obvious to the public at large.

There are some who argue that we are about to enter into a space race to the Moon with the Chinese, and so we can indeed relive our Apollo past. But the analogy is, at best, strained. The Soviet threat to our supremacy in space was not just to our pride, it was a threat to our lives. The Soviets were our global strategic adversary. China, by contrast, is a major trading partner and a potential ally in the war on terrorism, though clearly we have sharp differences in many areas. To be sure, the future of the United States and our prosperity lies in our continuing to be a dominant space power. The claim cannot be made, however, that we are engaged in an immediate life and death struggle with the Chinese for the Moon, which would galvanize public support.

It is time, I suspect, to rethink NASA and the space program to ensure that it has a role—a supported role—in today's society and in societies to come. The lesson of the weak support for the current version of the Vision for Space Exploration is that we cannot relive our past and base our claim for support on what a previous society was prepared to invest in. Today, there is a global economy. The United States will survive and prosper based on our leadership in technology. We face global environmental threats. We are wealthy and we have the resources and, still, the boldness to invest in opportunities that will increase that wealth. This is the world in which NASA must be a contributing participant, even a major player. Then the excitement will return.

SPACE STUDIES BOARD NEWS
VOLUME 18, ISSUE 4 October-December 2007

As this column is being written, the Presidential primary season is now officially underway with the Iowa caucuses and the New Hampshire primary. This early in the primary season there will be no definitive answer from either, and the remaining primaries will have to decide who will be the nominees. Or perhaps for the first time in recent memory, the political conventions this summer will be interesting and deciding.

From the perspective of the space program, the next President and his or her policies on civilian space will be the deciding factor for our future. The important lesson learned these past four years since the announcement of the Vision for Space Exploration is that strong and vocal support from the President is required for human space exploration to be adequately funded to make significant progress.

Four years ago, in November 2003, the Space Studies Board (SSB), together with the Aeronautics and Space Engineering Board (ASEB), held a workshop to discuss what civil space policy should be. The Columbia accident had occurred the previous February, and there was a clear need to set a new direction for human space exploration, which had been confined to low-Earth orbit. The workshop expressed optimism that it was possible to have a space program whose dominant theme is to explore space, by both humans and robots working synergistically. There was a certain satisfaction when the following January, President Bush announced his Vision for Space Exploration (VSE), which contained many of the features discussed at the workshop. There is no evidence that our workshop influenced the President's policies, since the workshop report appeared on the day of the President's speech. Nonetheless, it was encouraging that separate and politically diverse groups arrived at similar conclusions as to how the civil space program of the United States should go forward.

Last November, the SSB and the ASEB repeated the policy workshop to assess what has happened since the announcement of the VSE and to discuss how the space program should proceed. The participants were not exactly the same, but as with the previous workshop, they came from the science, human spaceflight, and industry sectors. Unlike the earlier workshop, however, there was little optimism, but rather discouraging pessimism about how the space program has fared in the past four years. Since the initial declaration of the VSE, we witnessed the attempted bifurcation of science into those disciplines that were judged to support exploration versus those that were not and should be cut. And most important, the President has provided no meaningful follow-up support for NASA, either through public statements or through subsequent budget requests.

Almost to a person, the participants in the November 2007 workshop expressed the opinion that NASA cannot succeed with its human exploration program to return to the Moon at its current funding levels. Moreover, the current NASA strategy of cannibalizing other parts of the NASA program to make even limited progress in building Ares and Orion is not a strategy for success, but rather one of desperation, and will not succeed.

There was a flaw in the VSE that was not recognized at the time it was announced. The VSE provides nothing for NASA to do that is of immediate relevance to the people who must pay for it. The VSE is about the future, which is what it should be—moving our civilization into space, utilizing the resources and the opportunities that space provides to make our future as a civilization better, more prosperous, and more interesting. However, when current distractions dominate the public consciousness, like the war in Iraq or the economy, the future becomes less of a concern, and NASA becomes an afterthought.

The Apollo program's immediate relevance was geopolitical—the space race with the Russians. It had enormous impact on our future, creating the aerospace capabilities of this country, driving education and technological growth. However, the immediate support for Apollo was based on the race to demonstrate U.S. technological leadership in the world. There is, unfortunately, no equivalent geopolitical role in the VSE. The role, of course, could have been based on leadership, but we are not making any serious attempt to lead the nations of the world in exploring space, perhaps because we can't be counted on to have the resources required to be the leader that we would like to be. There are some who would set up a space race to the Moon with the Chinese. However, such a race is not possible. The Chinese need only say that they are not racing, which is their official position. The U.S. also has a trump card, should we choose to use it. We can simply say we won that race years ago.

There are rumors these days about the possible formation of a U.S. Department of the Climate, which in its most extreme form would gather together not only relevant policy agencies, but also the programs

that undertake climate research, including Earth science in NASA. This would be tragic for NASA. There are only two programs in NASA that are undeniably relevant to the priorities of the U.S. taxpayer––aeronautics and Earth science. It was a mistake for the current Administration to reduce these programs to anemic levels of funding. It would be tragic for NASA and its claims of relevancy to lose Earth science to a newly created Department of the Climate.

NASA has many supporters in Congress, and they made a valiant effort this year to provide NASA with more funds than the President requested. But under the threat of a Presidential veto, and with the need to provide funds for programs that the President did not request but that Congress judged important, NASA was funded in the overall Appropriations Bill at about the same level as the President's inadequate request. In fact, all of science suffered. The NSF received less than Congress had hoped to provide, and the Office of Science in the Department of Energy was funded at $500 million less than either the House or the Senate proposed.

And so we are left as we began this column. Our future will be determined by whether the next President has a civil space policy that will provide NASA with an important role in the future of the nation, and the personal leadership to ensure, in the face of immediate budget demands, that NASA is provided with the resources it needs to succeed. It is never much money in the context of the overall Federal budget. It is, however, the difference between success and failure.

SPACE STUDIES BOARD NEWS
VOLUME 19, ISSUE 1 January-March 2008

The only certainty in NASA these days is uncertainty.

Alan Stern, the NASA Associate Administrator for the Science Mission Directorate (SMD), resigned in the last week of March, having had the position for less than one year. Alan is a person of talent, energy, enthusiasm, and dedication to the success of Earth and space science. I wish him well in his career after NASA.

The Associate Administrator for Science at NASA is one of the most demanding management positions in the Federal government. The program is large, diverse, and technically challenging; the interfaces are many. As Associate Administrator, you need to be the equivalent of the CEO of a large subsidiary of a major corporation, and your constituents are as varied as those of the president of a major university. You need to empower a competent staff to manage all the different elements of the science program. You need to coordinate your activities with your management chain and your many external stakeholders so that you in fact have the power to make the right decisions. You need to anticipate that the costs and technical challenges of space hardware are rarely fully predictable in advance, and you have to manage in this uncertainty and deliver successful missions.

Ed Weiler, the current Director of the Goddard Space Flight Center and past Associate Administrator for SMD (1998-2004), has returned as interim Associate Administrator for Science. We should be very grateful for Ed's willingness to re-enter the cauldron of NASA Headquarters and confident of his ability to succeed. Ed has a proven record of having been a highly successful Associate Administrator.

We need, however, to brace ourselves for bad news. The program that Alan Stern put together—seven new starts, an increase in the Research & Analysis budget, all within a budget that only grows at 1% per year—is, in all likelihood, too good to be true, particularly with the pending need to fully fund the Mars Science Laboratory and the James Webb Space Telescope. Ed may find himself in the position of delivering the bad news of reality. As a science community, we need to work with Ed to tell him which of Alan's initiatives are the most important, since all priorities are not possible unless we can get more funding for science at NASA.

There are also some potential liens on the budget for the Science Mission Directorate (SMD), one of which is to fund the cost of flying the Alpha Magnetic Spectrometer (AMS). AMS is an extraordinary project. Many of the world's leading scientists in particle physics formed a consortium to develop a highly capable cosmic ray detector, funded by ~$1.6 billion in international contributions. They did so based on the commitment of NASA, made through the Department of Energy, to launch AMS on the Shuttle and attach it to the International Space Station (ISS). But then the Columbia accident happened, the Shuttle is to be retired, and its remaining use is to complete the construction and supply of the ISS. And so AMS, now in final calibration, has no ride. There is discussion of adding another Shuttle flight, or finding some other solution to launch AMS, but this discussion is often accompanied by the threat of charging the solution to SMD. That is quite unfair. The small portion of AMS that has been NASA's responsibility has always been funded through the physical science organization, which in its latest incarnation is housed within the Exploration Systems Mission Directorate. AMS as an experiment has never been prioritized or even considered by any of the governing NRC studies in astrophysics, and so prioritizing this science within SMD is simply not possible. It would, however, be most unfortunate if AMS remains unflown. It would be yet another example of the United States abrogating an international scientific commitment. It would also be yet another example of the folly of building the ISS but having no way to use it for science, which after all was one of the main arguments for its construction.

There is also uncertainty in Congress these days. In all likelihood, Congress will go home before the election without passing a budget for most agencies, including NASA. There are strong disagreements between the Democratically-controlled Congress and President Bush on many domestic priorities, and the expectation is that Congress will not conclude the budget for FY2009 until there is a new Administration and a new Congress. That obviously places uncertainty on many of NASA's programs. It is likely that the House or the Senate or both will markup the NASA budget at the Appropriations Subcommittee level, even if the markups do not immediately result in a bill that is sent to the President. It is to be hoped that such markups aggressively fund NASA, since this would be an important signal to the next Administration as to what NASA actually requires to be able to execute the nation's priorities in space.

The most uncertainty results from wondering what the next President's policies will be with regard to NASA and civil space in general. Each of the leading candidates has made some statements about NASA, in varying degrees supportive. There are not many details, nor should we expect any. NASA is not a big issue with the voters who are deciding the highly contested primaries, nor should we expect it to be in the general election.

When the new Administration takes over there is an opportunity for a critical analysis of the Vision for Space Exploration and NASA's role in the national agenda. We are now four years into implementing the Vision. So far, with the exception of the initial FY2005 budget, the Administration has not requested the funds it said were required to execute the Vision. There were underestimates of the costs required to continue to fly the Shuttle and complete the International Space Station. Consequently, NASA has been forced to cannibalize much of the rest of its program to even begin to make progress on the Vision. And it is hard to say that the Vision of returning to the Moon has generated much excitement, or even understanding among the public, particularly among the young who are expected to benefit most from the future that the Vision promises.

As was discussed in previous Chair's columns, and was a subject covered in recent testimony before the House Science and Technology Committee, the new Administration should consider whether there was a flaw in the Vision for Space Exploration, which we did not recognize at the time. The Vision is all about the future – extending our civilization into space, with the long-term benefits that we expect to accrue for our country. There is, however, little in the Vision that is of immediate concern. So when near-term needs intervene, such as providing funds for the war in Iraq or for Hurricane Katrina, it is NASA that comes up short in funding.

It should be possible to provide NASA with a role that is not only about the future, but is important in the present. Perhaps it is a more important geopolitical role – cooperatively leading the nations of the world in the exploration of space, and by doing so improving the image of the United States. Perhaps it is a more important role in improving the competitive position of the United States or simply re-emphasizing the programs that are of demonstrable immediate importance to the taxpayers – Earth science to provide the scientific basis for understanding global climate change, and aeronautics.

And it is to be hoped that with a more important role for NASA, the new President and his/her Administration will care that NASA succeeds and provide the resources and the opportunity for success.

The future is uncertain, but there is no reason to assume that it cannot be better.

SPACE STUDIES BOARD NEWS
VOLUME 19, ISSUE 2 April-June 2008

This is my final quarterly column as Chair of the Space Studies Board. My service, after five years, ended on June 30. For me, being Chair of the SSB has been the highlight of my career. The times have been challenging but extremely interesting. The influence of the Board has never been greater or more important. I am grateful to the two Directors of the Board with whom I served: my long-standing friend Joe Alexander and my new friend Marcia Smith. Each of them, and the staff that they have led, has made the success we have enjoyed possible. And then of course there are the many scientists, engineers, and policy experts who have served on the Board and its many committees. Collectively, they produced nearly 50 reports on a broad range of topics, from a decadal survey for Earth science, to a report on the repair of the Hubble Space Telescope, to a study of weird life elsewhere in the universe, to a study of the NASA workforce. The time contributed to these reports was all freely given. It is greatly appreciated and essential to the success of the space program.

I am also very pleased that Charlie Kennel is my successor. It is difficult to imagine anyone more qualified to be Chair of the SSB than Charlie. His own science discipline is space plasma physics. He has directed Earth science both at NASA and at the Scripps Institute of Oceanography. He has chaired countless NRC studies, including the recent astrophysical study on the Beyond Einstein missions. Charlie is familiar with the ways of Washington and of academia. I am certain that he will use wisely and effectively the great bully pulpit for space science that the chairmanship of the SSB provides.

This was a wonderful year in which to end my chairmanship of the SSB. We have had a year-long celebration of the 50th anniversary of the seminal events that launched the space age: the International Geophysical Year and the launches of Sputnik and Explorer 1; the Space Act and the formation of NASA; and the establishment of the Space Studies Board. It is remarkable how quickly events unfolded at the beginning of the space age, how soon the institutions on which we have depended came into existence, and how effectively they have functioned ever since.

This is also the 50th anniversary of the establishment of COSPAR, the Committee on Space Research, which has as its function to promote international cooperation in space science. I have been asked to deliver a keynote speech at the upcoming COSPAR General Assembly in Montreal on the wonderfully broad topic, "The Impact of Space on Society." The preparation for this talk has caused me to marvel on how profound and how deep the impact of space has been, and to recognize how much more impact is possible.

We live in a global, highly interdependent world. Trade is global, our industrial base is global, we are knowledgeable of what is happening in the world at all places and at all times. So much of this has been made possible by the space age: satellite communications, remote sensing, direct broadcast, and GPS, to cite just a few. And from this globalization has come a degree of stability. It is difficult to imagine a confrontation among nations whose economies are thoroughly intertwined.

Space has also profoundly altered our sense of our place in the universe. For some of us, it was the Apollo 8 picture of the beautiful but fragile Earth in the black sea of space. For others it was Voyager's picture of the planets as it left the solar system, revealing small and insignificant objects. And then there has been the steady drumbeat of planetary and astrophysical observations that reveal the majesty and the unfathomable vastness of the universe. We are in the midst of a second Copernican-type revolution; the first of which displaced us from the center of the universe to just another planet around the Sun. As the true vastness of the universe becomes known and appreciated by all and as we realize how common are our planetary circumstances, we become evermore aware of our insignificance. Perhaps we will view our insignificance in a positive light—that our tensions and conflicts—our constant, everyday concerns—are truly insignificant in the grand scheme of the cosmos.

The space programs of the world, however, are an underutilized resource. The U.S. space program was sized during Apollo to be supported by 4 percent of the federal budget, yet today NASA receives less than 0.7 percent. Other nations have developed capable space programs, and they too could do more if they were asked to. There are many problems that our societies face to which space could contribute an important solution.

We are suffering global climate change, driven by fossil fuel consumption required by the industrial age. Policy changes are needed, and they need to be based on facts, which can only be provided through space observations.

We need to increase the economic opportunities that are available to our societies. Perhaps by

expanding our economic sphere to include the near space environment, the Moon, and asteroids. And why stop there?

Perhaps we will decide that the future of fundamental physics is in understanding dark energy, which appears to be powering the expansion of the universe. The expectation is that future societies will depend on and profit from the discoveries we make, as has always occurred in fundamental physics. If we decide to extend human presence into space, we no longer have the luxury of treating the conditions and the hazards of space as an interesting scientific problem to be solved at our leisure. Rather, there is a compelling scientific need to develop a true predictive capability of the space environment through which humans will travel.

It cannot be that we occupy this vast universe alone. Where are the other life forms? Finding someone else out there will profoundly alter the course of human history.

There is a worldwide need for technically competent workforces to solve the many problems facing our societies and to ensure our economic futures. Space has a proven record of creating technically competent workforces.

Above all, there is a worldwide need to believe that the future can be better than the present and to collectively work to secure that brighter future. Space is all about the future. We envision a time when our planet is safe from ourselves. When our economics grow without bound. When our knowledge of the wonders of the universe becomes true understanding. When we are a true space-faring civilization.

During the past 50 years, space has had a profound impact on our societies. It has facilitated the globally interdependent world in which we live. It has forever altered our sense of our place in the universe. It is my fervent hope that in the years ahead we will be called upon to do so much more. We can make it a much better world, if we are set loose and supported to do so.