Testimony for the House Committee on Science and Technology's Subcommittee on Space and Aeronautics

"NASA's Science Programs: Fiscal Year 2009 Budget Request and Issues"
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Introduction

Mr. Chairman, Ranking Minority member, and members of the subcommittee, I want to thank you for inviting me to appear before you today to discuss NASA's Astrophysics program. My name is Jack Burns and I am a Professor of Astrophysical and Planetary Sciences at the University of Colorado, Boulder and Vice President Emeritus for Academic Affairs and Research for the University of Colorado System. I also have the privilege to serve as Chairman of the American Astronomical Society's Committee on Astronomy and Public Policy and as a member of the NASA Advisory Council.

Let me begin by thanking this Committee and the Congress for its leadership in crafting and passing H.R. 2272, America Creating Opportunities to Meaningfully Promote Excellence in Technology and Science Act (COMPETES), signed into law by the President on August 9, 2007. As aptly stated by Chairman Gordon, the America COMPETES Act "will help secure the United States' ability to compete in the global marketplace." It is an admirable response to the critical issues defined in the 2005 National Academies' report entitled "*Rising Above the Gathering Storm***"** led by former Lockheed-Martin CEO Norm Augustine. I urge the Congress to fully finance the programs authorized in the COMPETES Act to provide a much needed enhancement of the nation's innovation economy.

Speaking of innovation, NASA continues its long history of contributing to the country's high technology economy via spin-offs from it science programs. For example, Hubble Space Telescope (HST) images form one of the key databases behind *GoogleSky* bringing state-of-the-art imagery of the Universe into a tool now available to anyone, anywhere in the world with a computer (http://www.google.com/educators/spacetools.html).

In a similar vein, Microsoft recently announced its *WorldWide Telescope* software (http://worldwidetelescope.org/). The WorldWide Telescope is being developed using images from the HST and the ground-based Sloan Digital Sky Survey. A third example is a company called *Teraview, Inc.* that was founded to utilize Terahertz (i.e., very high frequency) technologies and sensors developed at JPL. These spin-off technologies from the space science program are being used for 3-D imaging and spectroscopy for biomedical and materials research (http://www.teraview.com/).

These examples demonstrate NASA's broad applications in astronomy, education and public outreach that are also fueling the private sector's technology innovations. NASA's leadership in these areas brings high visibility to U.S. science and technology achievements and attracts young people to these fields.

This is an exciting time for space science and astrophysics. In the next two years, NASA will launch several much anticipated missions including the gamma-ray large area space telescope, GLAST, the wide-field infrared survey explorer, WISE, and the planet-finding photometry telescope, Kepler. NASA will also be a major participant in international missions with the European Space Agency (ESA) such as *Herschel* that will seek thermal radiation from newly forming stars, planets, and ancient galaxies, and *Planck* that will probe the earliest epochs after the Big Bang. And, very importantly, the next Hubble Servicing Mission (SM4) will extend and enhance the life of the Hubble Space Telescope with the installation of new instruments including the Cosmic Origins Spectrograph.

While we enjoy a generous flow of data from past and current space telescopes, we are looking forward to new telescopes and new scientific challenges in the next decade. The astronomical community, under the leadership of the National Academy of Sciences (NAS), is preparing for the commencement of the Astronomy and Astrophysics Decadal Survey that is carried out once every ten years. This is an opportunity to look forward toward the future of space astrophysics in the context of a broad, national astronomy and astrophysics program. The next Decadal Survey will provide guidance for federal investment in the next generation of ground and space-based telescopes.

This priority-setting exercise has been *the* key ingredient in the success of U.S. astronomy and astrophysics for the past five decades. It is very important for the health of NASA's astrophysics program that we conduct an orderly evaluation of concepts across the full spectrum of astrophysics missions and wavelengths. To emphasize this point, the American Astronomical Society issued this statement in January 2008:

"*The American Astronomical Society and each of its five divisions strongly endorse community-based priority setting as a fundamental component in the effective federal funding of research. Broad community input is required in making difficult decisions that will be respected by policy makers and stake-holders. The decadal surveys are the premier examples of how to set priorities with community input. Other National Academy studies, standing advisory committees, senior reviews, and town hall meetings are important components. Mid-decade adjustments should also be open to appropriate community input. Pleadings outside this process for specific Congressional language to benefit projects or alter priorities are counterproductive and harm science as a whole. The American Astronomical Society opposes all attempts to circumvent the established and successful community-based priority-setting processes currently in place.*"

The astronomy community appreciates the continuing efforts of Congress to fund the programs that reflect these community priorities.

Responses to the Questions from the Chairman

1. **Do you believe the space science program, and especially the Astrophysics program, is moving in the right direction? If not, what changes do you think would improve the program and why? Please elaborate on your perspectives.**

Associate Administrator Alan Stern and Astrophysics Division Director Jon Morse are to be congratulated for their prompt, constructive responses to the community's deep concerns regarding the previous Astrophysics program budget that was in place before they joined the Agency last April. As noted by several individuals at hearings of this Subcommittee last year, there was discontent with the proposed future of astrophysics at NASA. Some important changes have been made by the new leadership that are highly laudable, although some key long term challenges remain.

Let me describe a few of the positive budgetary developments proposed for fiscal year 2009. First, the previous cuts in the Research and Analysis (R&A) budget have been largely reversed. This budget is proposed to increase by 8.5% in FY2009 and is forecast to increase further through FY2013 for a total of 48% growth over 5 years between 2007 and 2013. The R&A program permits researchers and their students to mine NASA's investments in astrophysics missions from the last decade. It provides investigators at universities and laboratories opportunities to conduct research on archived data, theoretical investigations of astrophysical phenomena related to NASA telescopic observations, laboratory studies, and the development of new instrumentation for future missions. In particular, it provides funding to attract young people and to train them in science and engineering, a key component of the America COMPETES Act.

Second, the Science Mission Directorate (SMD) has made a swift and positive response to the NAS' Beyond Einstein Program Assessment Committee (BEPAC) recommendation to begin funding for a Joint Dark Energy Mission (JDEM) in partnership with the Department of Energy (DOE) Office of Science. JDEM is proposed to have a budget of $8.5 million in FY2009 increasing to $125 million in FY2013. The challenges here are concluding an equitable partnership agreement with DOE and putting a strong cost cap in place at the level of $600-800 million for the total JDEM mission (including all life-cycle costs).

Third, NASA SMD has opened competition for three new small Explorer missions. This will help fill the previously identified "valley of death" in NASA's science mission launch schedule. It will also bring new university, laboratory, and industry teams, including graduate students and postdoctoral fellows, into partnerships for space science missions. In addition, SMD has restarted the previously canceled Explorer-class mission called the Nuclear Spectroscopic Telescope Array, NuSTAR, to explore the high energy X-ray sky up to energies of 80 keV. Similarly, NASA is reinvesting in sounding rockets and balloon experiments to prototype detectors and spectrographs for potential future satellite missions. SMD has begun to restore the balance within its portfolio of science launches with a healthier number of small missions.

The above investments and new starts are much appreciated by the astrophysics community. Drs. Stern and Morse have been very responsive to the recommendations of the previous NAS Astronomy and Astrophysics Decadal Survey as well as suggestions from other NAS committees. In all these areas, NASA Astrophysics is moving in the right direction.

However, I am very concerned about the overall drop in funding for Astrophysics from $1.363 billion in FY2008 to a proposed $1.162 billion in FY2009 (a decline of 14.7%). The budget is projected to remain flat thereafter. Using NASA's new-start inflation index, this forecast is a reduction of $423 million (31%) for FY2013 in real buying power over that for FY2008. This decrease is proposed to occur during an era of significant new astrophysics discoveries with observatories such as the James Webb Space Telescope and with the expected exciting recommendations from the Decadal Survey.

NASA's overall budgetary increases for several years have been below inflation and SMD's budget reflects this decline. Thus, Dr. Stern is attempting to rebalance the science portfolio, create new missions, support research and analysis of a rich archive from previous missions, and invest in future technology development – all with a flat or declining budget in inflation-adjusted dollars. This is a truly Herculean task!

The fundamental issue is that NASA is underfunded for its overall mission which, in turn, creates budgetary stress for all of the Directorates including Science. In my view, this is the key problem that must be addressed by the Congress and the next Administration.

2. What, if any major challenges do you foresee for the future of the NASA astrophysics program, as proposed in the FY2009 budget request? What are your suggestions for addressing those challenges?

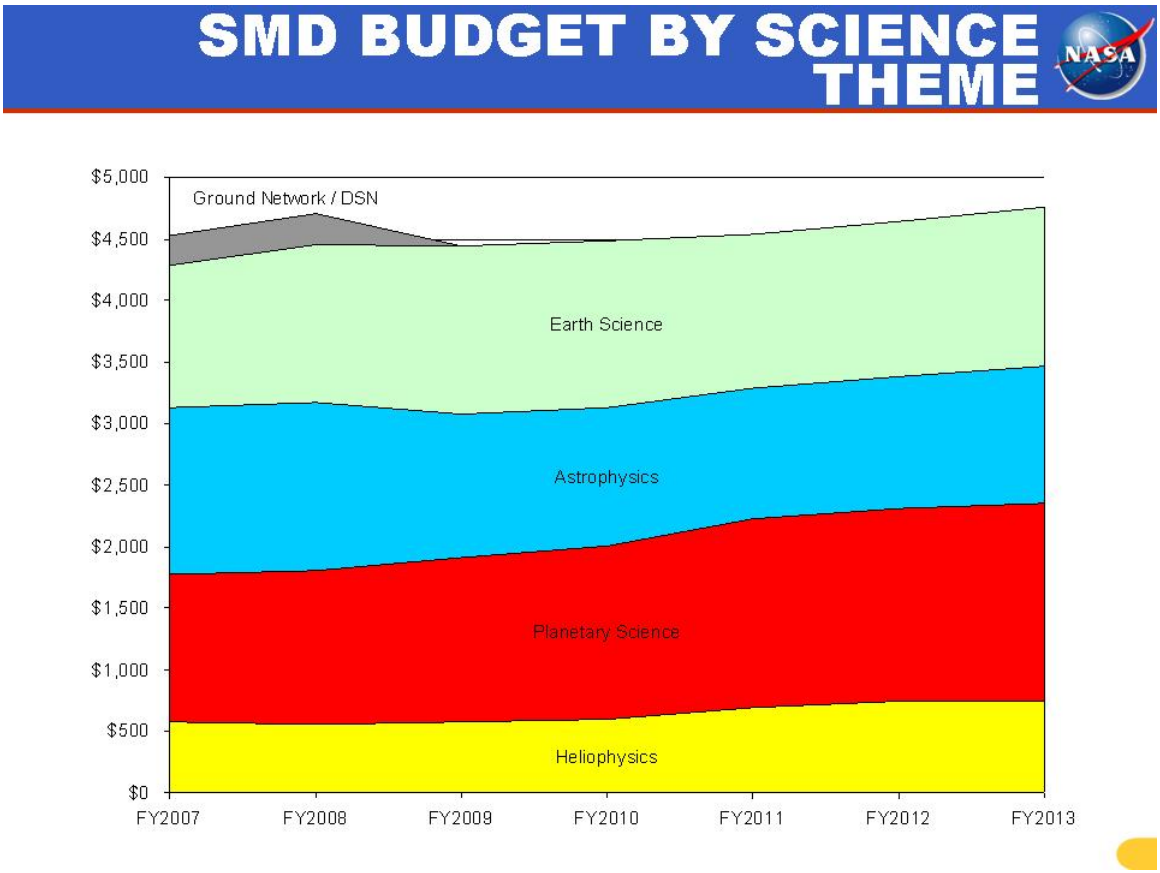
As noted above, the Astrophysics community will soon begin its Decadal Survey under the leadership of the NAS. A great deal of effort from our community, involving hundreds of astronomers, as well as significant resources from federal agencies will be expended in this priority-setting endeavor. But, this is well worth the effort. Our challenge in this Decadal Survey will be to set priorities over an ever-broadening scientific landscape and to embrace new ventures beyond those that we have pursued in the past. We will build consensus on a select set of priorities for new telescopes and new missions that will advance the astrophysical frontiers ranging from exoplanets to cosmology. These new missions must be realistically costed (for construction, operations, and de-commissioning) and cost-capped based upon the best available models and experience.

I believe that all missions, even those ranked by previous Decadal Surveys but without a funded new start, must be evaluated and ranked along with new ideas. The resulting roadmap of telescopes and technologies will help guide the Congress and federal agencies toward the most prudent and productive investments in the next decade. In the past, the Congress has praised the Astrophysics community as being the first to undertake

this difficult task of prioritization which has led to spectacular successes for missions such as the Hubble Space Telescope, the Chandra X-ray observatory, and the Spitzer Space Telescope.

As we begin the next Decadal Survey, we are facing a daunting challenge due to NASA's Astrophysics budget. How do we start new missions as recommended by the Decadal Survey with a budget that is forecast to decline by 31% in real buying power over the next 5 years? Even within SMD, Astrophysics is shrinking relative to the other divisions. This is shown in the figure below provided by SMD.

From FY2007 to FY2013, Astrophysics' budget "wedge" diminishes while Earth Science, Planetary Science and Heliophysics all grow. Earth Science is increasing in response to the exciting agenda put forward by its Decadal Survey. The declining wedge for Astrophysics has been developed before the astrophysics community has had an opportunity to make its case among the other science themes with the results from the Astronomy and Astrophysics Decadal Survey. I think we may have the cart before the horse here. I urge flexibility in budget planning for the outyears in SMD to insure that we, too, in Astrophysics have an opportunity to make our case for new investments after our Decadal Survey is completed.



The Astrophysics community must continue to assist NASA during this time of tight budgets. We must do a better job of full-costing for new missions and then we must hold

these missions to those costs within realistic contingencies. This must be a partnership between astrophysicists, aerospace contractors, and NASA with an *a priori* agreement on terms by all parties.

Our community, working together with NASA, must continue to shutter space-based observatories as they age and decline in scientific effectiveness. This is often difficult and challenging. But, such decisions will become even more important in the future as we face limited budgets and a cadre of exciting new telescopes waiting in the wings.

I commend NASA Astrophysics for convening a Senior Review this Spring composed of members of the scientific community to examine most of NASA's current astrophysics missions. I urge NASA to perform a Senior Review on all its missions, including the Hubble Space Telescope after the SM4 servicing mission, over the next several years.

NASA Astrophysics faces the following challenges:

- How will NASA continue to support future technology development in key areas relevant to its next missions? NASA needs a technology-development fund agency-wide and, specifically, for the space sciences. Our community also needs further relief from the restrictions imposed by the International Traffic in Arms Regulations (ITAR) that are impeding international collaborations in space science technologies and astrophysics missions.

- How will NASA address the most exciting astrophysical questions that will inevitably emerge from the Decadal Survey in areas such as exoplanets, black holes, and dark energy? Budget stability, unlike that of the past few years, along with budgetary flexibility and new funding will be required.

- How do we train the next generation of space scientists given that the timescales for development and launch of new space missions are often measured in decades, much beyond that of the tenure of students in undergraduate and graduate programs? It is becoming extraordinarily difficult to train instrumentalists in this field. We need to consider creative new programs that fund students to work on missions while in graduate school through a faculty position, and/or a closer integration of rocket/balloon programs with space missions.

3. The FY2009 budget proposes initiating missions that will have budgets over $500 million. Is NASA's approach to these proposed new missions in terms of potential scope, preliminary NASA cost estimates, alignment with science priorities, estimated launch timeframes, approach to technology development, and opportunities for international or interagency partnerships consistent with the Astronomy and Astrophysics Advisory Committee (AAAC) and decadal survey recommendations? What, if any, risks or issues need to be considered with respect to these proposed initiatives?

Within the tightening budgetary framework, NASA is following the AAAC, Decadal Survey, and other NAS committee recommendations. Let me describe some of the challenges facing NASA's largest astrophysics missions over the next few years.

In the near-term, there remains much concern about potential JWST cost growth. Most of the astronomical community was shocked by the large increase in the cost of this mission several years ago. It was caused by unrealistic estimates of the development, construction, and lifecycle costs in the early design phases of this mission. I believe we have learned an important lesson from this undercosting and we must do a better job of cost estimation for new missions in the future. Although the history of JWST continues to produce nervousness among astronomers, I have not heard of any additional, imminent problems in completing and delivering the telescope to its orbit in 2013.

JWST is a remarkably powerful mission with potential science returns comparable to or exceeding those of the Hubble Space Telescope over the past two decades. The upcoming technical reviews for JWST will be important in truly understanding how well the project is doing. Such "flagship" missions have an essential role in Astrophysics since they involve the broadest cross-section of the community in observations ranging from planetary bodies in our solar system to the first galaxies that formed in the Universe. Smaller projects of the Explorer and Discovery class are faster and more nimble (i.e., able to respond quickly to new discoveries), but flagship missions such as JWST push the scientific discovery boundaries as only large aperture telescopes can do.

JDEM has been vetted by both the NAS *Quarks to Cosmos* Committee and, more recently, by the NAS BEPAC. The BEPAC concluded that "a JDEM mission will set the standard in the precision of its determination of the distribution of dark energy in the distant universe. By clarifying the properties of 70 percent of the mass-energy in the Universe, JDEM's potential for fundamental advancement of both astronomy and physics is substantial." This Committee found that the JDEM mission candidates have mature technologies, most having flown in space or developed in other programs. The BEPAC recommended as its top priority that "NASA and DOE should proceed immediately with a competition to select a Joint Dark Energy Mission for a 2009 new start." The charge and execution of this academy review was handled superbly, and NASA has acted swiftly and impressively on the BEPAC recommendation. NASA must now run a competition to evaluate and then select a single JDEM concept for its new start. In this process, the technology, the full lifecycle costs, and the risks must be carefully weighed. As I noted earlier, it is critical to cap the total budget from NASA and DOE to the $600-800 million level for JDEM so as to not impose further stress on the Astrophysics budget.

Other large, potential missions are awaiting evaluation by the next Astronomy and Astrophysics Decadal Survey. One very exciting potential mission for the next decade will be the search for extrasolar, including Earth-like, planets around other stars in our Galaxy. NASA will begin this effort with the 2009 launch of Kepler, a mission designed to indirectly detect exoplanets from the change in the light as these planets transit behind and in front of their parent stars. Recently, the Exoplanet Task Force convened by the AAAC has recommended a large-scale astrometric mission. They carefully avoided

specifying a particular concept because they believe a re-evaluation of the approach for an astrometric mission for planet searches is needed.

Furthermore, NASA has recently awarded several new "mission concept study" grants to examine additional ideas for exoplanet discovery with very different technologies. For example, the New Worlds Observer would use a 4-meter class telescope and a flower-petal-design star shade to dramatically reduce the light from the parent star and to directly image terrestrial as well as gas-giant planets in extrasolar systems. All these exciting concepts must all be carefully vetted and reviewed by the Decadal Survey. *This community-based priority setting must be allowed to proceed without intervention if we are to select which concept is best suited, both scientifically and technologically, to fulfill the goal of detecting exoplanets.* The entire balance of the astrophysics program is threatened if we attempt to start a new large project before JWST is completed and before the Decadal Survey has finished its analysis.

Other potential flagship missions evaluated by BEPAC include the Laser Interferometer Space Antenna, LISA, that would search for gravitational waves from the merger of black holes, and Constellation-X that will view compact and extended sources of X-ray emission with ground-breaking spectral resolution. These projects are continuing to develop with support from the FY2009 Astrophysics budget which I heartily endorse. Once again, this is consistent with the recommendations of BEPAC. Both projects have counterparts being developed by ESA. I strongly recommend that NASA enhance its efforts to seek collaborations on both projects from the international community to reduce costs and risks for these flagship missions. International partnerships will likely increase their appeal to the Decadal Survey.

4. The Committee on Science and Technology plans to reauthorize NASA this year and in so doing will communicate policy direction to NASA as well as to the next Presidential Administration. What, in your view, are the important issues with respect to NASA's space science programs that Congress should consider in its reauthorization of NASA?

From its founding days, NASA's mission has been exploration -- human and robotic, scientific and technological, near-Earth and the larger cosmos. I recommend that this Committee and the Congress reauthorize NASA to execute this mission on behalf of and for the benefit of our nation of explorers. The value of NASA to America is seen best via its pioneering outlook in exploring scientific frontiers, its human reach into and beyond Earth orbit, its inspiration to the next generation to study the STEM fields, and its development of new technologies to grow America's innovation economy.

Most importantly, NASA should be reauthorized with a budget that reflects this bold mission and its value to the nation. Much of NASA's current problems in transitioning from the Shuttle to the CEV, in its aeronautics programs, and in its science research missions are caused by underfunding. The budget is simply too small for the mission. *In my view, NASA should be reauthorized at a budgetary level sufficient to fulfill its mission*

or the mission should be descoped to reflect a lower level of commitment. The current limbo cannot continue as it demoralizes a dedicated NASA workforce and promises unachievable goals to the taxpayers. I hope that the Congress and the next Administration will choose the high road of investment and hold both NASA and its partners in the university and industry communities to high levels of efficiency, accountability, and effectiveness. I believe that the astronomical community is ready to generate a high return on investment for our fellow taxpayers.

The reauthorization should encourage NASA to move forward with the priorities developed in the community-wide Astronomy and Astrophysics Decadal Survey. It should also authorize enough funding to execute the most important priorities in the Decadal Survey. NASA must be able to accomplish its science mission, as well as those of the other directorates, in an adequate fashion.

There has always been a level of synergy between the science and the human exploration programs within NASA. NASA's first satellite launch 50 years ago, Explorer I, demonstrated new rocket technology that would take Mercury astronauts into space and also discovered the Van Allen radiation belts surrounding the Earth. More recently, astronauts aboard the Space Shuttle have ventured four times, and will return for a fifth time this August, to service the Hubble Space Telescope and to install powerful new instruments.

The Vision for Space Exploration promises some hopeful new synergy between human exploration of the Moon and science. The NAC Astrophysics Subcommittee and the NAS Report on *The Scientific Context for the Exploration of the Moon* recommended that the unique radio-quiet environment of the lunar farside is ideally suited for an array of low frequency radio telescopes that would uniquely detect the first structures to form out of the early Universe's "Dark Ages". In addition, the Ares V heavy-launch vehicle designed to deliver payloads and astronauts to the Moon has exciting capability to place very large telescopes, with apertures of 10-30 meters (compared to JWST's 6.5-meter aperture mirror), into the L2 Earth-Sun Lagrange point for extraordinarily deep viewing of the cosmos. NASA's reauthorization should promote further synergy between scientific and human exploration.

NASA must continue to explore in the broadest sense. Human explorations of the Moon and, in the future, near-Earth asteroids and Mars are exciting, fulfilling goals that will continue to define the U.S. as a great nation. Scientific exploration is equally fulfilling, contributes to the nation's high technology economy, adds to our intellectual development as a species, and inspires both young and old. NASA must continue to explore, in a balanced fashion, recognizing that all facets of exploration define the benefits of NASA to the nation. Human and scientific explorations produce excitement in equal measures and strong support for NASA.

In conclusion, astrophysics research continues to yield an unbroken string of revolutionary discoveries about the Universe with now over 250 planets known to orbit

around stars in our Galaxy, with giant black holes of a million to a billion times the mass of the Sun modulating star formation in galaxies, and dark energy dominating the energy density of the Universe possibly requiring another revolution in our conception of gravity and the nature of matter. Space astrophysics is a proven lure for students, a testbed for new technologies, and a training ground for the nation's next generation of innovators. As such, investments in astrophysics pay major dividends in elevating the nation's scientific and technological literacy.

Thank you again for this opportunity to share these thoughts with you today.