

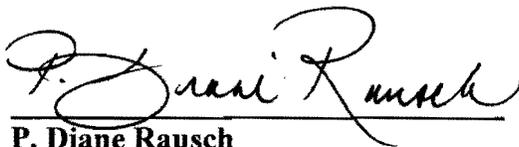
**National Aeronautics and Space Administration  
Washington, DC**

**NASA ADVISORY COUNCIL**

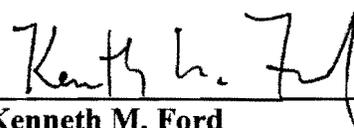
**August 5-6, 2010**

**NASA Jet Propulsion Laboratory  
Pasadena, California**

**MEETING MINUTES**



**P. Diane Rausch  
Executive Director**



**Kenneth M. Ford  
Chair**

**NASA ADVISORY COUNCIL**  
**NASA Jet Propulsion Laboratory**  
**Pasadena, California**  
**August 5-6, 2010**

**Meeting Report**  
**TABLE OF CONTENTS**

Call to Order, Announcements.....	1
Remarks by Council Chair.....	1
Welcome to NASA Jet Propulsion Laboratory.....	1
Remarks by NASA Administrator.....	2
Near-Earth Object (NEO) Program Overview.....	3
NEO Orbital Dynamics and Deflection.....	3
JPL Workforce: Recent JPL Hiring Patterns.....	4
Aeronautics Committee Report.....	5
Audit, Finance, and Analysis Committee Report.....	6
Commercial Space Committee Report.....	6
Education and Public Outreach Committee Report.....	8
Exploration Committee Report.....	9
IT Infrastructure Committee Report.....	10
Science Committee Report.....	11
Cost-Growth in NASA Earth and Space Science Missions.....	12
Space Operations Committee Report.....	14
Technology and Innovation Committee Report.....	15
Council Finding on Budget Request for Advanced Technology.....	17
Public Input.....	17
Appendix A	Agenda
Appendix B	Council Membership
Appendix C	Meeting Attendees
Appendix D	List of Presentation Material

*Meeting Report prepared by*  
*David J. Frankel*  
*Consultant*

**NASA ADVISORY COUNCIL**

**NASA Jet Propulsion Laboratory  
Von Karman Auditorium  
Pasadena, California  
August 5-6, 2010**

*Thursday, August 5, 2010*

Call to Order, Announcements

Ms. Diane Rausch, Executive Director, NASA Advisory Council (NAC or Council), called the meeting to order and welcomed the NAC members and attendees to Pasadena and the Jet Propulsion Laboratory (JPL). She stated that the NAC is a Federal Advisory Committee established under the Federal Advisory Committee Act. The meeting minutes will be taken by Mr. David Frankel, and will be posted to the NAC web site, [www.nasa.gov/offices/nac/](http://www.nasa.gov/offices/nac/), shortly after the meeting. Each NAC member has been appointed by the NASA Administrator based on the member's expertise. Each member is a Special Government Employee, subject to ethics regulations, and must recuse him or herself from discussions on any topic in which there could be a potential conflict of interest.

Remarks by Council Chair

Ms. Rausch introduced Dr. Kenneth Ford, Council Chair. Dr. Ford reminded everyone that the Council is a Federal advisory committee reporting directly to the NASA Administrator, providing advice and recommendations across the full-breadth of the U.S. civil space program. He noted that 10 of the total 12 members of the Council were present and that the vice-chairs for the missing members' committees were present in their place. General Edmonds was being represented by Dr. Charles Holmes, and Mr. Hanisee was being represented by Mr. Michael Montelongo. Dr. Ford extended thanks to the NASA Administrator, NASA Headquarters, and the Director of the Jet Propulsion Laboratory (JPL) and his staff for hosting the meeting. He explained that JPL is a very special place: it's the "home" of the U.S. solar system exploration program, along with a variety of astrophysics and Earth science missions. Since its beginning in the 1930's when California Institute of Technology (Caltech) Professor Theodore von Karman oversaw pioneering work in rocket propulsion, JPL has been at the forefront of this nation's ambitions in research, development, and technology innovation. He noted that incredible, cutting-edge R&D is taking place at JPL. He stated that the Council's tour of JPL the previous day was terrific, and noted that JPL is a fabulous place, filled with world-class scientists, engineers, and innovators.

Welcome to NASA Jet Propulsion Laboratory

Dr. Ford introduced Dr. Charles Elachi, Director, JPL. Dr. Elachi welcomed the Council members. He explained how JPL was started by Dr. Theodore Von Karman and described the various spacecraft in the auditorium. He described JPL's structure. NASA owns the facility and the employees are employed by the California Institute of Technology (Caltech). There is a contract between NASA and Caltech for the management of the facility. JPL is known for its work in planetary missions, astrophysics, and Earth science. They believe it is important to have an end-to-end capability where they conceive ideas, design and test, handle operations, and perform data analysis. That said, more than 50% of their funding goes to outside contractors. JPL is often assigned the toughest and most challenging Space Science missions. This approach helps maintain JPL's world-class expertise and ensures that JPL will be a "smart-buyer" with its contracted missions. Dr. Elachi observed that contrary to some pundits, innovation is alive and well at NASA. He explained that innovation can be something simple that no one had previously thought about or it can be the product of long and complex effort. One example is landing a Mars mission with air bags; another example is using planetary gravitation to reorient or change orbits. He described how mirrors for telescopes are being constructed with foil backed by tiny actuators, eliminating the need for milling and grinding, and allowing errors to be adjusted in space. He explained that this will revolutionize the way in which telescopes are built. The question is how do you innovate? It is not scheduled. You must hire the best people, give them an exciting environment, give them nearly impossible challenges, and turn them loose. Dr. Elachi explained that being part of Caltech is a great advantage because it gives access to Caltech's renowned research facilities and its emphasis on

excellence. World class researchers are also attracted to JPL due to its affiliation with NASA. He noted that the Caltech Board of Trustees makes sure that serving NASA is given the highest priority. Dr. Elachi explained that they work hard on early-career hiring. He observed that people usually want to hire people with experience. Early-career hires have to be mentored, but the advantage is that they do not know what is not possible and hence bring great energy. He described an approach focusing on high-tech, high touch, and high impact. He noted that JPL is quite concerned about the budget this year. The employees are not civil servants and have to be reasonably confident that money will be available. That is why new hires are down this year.

Dr. Ford thanked Dr. Elachi for addressing the Council and noted that JPL's hospitality had been fabulous.

#### Remarks by NASA Administrator

Dr. Ford introduced Mr. Charles F. Bolden, Jr., NASA Administrator. Dr. Ford noted that it is the Council's job to assist the Administrator by providing timely, relevant, and actionable advice through findings, observations, and recommendations.

Mr. Bolden thanked the Council members and audience for attending the meeting. He stated that they were in the innovation capital of the world. He agreed with Dr. Ford that JPL is a special place where amazing discoveries have the potential to happen almost every day. He noted that these are exciting and dynamic times for the U.S. space program. On June 28, 2010, the President issued the new National Space Policy for the United States. The goal is no longer just a single destination. The Policy broadens and strengthens NASA's research efforts and strengthens America's leadership here on Earth. NASA plays a fundamental role in the new direction described in the Policy. NASA is committed to working with other agencies, industry, and international partners to achieve our national goals in human and robotic exploration, and technology development that will ensure robust capabilities in the future. A new NASA Strategic Plan is being developed to serve as a road map for the implementation of the new National Space Policy. Congressional deliberations over the President's proposed FY 2011 Budget have intensified. While those discussions are continuing over several areas of NASA's budget, NASA is pleased that many key Administration policies are reflected in some way in the different pieces of legislation currently proposed by NASA's four Congressional oversight committees. In a time when fiscal restraint is critical, NASA appreciates the fact that the authorizers and appropriators have provided the Agency with a \$19 billion budget for FY 2011, as requested by the President. All the bills pave the way for the President's proposal to invest an additional \$6 billion in NASA over the next five years. All four bills recognize that the Constellation Program as it had been configured is no longer the right direction for achieving our boldest ambitions in space exploration. The bills support the President's proposed "flexible path" approach to space exploration, thus allowing us to reach a range of destinations that the President outlined in his April 15, 2010, speech at NASA's Kennedy Space Center, including the ability to visit Lagrange points, near-Earth asteroids, the moons of Mars, and Mars itself. The proposed budget bills provide funds for safely flying out the remaining Space Shuttle manifest, extending U.S. support for the International Space Station (ISS) through at least 2020, and increased spending for NASA's Earth science and NASA's aeronautics programs. They also support continuation of our strong space science program, enable transformative technology essential to human exploration, and support commercial spaceflight services to Low Earth Orbit (LEO). Mr. Bolden stated that he looks forward to receiving the Council's Observations, Findings, and Recommendations.

Dr. Charles Kennel stated that he chairs the California Council on Science and Technology and opined that the President's FY 2011 Budget proposal is very good for the state of California, not only because California receives around 20 percent of NASA's budget in different ways with three NASA Centers (i.e., Ames Research Center, Dryden Flight Research Center, Jet Propulsion Laboratory), but because the additions in the new budget provide very high quality money for technology development, entrepreneurial space launch facilities, and Earth science. Mr. Bolden expressed appreciation for this and suggested that Dr. Kennel could also have included aeronautics. Mr. Bolden described how NASA's Earth observing satellites have been used to help with the response to the Gulf oil spill, with the response to the earthquake in Haiti, and with the responses to the volcanic eruption in Iceland. Ms. Marion Blakey observed that there has been much cross fertilization between NASA's space programs and programs that come out of the Defense Advanced Research Projects Agency (DARPA). She stated that seeing that work at JPL is impressive, and that in Washington there used to be the National Space Council where the various aspects of the nation's space policy came together. She asked Mr. Bolden to share his insight on how that is being accomplished today. Mr. Bolden explained that the National Space Council was provided for in the National Aeronautics and Space Act of 1958, and has been used off and on over the years depending on the Administration. Due to past experience, Mr. Bolden is not a great supporter of the National Space Council concept. Dr. John

Holdren, Director of the White House Office of Science and Technology Policy (OSTP), coordinates these efforts today among all the science and technology agencies in the U.S. Government. Mr. Bolden also meets periodically with the Federal Aviation Administration (FAA), the Joint Chiefs of Staff, and the National Reconnaissance Office (NRO). The new National Space Policy announced on June 28, 2010, calls for increased cooperation and interaction among the international partners and across agencies. Mr. Bolden explained that it is very difficult to make Federal agencies effectively coordinate with each other, but that President Obama has encouraged the Federal agencies to work together and speak with one voice.

Mr. Bolden then awarded NASA's Exceptional Public Service Medal to Mr. Michael Montelongo for his past service on the NAC. Mr. Bolden awarded the NASA Distinguished Public Service Medal to Dr. Kenneth Ford for his service as NAC Chairman, and for his leadership of NASA's Blue Sky Study Groups.

Dr. Ford thanked Mr. Bolden for his remarks to the Council. At Dr. Ford's request, the Council members introduced themselves. Dr. Ford noted that they are an outstanding collection of distinguished experts with a fantastic set of diverse experiences in government, industry, and academia.

#### Near-Earth Object (NEO) Program Overview

Dr. Ford introduced Dr. Donald Yeomans, Head of the Near-Earth Object (NEO) Program Office (NPO), JPL. Dr. Ford stated that Dr. Yeomans is one of NASA's top experts in planetary small bodies, comets, and asteroids, which is a subject of continuing interest in NASA, Congress, and the White House. Dr. Yeomans provided an overview of NASA's NEO program. He explained that the population of NEOs is made up of active comets (one percent) and asteroids (99 percent) within 45 million km of Earth's orbit. The line between asteroids and comets is no longer clearly drawn. Comets are hazy balls that are mostly water, just below a dusty surface. Asteroids run the gamut from ex-comet fluff balls to slabs of iron. He described the history of the known NEO population and NASA's current NEO search survey results. NASA has discovered approximately 87 percent of all NEOs larger than one kilometer. NASA's goal for the next generation survey, as mandated by Congress, is to discover 90 percent of NEOs greater than 140 meters, and will require larger telescopes. Less than one percent of 30 meter-sized objects have been discovered. Radars and satellite observations have helped to characterize NEOs. Dr. Yeomans explained that a space-based infrared (IR) telescope in a Venus-like orbit would be extremely efficient for discovering NEOs and would dramatically improve the warning time for the small impactors, which are most frequent. The most likely damaging impactor will be around 30 meters in diameter. The average impact interval is estimated to be around 200 years, but warnings will be more frequent than that. Frequent sky coverage is all important. He discussed lessons learned about communicating the risks of impacts from NEOs: results must be authoritative, verified, and trusted; orbit and risk determination procedures must be explained in simple terms; verified results must be posted as soon as possible; and the public must be continuously informed. Educational websites for accessing this information are: [neo.jpl.nasa.gov](http://neo.jpl.nasa.gov), [ssd.jpl.nasa.gov](http://ssd.jpl.nasa.gov), and [jpl.nasa.gov/asteroidwatch](http://jpl.nasa.gov/asteroidwatch). Dr. Yeomans described the NEO program benefits to science, space resources, human exploration, and planetary defense. NEOs are the least changed remnants of the Solar System formation process. They may provide future watering holes and fueling stations in space. It is important for us to find them before they find us. He described the process for computing and verifying impact probabilities. The information is presented on JPL's Sentry NEO Risk page—[neo.jpl.nasa.gov/risk/](http://neo.jpl.nasa.gov/risk/).

Col. Eileen Collins suggested it would be helpful to know whether a 30-meter NEO was iron or another material that might not be as dangerous. Dr. Yeomans explained that this could be done using a spectroscopic analysis if it was found early enough. In response to question from Col. Collins, he explained how they calculated the total NEO population that remains to be discovered. In response to a question from Mr. Miles O'Brien, Dr. Yeomans explained that a NEO coming directly from the sun would be discoverable because it would have previously been in the dark.

Dr. Ford thanked Dr. Yeomans for his presentation.

#### NEO Orbital Dynamics and Deflection

Dr. Ford introduced Mr. Rusty Schweickart, former Apollo Astronaut and Co-Chair, NAC Ad-Hoc Task Force on Planetary Defense, who briefed the Council on the orbital dynamics and mitigation strategies for protecting Earth from NEO impacts. Mr. Schweickart explained that an "impact" is the coincident location of a NEO and the Earth or the NEO and a "keyhole" at the three-dimensional intersection of the orbits of the Earth and the NEO. A "keyhole" is a small gravitational region near the Earth's orbit, which if a NEO-passes through it, will cause the NEO to return

years later and impact Earth. Mr. Schweickart explained how a keyhole increases the probability of an impact, using as an example the asteroid Apophis. A potential impact can be mitigated through a deflection. This is a maneuver executed years prior to an impact to cause a small change in the velocity of a threatening NEO, resulting in the NEO arriving either too early or too late to impact the Earth or a keyhole. The challenge is to discover a potential impact in time to trigger a deflection campaign. A decision on a deflection campaign may need to be made between eight and eighteen years prior to the potential impact. A deflection campaign for a direct impact would require at least two coordinated missions to (1) precisely determine the NEO orbit, (2) execute the primary deflection, (3) observe and confirm the primary deflection, (4) determine the new NEO orbit, and (5) trim the new orbit to avoid a keyhole impact, if necessary. A deflection campaign for a keyhole impact would require a single mission to (1) determine the NEO orbit, and (2) adjust the NEO orbit to avoid a keyhole impact, if necessary. Mr. Schweickart described the current range of possible approaches for deflection. A "kinetic impact" can be used to push the asteroid by direct impact. This method is robust, but imprecise. A "gravity tractor" could pull the asteroid using mutual gravitation as a tow-rope. Any spacecraft can be used for this. The method is weak, but precise, and would be adequate if it is used before an asteroid passes through a keyhole. A third method would be a "standoff nuclear explosion" that explosively vaporizes surface from the NEO to create an impulsive push. This method is robust, but imprecise. The primary issues are uncertainty and variability for kinetic impacts, the uncertainty of fragmentation, and the validation of gravity tractor position control in proximity to rotating NEOs. A major asteroid impact would release energy levels equivalent to hundreds of thousands of nuclear weapons going off at one time and would cause world-wide panic.

Dr. Kennel observed that eventually more and more objects will be discovered heading towards a keyhole. The question, therefore, is how large would the impact probability have to be for the country to decide that there needs to be a standby gravitational tractor ready to go. Mr. Schweickart explained that while the incidence of actually getting hit with a 30-meter NEO is once every 200 years, the decision must be based on the probability that the Earth would be hit. Under that circumstance, a difficult decision on whether to launch a deflection campaign may be required every four years. In response to a question from Mr. O'Brien, Mr. Schweickart stated that the Task Force's recommendations will include recommendations on public information and education. The recommendations are being drafted for submission from the NAC to the Administrator. In response to a question from Mr. Montelongo, Mr. Schweickart stated that the most critical task is to find the asteroid well before it passes through a keyhole. He predicted that a decision to launch a deflection mission will be very difficult to make and that it is unfortunately likely that an impact with the Earth will occur before the political will be strong enough to enable appropriate action.

Dr. Ford thanked Mr. Schweickart for his presentation.

#### JPL Workforce: Recent JPL Hiring Patterns

Dr. Ford introduced Ms. Cozette Hart, Director, Human Resources Department, JPL, to brief the Council on hiring trends for new hires at JPL. He noted that the Council had been briefed on hiring trends at the other NASA Centers at the last Council meeting. Ms. Hart stated that her data covers regular employees, early-career hires, students, and student conversions. She defined an early-career hire as someone who is employed at JPL within three years from earning their highest degree. Ms. Hart reviewed charts showing new hires by year, type, and function. Student hires and student conversions make up 34 percent and 37 percent, respectively, of new hires. She reviewed a chart showing the pipeline for student hires by employment program. The employment programs are academic part time, cooperative education, academic intern, and summer. Historically, the average age for all employees has been around 46. Recently, for the first time, the average age has moved to 47. There has been a dramatic increase in the numbers for student hires. The focus now is on geographic diversity. Their strategy is to bring students in for a few summers and get to know them. JPL's goal was to increase the summer students by 50 percent; they achieved 70 percent. Ms. Hart reviewed a chart showing the number of hires by state. For the years covered by the study, new hires came from 39 states. Twelve new hires came from foreign countries.

Ms. Esther Dyson described how it had been inspiring to tour JPL and meet the students and early-career hires. An older employee she met was not as excited as the early-career hires. Ms. Hart stated that JPL has made a commitment to increase its early-career hires. She reported that the greatest turnover occurs when people reach the 10-14 year mark, which is when people have families and want to have a home and move back to their home state. She believes that JPL employees are satisfied because the turnover rate is low compared to industry. Dr. Ford explained that having people leave in the 10-14 year mark creates opportunities for new hires and, therefore, is not necessarily a bad thing.

Dr. Ford thanked Ms. Hart for her presentation.

Aeronautics Committee Report

Dr. Ford introduced Ms. Marion Blakey, Chair, Aeronautics Committee. Ms. Blakey briefed the Council on technical challenges to the Next Generation Air Transportation System (NextGen) relating to mobility, energy and environment, and safety. She described technical barriers to meeting the air transportation system's needs. The system is governed by manual processes. There are limited automation and decision support tools, and the system lacks up-to-date infrastructure for better surveillance, navigation, and communications. She discussed the approach to removing these barriers through advanced concepts and technologies, and integrated solutions. Ms. Blakey described NASA's Airspace Systems Program (ASP) in the Aeronautics Research Mission Directorate (ARMD) and the NextGen challenges in energy and the environment, affecting fuel efficiency, emissions, and noise. She noted that 40 of the top 50 U.S. airports are in areas that do not meet air quality standards. Since 1980, the FAA has invested over \$5 billion in airport noise reduction programs. Ms. Blakey discussed subsonic fixed wing and supersonic technical challenges. She described novel operation concepts that are being used to safely increase throughput while reducing environmental impact. Continuous Descent Approaches (CDA's), which minimize noise exposure and are currently being flown at off-peak hours or in low-congestion airspace, will be optimized through tailored arrivals and an Enroute Descent Advisor (EDA). Airborne merging and spacing will be delegated to the flight deck. An energy navigation concept (eNAV) will optimize fuel burn, noise, and admissions reduction. Ms. Blakey described rotorcraft technical challenges and new concepts in open rotor research. She presented a chart showing NextGen challenges in safety. These include Verification & Validation (V&V) of flight critical systems, decision-making, strategies for loss of control, situational awareness, in-flight icing, and other hazard sensing. She described the Icing Research Tunnel (IRT) at NASA's Glenn Research Center. This is the world's largest refrigerated wind tunnel dedicated to studying aircraft icing. It is in high demand by both military and commercial customers. Ms. Blakey noted that V&V is a widely recognized concern that had been discussed by the President's Council of Advisors on Science and Technology in a 2007 report. The problem is that developers do not have effective ways to model and visualize software complexity. Developers also do not have effective ways to test, validate, and certify that software-based systems will perform properly, particularly under attack or in partial failure. Ms. Blakey described V&V objectives for flight critical systems and the V&V planning approach in the ASP. She reported that a July 8, 2010, meeting of V&V experts concluded that there were no major gaps and NASA has the right people. Dr. Ford explained that verification means "Are we building the system right?" and validation means "Are we building the right system?"

Ms. Blakey presented for the Council's consideration two proposed Findings on ASP's work. The Council approved the Findings as follows:

- 1) With regard to ASP's NextGen work, the Council suggests that greater emphasis be placed on environmental and energy aspects rather than on capacity problems to reflect the increasing importance of these emerging issues.
- 2) We support the new research focused on broader benefits of Automatic Dependent Surveillance Broadcast (ADS-B) and urge that ASP carefully survey complimentary research before committing to specific research.

Ms. Blakey presented for the Council's consideration a proposed Observation on ARMD's NextGen research and a proposed Observation on V&V research. The Council approved the Observations as follows:

- 1) Judging by the presentations that were focused on the process and program alignment, ARMD's NextGen research is very well connected to national research goals. In order to make a more complete assessment, the committee has requested further discussions be focused on technical content and measures of success.
- 2) V&V is an important new area of research within aeronautics for NASA. From the information presented, the Council could not determine the focus and technical content of the research in the V&V program plan and the practical application of this research.

Dr. Raymond Colladay stated that several years ago the NAC had recommended that NASA put more emphasis into new emerging technologies. He explained that it doesn't help to reduce fuel consumption if noise goes up as a result. He noted that the National Research Council's (NRC) Aeronautics and Space Engineering Board (ASEB) will be examining what can be done for experimental aircraft. The ASEB has a growing concern that NASA does not have adequate resources for experimental aircraft. He predicted that when NASA converts to the unified labor account, people will be shocked at the numbers for aeronautics because it is so manpower intensive. Dr. Ford suggested that in many ways, aeronautics is grievously underfunded.

Dr. Ford thanked Ms. Blakey for her presentation.

#### Audit, Finance, & Analysis Committee Report

Dr. Ford introduced Mr. Michael Montelongo, Vice-Chair, Audit, Finance, and Analysis Committee, who represented Dr. Robert Hanisee, Chair. Mr. Montelongo briefed the Council on the Committee's meeting with Dr. Beth Robinson, NASA's Chief Financial Officer (CFO) and Mr. Paul Martin, NASA's Inspector General (IG). He described the Strategic Investment Division (SID), which is now part of the Office of the Chief Financial Officer. SID has two major functions: agency-level strategy and performance management with an external focus, and program analysis with an internal focus. It provides the link between performance and budget. It oversees and coordinates planning and performance reporting, assesses budget requirements and competing funding demands, and evaluates the effectiveness of programs, policies and procedures. Mr. Montelongo described NASA's strategic investments process. It has four phases: a planning phase, a programming phase, a budget phase, and an execution phase. He reviewed the status of the FY 2010 financial statement audit. There are three high-risk areas that could adversely impact the auditor's opinion: the ISS valuation, unfunded environmental liabilities, and the line item for other property, plant, and equipment (PP&E). The PP&E line item, which had not been previously tested or audited by Ernst & Young, is valued at \$3 billion and covers property held by contractors—primarily Boeing. Mr. Montelongo described NASA's Open Government Initiative, which was developed in response to the December 8, 2009, White House Open Government Directive calling on all Executive Branch agencies to become more open, accountable, and centered on the principles of transparency, participation, and collaboration. He described NASA's Open Government Plan. He also described NASA's Federal Spending Information Data Quality Plan, which is a document required under the Open Government Directive. Mr. Montelongo provided an update on NASA's Earned Value Management (EVM), which is a tool for the cost and schedule progress of programs and projects. It is part of the comprehensive "plumbing" that NASA is installing to demonstrate that it can improve its delivery of projects on time and within budget. NASA's goal is to develop and deploy an Agency-wide organic EVM capability that is ANSI/EIA-748 compliant. Only JPL is currently ANSI/EIA-748 compliant.

Dr. Colladay asked who was responsible for independent cost estimations. Mr. Montelongo researched this question and advised the Council on Friday that the cost estimating function is performed within the Office of Independent Program and Cost Evaluation (IPCE), which is not in the Strategic Investment Division of the Office of the CFO. The IPCE has four divisions: Studies and Analysis Division, Cost Analysis Division, Independent Program Assessment Division, and Mission Support Division. Dr. Kennel stated that the Constellation transition is a surprisingly interesting topic and that its implications will generate many Congressional questions. Dr. Colladay asked whether there is a turnover problem with the CFO's staff. Mr. Montelongo responded that it has been a challenge for the CFO to staff all its positions due to the demand in the private sector for qualified accountants and the implications from the retirement of senior staff. In response to a question from Ms. Blakey, Dr. Ford explained that the NAC will have an opportunity to review NASA's Strategic Plan, which is undergoing a major revision. Ms. Blakey requested a presentation on the way in which the plan is developed and how it is used.

Dr. Ford thanked Mr. Montelongo for his presentation.

#### Commercial Space Committee Report

Dr. Ford introduced Mr. Brett Alexander, Chair, Commercial Space Committee, who briefed the Council on their findings and recommendations concerning commercial crew activity. He noted that NASA has been doing an excellent job working through these issues, notwithstanding the outside interests that are pulling from different directions.

Mr. Alexander presented for the Council's consideration a proposed Finding on the use of Space Act Agreements (SAAs). He noted that the use of SAAs is appropriate due to the combination of public and private partnerships. The intent is to mimic the Commercial Orbital Transportation Services (COTS) Program. In response to a question from Mr. O'Brien, Mr. Alexander explained that, in his view, SAAs give the U.S. Government and its contractors greater flexibility than is afforded by the Federal Acquisition Regulations (FAR). The Council approved the Finding as follows:

The Council finds that the use of Space Act Agreements (SAAs) is appropriate for the proposed Commercial Crew Transportation program to develop and demonstrate commercial crew capabilities for the delivery of astronauts to and from the International Space Station. The use of SAAs is appropriate because the program is envisioned as a public-private partnership, in which both parties provide funding, to develop capabilities that will be owned and operated by the private sector to serve both government and private sector markets. In addition, SAAs allow flexibility in the development of transportation capabilities. For subsequent crew transportation services, the use of Federal Acquisition Regulations (FAR) Part 12 commercial services contract is appropriate.

Mr. Alexander presented for the Council's consideration a proposed Recommendation on NASA's traffic requirements for commercial crew transport to and from the ISS and other LEO destinations. Mr. Alexander explained that the CSC has been given different numbers on NASA's expectations. Dr. Colladay advised that this would always be an estimate and will change all the time. Dr. Kennel explained that it is important to the commercial industry to have an idea about what is going to happen. NASA should provide the framework for how it thinks so that industry can work out the numbers for itself. Ms. Dyson suggested that this might be viewed as a subtle budget request. Mr. Alexander noted that these services, if available from commercial providers, must be purchased from those commercial providers, rather than from Russia. Dr. Wes Huntress asked how NASA would be able to assess and define its traffic requirements without knowing what the commercial capabilities will be. Mr. Alexander responded that the commercial companies need to know the requirements so they know how to design their products. Dr. Kennel explained that cargo requirements can be defined because you know what is needed for ISS resupply. He'd prefer to see an estimate or range of estimates and noted that industry deserves NASA's best thinking about the direction in which it is going. After further discussion, the Council approved the Recommendation as follows:

The Council recommends that NASA assess and define the NASA traffic requirements for crew transport to and from the International Space Station (ISS) and other Low Earth Orbit (LEO) destinations prior to issuing a draft solicitation for the Commercial Crew Transportation program. The number of flights and/or seats per year purchased by NASA on U.S. commercial spaceflight vehicles has a significant impact on the business plans of and availability of private investment for commercial providers. In assessing its requirements, NASA should consider how the availability of commercial space transportation capabilities could change the concept of operation of the ISS to get the most out of its infrastructure.

Mr. Alexander presented for the Council's consideration a proposed Recommendation on NASA's concept of operations and acquisition approach. Dr. Colladay stated he understands why the commercial industry would like this recommendation as drafted and that he does not know why NASA would want to commit to it. After further discussion, the Council approved the Recommendation as follows:

The Council recommends that NASA structure the crew transportation service acquisition approach and associated ISS concept of operations to take maximum advantage of the variety of potential commercial transportation capabilities. The Council recommends that future commercial crew transportation service solicitations simply specify the minimum and maximum number of seats to and from the ISS NASA would purchase in a given solicitation. This approach will allow bidders flexibility to structure the offer that best fits the offeror's business model.

Mr. Alexander presented for the Council's consideration a proposed Recommendation on FCC licensing. Mr. Alexander explained that from a commercial perspective it is important to have a single regulatory regime. In response to a question from Col. Collins, Mr. Alexander explained that the FAA licenses commercial cargo. Dr. Ford stated that as he understood it, the Commercial Space Committee thought that FAA licensing would not limit NASA's ability to specify safety standards; however, he added, that is not everyone's view at NASA. Ms. Blakey suggested making distinctions between LEO and suborbital flights. Mr. Richard Kohrs noted that this would be the first time that the FAA would be involved in the safety of humans returning from space. Dr. Kennel stated that NASA will have to help support the FAA develop an expeditious licensing process. Mr. Alexander explained that NASA is not likely to give up its responsibility to ensure safety and that NASA, as a customer, would be able to insist that the transportation is safe for its people. A company will need to ensure that it can be flight certified if it wants to fly for NASA. In response to a question from Dr. Kennel, Mr. Alexander stated that the FAA would specify basic safety requirements and that NASA could impose more stringent standards. The Council approved the Recommendation as follows:

The Council agrees with NASA that Federal Aviation Administration (FAA) licensing of Commercial Crew services should be the "eventual state." The Council recommends that NASA engage the FAA as soon as possible to discuss FAA licensing of Commercial Crew with the goal of providing clarity to potential offerors regarding the regulatory framework for both development and operation of Commercial Crew capabilities.

Mr. Alexander presented for the Council's consideration a proposed Recommendation on the business case for the Commercial Crew Transportation program. After a brief discussion, the Council approved the Recommendation as follows:

The Council recommends that NASA continue to develop internal metrics and milestones to oversee its Commercial Crew Transportation program and associated industry. Appropriate internal experts can then use these tools to measure whether NASA crew needs will be met in a timely and cost effective manner under this program. Among other things, NASA should be aware of the impact of non-human spaceflight markets, such as cargo and traditional spacecraft launch, on the ability of commercial providers to offer viable crew transportation services, the cost, reliability, and safety implications of the overall commercial space transportation business, and the impact of domestic and foreign competition.

Dr. Ford thanked Mr. Alexander for his presentation.

#### Education and Public Outreach Committee Report

Dr. Ford introduced Mr. Miles O'Brien, Chair, Education and Public Outreach Committee. Mr. O'Brien introduced Mr. David Weaver, NASA's new Associate Administrator for the Office of Communications, and noted that the Committee is working with him on a work plan. Mr. O'Brien discussed NASA's reticence about marketing. He explained that useful dissemination of information and education can be perceived as marketing and, as a result, NASA is reluctant to push forward in that area. The Committee wants to look into the origins of this concern. He reported that the Committee received a presentation from Dr. Carl Person, Manager, Minority University Research and Education, NASA Office of Education. That program has responsibility for attracting minorities into NASA and has had a large budget loss over the last five years. The Committee heard from NASA's Education Design Team. Its budget is only \$180 million and the question is how to spend it and what the metrics should be. The Committee will be helping the Team develop ways for NASA to use the media to build interest in science, technology, engineering, and mathematics (STEM), develop ways the Team can partner to increase its leverage, and develop ways for NASA to help educators. Mr. O'Brien briefed the Council on the Summer of Innovation Program. He described how JPL's Manager of News Services, Ms. Veronica McGregor, using Twitter, became the voice of the Mars Phoenix Lander. He noted that she gets much harder questions from Tweeters than she does from the mainstream media. Her team recently rolled out a live web cam for the Night Sky Live (NSL) project ([www.nightskylive.net](http://www.nightskylive.net)). This, he noted, has presented some issues relating to International Traffic in Arms Regulations (ITAR). He described an exciting new website, Eyes on the Earth 3D (<http://climate.nasa.gov/Eyes/eyes.html>) where viewers can watch in real time what satellites are doing. It is being expanded for the solar system probes and is a tremendous resource that deserves more publicity. Mr. O'Brien described the Conrad Foundation and its Spirit of Innovation Awards program. He reported that it is having difficulty interfacing with NASA, and that the Committee feels that the process of interacting with

outside educational groups and foundations may need to be streamlined. The Committee is hopeful that NASA's new social media policy will offer clear guidance and still permit NASA employees to share their passion. Mr. O'Brien opined that many employees might be afraid to participate in social media because they do not know where the boundaries are and what is permissible. Contractors present a greater challenge in this area because they have their own rules and are generally more conservative because they are concerned about upsetting NASA as a client.

Ms. Dyson encouraged more collaboration between the NASA Centers and their local universities. Dr. Kennel noted that there are two first-class film schools on theatre, film, and television based in Los Angeles that might be interested in becoming involved with NASA's educational programs. Dr. Ford added that there is a world class film school at Florida State University. Ms. Blakey stated that the issue of Science, Technology, Engineering and Mathematics (STEM) education is an "enormous beast." She explained that industry is very concerned with the investments being made in STEM education and noted that a new initiative launched by the Obama Administration is focused on STEM education. She urged the Committee to look at existing broad coalitions where industry and education have joined together to further education, and she noted that Raytheon has developed a model for measuring the success of those programs. Mr. O'Brien suggested that NASA should be involved with those coalitions.

Dr. Ford thanked Mr. O'Brien for his presentation.

#### Exploration Committee Report

Dr. Ford introduced Mr. Richard Kohrs, Chair, Exploration Committee. Mr. Kohrs briefed the Council on the budget status for the NASA Exploration Systems Mission Directorate (ESMD). He described the differences between the President's FY 2011 Budget request, the Senate Authorization Bill, and the House Authorization Bill. He described the challenges that ESMD is facing for acquisition planning, for working under a "Continuing Resolution" for the budget, and for the Constellation (Cx) Program transition. He noted that fulfilling the guidance in the President's budget request will require issuing Requests for Proposals (RFPs) early in Fiscal Year 2011. He reviewed slides on the Cx Program Initial Capability Preliminary Design Review (PDR) and on upcoming Cx milestones. He reported that NASA is proceeding towards an August 2010 test firing of the five-segment Solid Rocket Motor, and that the cancellation of the program is causing contractor layoffs. Mr. Kohrs described NASA's Heavy Lift near-term activities and described preliminary findings on liquid propulsion synergies. He briefed the Council on NASA's Human Research Program (HRP), which conducts space biomedical research critical to crew health and safety. It was formed to focus NASA's research on the highest risks to human health and performance during exploration missions. He described an emerging risk of intracranial hypertension with associated visual changes that appears to be affecting male astronauts over the age of 40. Col. Collins reported that the damage may be permanent, and that the astronauts have been briefed on it. She added that it is not something that has been tracked by the Russians. Mr. Kohrs reviewed a slide showing the accomplishments since April 2010 of NASA's Human Exploration Framework Team (HEFT). He described two programs within NASA's Exploration Research and Development Team: the Enabling Technology Development and Demonstration Program, and the Flagship Technology Demonstrations Program. He described Robonaut, a robot developed under the Flagship program. Mr. Bolden explained that the robot was developed as part of an SAA between NASA and General Motors. Dr. Ford noted that this is the most advanced humanoid robotic upper body in the world. Mr. Kohrs reviewed a slide describing NASA's international partnerships strategy. The strategy is based on the principle that NASA leadership in sustainable and affordable human space exploration of many destinations is enabled by, and may require, critical international partnerships. The strategy recognizes that NASA leadership is considered essential to advance the global exploration strategy and calls for NASA to continue to participate in the International Space Exploration Coordination Group (ISECG) and the International Space Station (ISS) Multilateral Coordination Board (MCB). Mr. Bolden noted that China participates in the ISECG and that NASA has been working there with China at a low-level.

Mr. Kohrs presented for the Council's consideration a proposed Observation on the absence of a budget for space exploration. He commended Mr. Doug Cooke, ESMD Associate Administrator, for keeping the team together during these difficult times. The Council approved the Observation as follows:

We note that there is currently no budget or roadmap for space exploration agreed to by the White House, Congress, and NASA leadership. This complicates ESMD operations.

Mr. Kohrs presented for the Council's consideration a proposed Observation on propellants. The Council approved the Observation as follows:

If NASA selects Liquid Oxygen (LOX)-Kerosene combination of propellants for Heavy Lift Launch Vehicle first stage, the following two considerations should be kept in mind: (1) Russia currently leads LOX-Kerosene propulsion technology; (2) LOX-Kerosene will provide NASA with an opportunity to create a huge operability improvement by using high pressure kerosene as the working fluid in the Thrust Vector Control (TVC) actuation system, thus eliminating the need for hydraulic power generating system. This approach has been successfully used in Russian RD-170 1500K lbs thrust LOX-Kerosene engine resulting in simpler and lower weight engine/TVC system, much easier to operate. In order to benefit from this approach the engine and its TVC should be designed as an integrated system. Outcome of this design decision will not only be a lighter, less expensive to operate propulsion/TVC system, but a "green" stage with complete absence of toxic reactants and conventional hydraulic fluid.

Mr. Kohrs presented for the Council's consideration a proposed Finding on the Office of Chief Technologist (OCT). He explained that this is a joint finding with the NAC Technology and Innovation Committee. He acknowledged OCT and ESMD for working well together. Dr. Colladay observed that the cooperation across the Agency is impressive and that the management of the "push and pull" for technology, where the managers pull and the Chief Technologist pushes, is very creative. The Exploration Committee and the Technology and Innovation Committee met in a joint session at JPL on August 4, 2010, and at that meeting they drafted a joint finding. The Council approved the Finding as follows:

Uncertainties and lack of budget consensus complicate efforts to define, fund, and promote requirements for space technology. The Office of Chief Technologist (OCT) is charged in part to address future technology development within NASA. The Exploration Systems Mission Directorate (ESMD) has funding for technology development and demonstrations. We observe that the recently established OCT has made significant and positive advances in identifying advanced technologies required for future human and robotic exploration of space. They have moved forward quickly and aggressively with plans and an organization to rapidly facilitate technologies that will be required for a variety of future missions to the Moon, Mars, or a Near Earth Object (NEO). We support and applaud the direction of OCT for maintaining close communications and interactions with ESMD, coordinating critical-path technologies and technology development required to execute a roadmap to future human exploration beyond Low Earth Orbit (LEO). Because future technologies represent an area of overlap between OCT and ESMD, these interactions are critical to avoid duplication, cross purposes, and gaps, and may result in schedule and cost savings, and position NASA to more effectively execute a future space exploration effort. We encourage continued collaboration and request a future update on coordination within the NASA OCT and ESMD.

Dr. Ford thanked Mr. Kohrs for his presentation.

#### Information Technology Infrastructure Committee Report

Dr. Ford introduced Dr. Charles Holmes, Vice-Chair, Information Technology Infrastructure Committee, representing Gen. Albert Edmonds, Chair. Dr. Holmes described the Committee work plan. He described a recent visit to Lockheed Martin's Center of Excellence, where the host demonstrated new ideas and techniques in cyber security. They visited Goddard Space Flight Center (GSFC) and received classified presentations that furthered clear understanding on how cyber security is planned and integrated into NASA programs and missions. He described two NASA virtual institutes hosted at the NASA Ames Center: the NASA Astrobiology Institute (NAI) and the NASA Lunar Science Institute (LSI). They have a website (<http://astrobiology.nasa.gov>) that was a "Webby" honoree in 2009, and have developed new technologies for video conferencing. They are partnering with leaders in science and data visualization to make the state of the art tools available to researchers. Dr. Holmes reviewed a slide describing the NAI Workshop Without Walls. He described the Center for Collaboration Sciences and Applications (CCSA), which was formed by NASA Ames, Carnegie Mellon, and Lockheed Martin to explore the science and applications of collaboration. Dr. Holmes reviewed a slide depicting a generalized mission communications topology and a slide about network "glue" – interface standards. He discussed the Consultative Committee for Space Data Systems

(CCSDS), a multi-national forum for the discussion of common space communications issues, and reviewed slides

showing its working groups and statistics on its standards and practices. It is staffed by ad-hoc working groups from the various space-faring nations. He explained the model for standards is that one should prepare an engineering prototype, show what works, bring it to a standards group, and let them develop standards. He presented a slide on the history of software system architectures and described the GSFC Mission Services Evolution Center (GMSEC). Dr. Holmes briefed the Council on plans for the upcoming First Annual NASA IT Summit. The Summit's theme is "Make IT Stellar at NASA." There are over 900 registrants for the summit which will take place on August 16-18, 2010, at National Harbor, MD, near Washington, DC.

Dr. Kennel noted that there are distinct differences in the engineering cultures in the United States, Japan, Russia, and Europe, and asked whether there have been any IT support distributed efforts within the ISS collaboration where the work was done largely in a distributed fashion, and if so, how successful they were, and if they would be open to an enhancement through advanced IT techniques like the ones the IT Infrastructure Committee is looking at. Dr. Holmes stated that it is his impression that they cannot be adopted. Dr. Ford noted that in the commercial sector, there has been a lot of work in this area and that Boeing and other companies collaborate in that manner.

Dr. Ford thanked Dr. Holmes for his presentation and adjourned the meeting for the day.

### *Friday, August 6, 2010*

#### Call to Order

Ms. Rausch called the meeting to order.

#### Announcements

Dr. Ford welcomed the Council Members back for the second day of the NAC meeting. He described the agenda for the day and reviewed the presentations from the previous day.

#### Science Committee Report

Dr. Ford introduced Dr. Wesley Huntress, Chair, Science Committee. Dr. Huntress notified the Council that Dr. Judith Lean and Dr. Jack Burns would be leaving the Committee. He presented slides showing recent science results. One slide depicted an unusual thermosphere collapse deeper than expected from the current solar cycle. Another slide showed satellite images used to help in the response to the Gulf oil spill. Dr. Huntress noted that NASA responded to the disaster with four satellites having six instruments, employed airborne instruments, and provided customized data sets on a daily basis. Another slide showed images of craters taken by the Mars Reconnaissance Orbiter (MRO). The images show patterns from small meteorites breaking apart in the Martian atmosphere. This cannot be studied on Earth because they would burn up in the Earth's atmosphere. Another slide showed an image of Phobos from the European Mars Express that will be used to help Russia's planned mission to land on Phobos and return samples to Earth. Another slide showed a 5 km-wide dust-covered glacier on Mars, providing additional evidence for water or ice on Mars at mid-latitudes. Another slide showed Rosetta's encounter with Lutetia, which is a main belt asteroid. Another slide showed an image of the Abell 2218 cluster as seen by the Spectral and Photometric Imaging Receiver (SPIRE) instrument on Herschel in relation to an iconic image from the Hubble Space Telescope (HST), and demonstrates a gravitational lens. Another slide showed an array of Swift-detected active black holes in merging galaxies.

Dr. Huntress noted that the NRC's Astro 2010 Astronomy and Astrophysics Decadal Survey report will be released in mid-August 2010. He briefed the Council on recent programmatic accomplishments. The Earth Science Implementation Plan was released in June 2010. A Pu-238 restart plan has been completed by NASA and the Department of Energy (DOE) and has been delivered to Congress. He showed a slide with the first science images taken by the Stratospheric Observatory for Infrared Astronomy (SOFIA), which is an airborne observatory. He briefed the Council on the construction status for the James Webb Space Telescope (JWST). Dr. Huntress described the Planetary Protection Subcommittee. It has two roles. In its regulatory role, it helps with adherence to international agreements that require space activities to be conducted in a manner that protects planetary

environments from biological contamination, in either direction. In its science role, it helps preserve the ability to ascertain the natural occurrence and varieties of life. He briefly discussed a recent National Research Council study just completed on Cost Growth in NASA Science Mission Directorate (SMD) Missions. He noted that one possible cause for the cost growth may be that SMD has not been spending enough money in the early phases to retire new technology development risk. He presented a slide showing how the ISS is currently being used by SMD and discussed how the ISS might possibly be used by SMD in the future.

Dr. Huntress presented for the Council's consideration a proposed Recommendation for interaction between the Earth Science Subcommittee and the Joint Program Satellite System. He explained that NASA builds and launches weather satellites for NOAA. Both NOAA and DOD have their own set of requirements, and there is little opportunity for input from science. Dr. Kennel explained that besides the intelligence agencies, there are four agencies that observe Earth from space: NASA, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), and the U.S. Air Force. Each has very separate primary requirements. To observe the Earth, 24 separate measurements are required. Interagency cooperation is very important in accomplishing that goal. Interagency collaboration has to occur at three levels. The first is programmatic. That could be done by an Earth observation subcommittee of the U.S. Global Change Research Program. The second level is operational collaboration. The third level is to have separate data management collaborations. This is a comprehensive issue and requires direction by the White House.

Dr. Huntress noted that the Science Committee is concerned about potentially conflicting data product requirements between the operational needs of NOAA (as well as other agency partners) and the research needs of the NASA Earth Science Division. They propose that the Science Committee's Earth Science Subcommittee (ESS) could provide a suitable body for regular review of the Joint Program Satellite System (JPSS). The consequences of no action would be that the opportunity to assess the availability and quality of critical climate measurements, assumed as a foundation for the Earth Science Program described in the National Research Council's Decadal Survey will not be achieved.

The Council approved the Recommendation as follows:

The Council recommends that appropriate forums be established that will facilitate the development of an integrated observing space-based strategy for both research and operational National Satellite Systems.

Dr. Huntress presented for the Council's consideration a proposed Recommendation to protect the scientific integrity of sites on the Moon containing evidence of past human activity. In response to Dr. Colladay questioning whether NASA would know how to implement the Recommendation, it was agreed that it should be considered as an Observation. Dr. Ford advised that it is a complicated issue. Ms. Dyson suggested that it would require an oversight agency. Dr. Huntress stated that the Science Committee is recommending that NASA pursue appropriate external avenues for ensuring that sites on the Moon containing evidence of past human activity be protected from damage by future exploration efforts. With the advent of the Google X-Prize and plans for increased exploration of the Moon (or Mars), it is critical to ensure the scientific integrity of these sites – whether explored by governmental or commercial entities. The consequences of no action would be that a unique record of potential human impact in the space environment will be susceptible to being compromised in the course of non-governmental lunar exploration.

The Council approved the Observation as follows:

Future exploration of the Moon, whether by governmental or commercial entities, is likely to result in visits to sites of past human activity such as Apollo landing sites, Surveyor and Luna landing sites, and sites of crashed spacecraft and rocket stages. Such sites contain uniquely valuable artifacts of human presence and of the sequelae of human presence in the space environment. Unique and fragile evidence of such phenomena as "weathering" on the lunar surface, the fate of microbial matter, and the potential long-term viability of spores exposed at the lunar surface are present at these sites. These sites should be protected and their scientific integrity preserved.

Dr. Ford thanked Dr. Huntress for his presentation.

#### Cost-Growth in NASA Earth and Space Science Missions

Dr. Ford introduced Dr. Ronald Sega, a former NASA Shuttle Astronaut and Chair, NRC Space Studies Board (SSB) Committee on Cost Growth in NASA Earth and Space Science Missions (the Committee). Dr. Sega briefed the Council on a report produced pursuant to a Congressionally-mandated task assigned to the NRC to identify the primary causes for cost growth in NASA's space and Earth science missions. The Committee was established to conduct the study. The findings and recommendations in the report are based on the experience of the Committee members and on earlier studies. Dr. Sega described the NRC study approach. The consensus draft report was reviewed following the standard NRC process. In response to a question from Dr. Colladay, Dr. Sega identified the persons who reviewed the report. The report found that recent changes by NASA in the development and management of Earth and space science missions are promising and recommends that NASA should develop a comprehensive, integrated strategy to contain cost and schedule growth. The most commonly identified factors contributing to cost growth were unrealistic initial cost estimates, project instability and funding issues, problems with developing technology, and launch services issues.

Dr. Sega explained how cost growth is measured. The Preliminary Design Review (PDR) is the point when cost estimation should start. Most cost growth occurs after Critical Design Review (CDR). Dr. Kennel asked whether the Committee had looked at the rough cost estimation that is possible in pre-phase A. Dr. Sega responded affirmatively. He stated that it was important for the NAC to forward the message to NASA, Congress, and the Office of Management and Budget (OMB) that work remains to be done to understand and reduce risk and uncertainty and make cost estimation at PDR as strong as possible. Dr. Kennel opined that this was reasonable and explained that the optics and politics can be adversely affected by a poor pre-phase A estimate. Dr. Ford explained that the National Science Foundation (NSF) has had the same struggle. It tries to use vagueness to avoid the problem by using a range for its cost estimates and using code names for its projects. Mr. Kohrs explained that many PDR and CDR reviews are premature and, therefore, cost estimates at that time would also be premature and not useful for the study. He recommended looking at change order traffic to determine whether a cost estimate was valid for a study. Dr. Sega reviewed a series of charts analyzing the cost growth in SMD.

Dr. Sega described the report's findings and recommendations. The report found that the current system incentivizes overly optimistic expectations regarding cost and schedule. It recommends that NASA should strengthen the role played by its independent cost estimating function. In response to a question from Mr. Alexander, Dr. Sega explained that "independent" did not necessarily mean external to NASA—it could be satisfied with a group outside the Center structure. The report found that the methodology for measuring cost growth has been inconsistent throughout NASA, and recommends that NASA, Congress, and OMB should consistently use the same method to quantify and report cost. The report recommends that NASA Headquarters' project oversight function should pay particular attention to the cost and schedule of its larger missions. The report recommends allocating a larger percentage of project funds for risk reduction and improved cost estimation, including incentives in the proposal selection and project management processes to establish realistic cost estimates, establishing a robust instrument technology development effort, and including guidance on developing technologies in decadal surveys and other strategic planning efforts. Dr. Ford advised that it is important to note that too much cost growth is attributable to the need to develop technology late in the process. Dr. Colladay concurred with Dr. Ford and observed that this recommendation has been made many times and that it has to continue to be emphasized. He noted the problem is that development is deferrable. Dr. Ford agreed and stated that this is a key point. The report found that the increase in the size and number of external project reviews has become counterproductive and recommends that the value added by each review outweigh its cost, that the review be appropriate to the project size, and that major reviews occur only when specified success criteria are likely to be met. The report recommends minimizing mission-unique launch site processing requirements and recommends selecting launch vehicles as early as possible and with minimal changes. In response to a question from Mr. Alexander, Dr. Sega explained that this recommendation is related to NASA's ability to make decisions and is driven from the project side, not the vehicle side. Mr. Montelongo noted that Congress has mandated that a single individual subject to Senate confirmation be responsible for DOD's cost estimating. Ms. Dyson asked whether the Committee considered cost growth attributable to schedule delays caused by lack of funding. Dr. Sega responded that funding stability needs to be maintained by Congress to assure that programs stay on schedule, especially after PDR. Dr. Colladay observed that Congress may be "poised to do some damage" again to the space technology investment that is in the President's proposed budget. In response to a question from Dr. Colladay, Dr. Sega reported that the response to the report by Congressional staffers has been positive.

Dr. Ford thanked Dr. Sega for his presentation.

Space Operations Committee Report

Dr. Ford introduced Col. Eileen Collins (Ret.), Chair, Space Operations Committee. Col. Collins observed that with the shutdown of Shuttle operations, it is a turbulent period. She described a site visit to the Kennedy Space Center (KSC), where the Committee visited the Space Life Sciences Lab (SLSL), Launch Complexes, Technology Development Facilities, Vehicle Assembly Building, and Orbiter Processing Facility. She noted that on the day of the site visit, layoff notices had been given to 900 employees at KSC. Morale was mixed. Many skilled people were laid off and had no place to go. The SLSL was built in 2004 by the State of Florida and is available for use by commercial launch companies. She described several technology labs that are located there. Col. Collins briefed the Council on the plans for the 21st Century Launch Complex at KSC. The President's budget request invests \$1.9 billion in the complex over five years. The primary focus is to change KSC from a vehicle-centric infrastructure to a multi-use architecture. Potential users will be the Heavy Lift Launch Vehicle (HLLV), the Commercial Crew Development Program (CCDP), the Launch Services Program (LSP), the ISS, and Flagship Technologies Demonstrations. Potential partnerships will be the United States Air Force and other government agencies, Space Florida, commercial providers, and internationals. She presented a slide describing the Committee's informal observations from its visit. The Committee felt that NASA needs to generate specific requirements before investing in upgrades, and that NASA needs to have a business model to help determine investment priorities.

Col. Collins presented for the Council's consideration a proposed Recommendation on establishing a technology and development clearinghouse. Ms. Dyson expressed concern that without appropriate integration, the information could be fragmented among several clearinghouses. She explained that the information must be intelligible and findable, and that people need to know that it is there. For the information to get there, people have to want to put it in, so there must be a social cultural system including incentives, motivation, and recognition. Col. Collins agreed with Ms. Dyson, and arrangements were made for their two committees to meet on this in the future. Mr. Montelongo explained that in the corporate world this is known as the knowledge management infrastructure and is a way to capture, catalog, and disseminate across the enterprise innovation and knowledge. Dr. Ford explained that Ms. Dyson hit on a key point with respect to the need to have an incentive mechanism for very busy people and suggested that incentives could be made available at either individual or group levels. Ms. Dyson suggested perhaps adopting a model based on "FarmVille" (a highly popular social networking real-time simulation game) and calling it "SpaceVille." Dr. Holmes noted that this had been previously attempted at the NASA Headquarters level and bogged down. He stated that the "wiki" approach could be successful if it is properly incentivized. Mr. Montelongo explained that many companies have already set up these platforms. In response to a question from Ms. Blakey, Dr. Ford explained that wiki technology is readily available at minimal cost. The Council approved the Recommendation as follows:

NASA should establish a technology and development clearinghouse across all NASA disciplines. This could be in the process, format and style of an online wiki where researchers input their own information (such as type of technology, application, license information, key words, and contact info). This information should be organized to be readily available online to other researchers and the public.

Col. Collins noted that the ISS is being packed with goods and supplies for the years to come after the Space Shuttle is retired. She explained that two more Shuttle flights are being prepared for flight, and one Shuttle is being held in reserve for a possible rescue mission. NASA is studying whether that Shuttle can be flown as a separate flight without a backup rescue flight. She discussed a slide on the Space Shuttle Program (SSP) manifest schedule. She presented for the Council's consideration an Observation recognizing the SSP's leadership. The Council approved it as a Finding as follows:

The NAC Space Operations Committee would like to recognize the Space Shuttle Program Manager John Shannon and his team for their outstanding leadership in safely flying the Shuttle manifest and planning for the safe transition of the Shuttle from flight status to retirement.

Col. Collins discussed the Commercial Orbital Transportation Services (COTS) and the Commercial Resupply Services (CRS) Operational Plan. She reported that the Committee had been briefed as requested on the operational model for commercial space vehicles that will enable NASA flight resources and crews to be committed to commercial space assistance. The Committee is satisfied that NASA is developing the model. Col. Collins requested a briefing for the Committee on how deep spaceflight operational concepts are being developed or used on the ISS.

Dr. Ford noted that there is a huge amount of activity related to utilization of ISS for future exploration beyond LEO. Col. Collins discussed the ISS Logistics Plan. Four vehicles will comprise the resupply fleet following Space Shuttle retirement. Two vehicles will be supplied by NASA's international partners. The European Space Agency (ESA) will provide the Automated Transfer Vehicle (ATV) and the Japan Aerospace Exploration Agency (JAXA) will provide the H-II Transfer Vehicle (HTV). There will be two NASA CRS vehicles: the Orbital Cygnus and the SpaceX Dragon. Only Dragon will be able to return scientist's equipment to Earth. She reviewed a chart comparing the delivery capability against delivery demand at the ISS. She discussed the Commercial Human Rating Plan (CHRP) and the issue of NASA insight versus NASA oversight.

Col. Collins presented for the Council's consideration a proposed Observation on planning for the transition to the new proposed National Space Policy. The Council approved it as a Finding as follows:

Due to recent announcements in proposed national policy resulting in a changing environment, there is a need for the deliberate and careful integrated planning of the transition to the new direction, including careful phasing of the Shuttle manifest, transition of the Constellation program, and development of the 21st Century Launch Complex and Technology Development programs.

Col. Collins presented for the Council's consideration a proposed Observation on the development of NASA's new Strategic Plan. The Council approved the Observation as follows:

The Council understands that NASA is developing a Strategic Plan. We are following this process as we believe is it important for NASA's employees to have specific direction as to carrying out the national policy.

Dr. Ford briefed the Council on an outstanding action item relating to the Office of Space Communications and Navigation (SCaN). A Recommendation on SCaN had been submitted by the NAC last year. There has not been an official response pending the completion of an independent study. He expects the study results to be presented to the NAC in the near future.

Dr. Ford thanked Col. Collins for her presentation.

#### Technology and Innovation Committee Report

Dr. Ford introduced Ms. Esther Dyson, Chair, Technology and Innovation Committee. Mr. Dyson explained that her Committee deals with almost everything done by NASA and that networking with the other committees gives her Committee substance to work with, rather than the abstractions of innovation. She noted that Space Technology is a new budget line in the President's FY 2011 Budget request for NASA. It contains 10 technology development and innovation programs that will be managed by the OCT through three Divisions: Early-Stage Innovation, Game Changing Technology, and Crosscutting Capability Demonstrations. She noted that an amazing amount has been done in a short period of time. NASA's Innovative Partnerships Program (IPP) and its budget are integrated into the OCT. She presented a slide showing how Space Technology will allow for a range of technology development using ideas submitted from industry, academia, NASA, and other U.S. Government agencies. Formulation of the Space Technology Program was initiated in February 2010 and has proceeded on a pace to allow the release of solicitations in the early Fall, pending Congressional approval.

Ms. Dyson described how Space Technology has been engaging with the external community. A Technology Industry Day was held with over 300 participants from industry, academia, and other government agencies. She presented a slide showing the status of this year's Centennial Challenges, and reviewed highlights from last year's Centennial Challenges. She described the InnoCentive Pilot Phase 1 results and noted that the amounts spent there were "pathetic" given its results and NASA's overall budget. Ms. Dyson described the Space Life Sciences approach to innovation. She presented a slide about the NASA@Work pilot program and described the NASA Human Health and Performance Center. She presented a chart on OCT's recently released "Process to Create and Maintain NASA's Aero-Space Technology Area Roadmap (A-STAR)," which has been posted at [www.nasa.gov/OCT](http://www.nasa.gov/OCT). A-STAR proposes a Decadal Survey creating fifteen cross-cutting Technology Area (TA) roadmaps and links them to an integrated strategic roadmap to show the overall technology strategy and priorities across NASA's technology investments.

Dr. Ford observed that a notable technology area that is missing from the roadmap list is software and the whole area of computing, on which NASA's systems are increasingly reliant. Ms. Dyson agreed that software and computing should be included. She explained that NASA needs to better understand what is being developed externally that NASA can use, rather than doing the development itself. Dr. Ford noted that NASA used to have leadership in several areas in computing, but has under-funded those areas, and many of the people involved have left the agency. It is important, he asserted, for that slide not to be allowed to continue now that there is a hope for a technology program.

Ms. Dyson presented and the Council approved the following Finding:

The Office of the Chief Technologist (OCT) should be commended for its outstanding efforts over the past six months in planning and formulating the new Space Technology programs. Additionally, there is strong and broad external support for the Space Technology Program. The Council believes the mechanisms are in place for the Space Technology Program to move from its program formulation phase and to begin program execution once approved by Congress. However, the uncertain resolution of the FY 2011 Budget may cause a significant adverse impact on the OCT's ability to execute the new Space Technology Program.

Ms. Dyson presented and the Council approved the following Recommendation:

The Council recommends that NASA allow the Office of the Chief Technologist (OCT) to begin program implementation activities for the new Space Technology programs. This should include the OCT requesting a budget anomaly to the forthcoming "Continuing Resolution," allowing the OCT to begin initial program implementation activities including the issuance of Broad Area Announcements (BAAs) for the new Space Technology programs.

In response to a question from Ms. Blakey, Dr. Ford explained that NASA has in the past made similar requests for specific programs under a Continuing Resolution. Ms. Dyson suggested that it would help NASA's budget effort by being able to show Congress that this recommendation was made by a group of outside experts.

Ms. Dyson noted that many factors can affect the morale and operational efficiency of an organization and influence the environment for creativity and innovation. The Committee finds that the FedTraveler travel management process is such an example. It uses a bureaucratic approach that instead of improving efficiency – as was no doubt intended – does just the opposite. It can frustrate the user, sap productivity, and undermine users' sense of professionalism.

Ms. Dyson presented and the Council approved the following Recommendation:

The Council recommends that a small ad-hoc NASA Advisory Council group work with NASA to identify the top three most egregious productivity and individual initiative killers (starting with FedTraveler), and determine their costs not just in money but also in employee time. This group should then make recommendations for either eliminating/replacing the offending policy and procedure or software, or replacing it with a small pilot program to establish a best-practice benchmark that might let NASA break out of (sometimes government-wide) solutions that fail to meet the interests of the agency and its people – and provide a positive example to other government agencies.

Ms. Dyson noted that this Recommendation is both hilarious and tragic. She stated that FedTraveler is a symbol of everything that helps to hurt morale; it waste people's time foolishly and is unnecessary. She noted that the NASA Administrator has expressed the same angst. Dr. Ford explained that the most worrisome aspect of things like FedTraveler is in the message it sends to employees; it diminishes morale and good feelings about their employer.

Council Finding on Budget Request for Advanced Technology

Dr. Colladay expressed concern over finally getting close to obtaining a consensus on investing in advanced technology, only to watch it possibly go away. He asked the Council to go on record stating that would be a huge mistake, and he noted it could be helpful when the NASA FY 2011 Budget bill goes into reconciliation between the Senate and the House of Representatives. Towards that end, the Council approved the following Finding:

The Council emphasizes the importance of the President's FY 2011 Budget request for advanced technology R&D (in both the Office of the Chief Technologist and Exploration Systems Mission Directorate) because it provides a strong foundation for NASA's future.

In response to a question from Ms. Blakey, Dr. Ford explained that it has been a while since the NAC stated its position directly in a letter to Congress. He will ascertain the NASA Administrator's sentiment on doing this. Dr. Kennel stated that it is important to ensure that a technology budget line emerges from the reconciliation process that is sufficient to address at least one Exploration objective conceivable by NASA. However, he noted, people will want to know where NASA is going before providing budget funds, which is difficult because of the Flexible Path approach. He suggested recommending that NASA adopt one of the Flexible Path goals and identify what the technology development requirements for that would be. A highly plausible goal would be to look at a human mission to an asteroid. Dr. Colladay supported Dr. Kennel's proposal. The Council discussed whether this should become a Recommendation. Dr. Ford explained that the budget for OCT is under stress because NASA's destination is not clear. Dr. Colladay described the dilemma: you want the entire national space enterprise as a broad base for support, but you want to enable that with a specific destination. Dr. Kennel explained that NASA believes that having unusually difficult goals will drive technology development. Dr. Ford stated that more work on this Recommendation would be needed. Dr. Colladay supported Mr. Blakey's proposal for the NAC to send a letter to the Hill because it would open a dialogue. Dr. Ford stated that he would discuss this with Mr. Bolden. Ms. Blakey suggested that a human mission to an asteroid had many compelling elements from a public standpoint: health and safety, resource acquisition, economic benefits, exploration, and inspiration. She noted that everyone is searching desperately for near-term objectives that are measurable for success over the next five years.

Public Input

Dr. Ford asked the members of public at the meeting whether any of them would like to briefly address the Council. Mr. Buzz Aldrin (a former Apollo Astronaut) stated that most people are in agreement that in the very long term, the destination for human exploration is Mars. He is not sure that an asteroid is a strong destination for the public or for many members of Congress. He opined that it would be better to use an asteroid mission as a stepping-stone leading to the Moon and Mars. Dr. Ford concurred and advised against falling into the mistake of framing an Exploration Program in a way that it becomes narrowly defined (and often mischaracterized) by its first destination. Dr. Huntress stated that in the same sense as we had steppingstones for Apollo, going to a near-Earth asteroid is a stepping-stone in preparation for going to Mars.

Final Wrap-Up

The Council discussed using electronic media in the future, rather than receiving hard copy binders for the presentations at meetings. Dr. Ford then discussed the Council meeting dates for the coming year. The next and final meeting of 2010 will take place October 5-7, at NASA's Dryden Flight Research Facility in California. The proposed Council meeting dates for calendar year 2011 are as follows:

February 9-11, 2011:	NASA Headquarters
May 4-6, 2011:	NASA Glenn Research Center
August 3-5, 2011:	NASA Center (TDB)
November 2-4, 2011:	NASA Center (TBD)

There was no Council objection to these dates or locations; several locations were discussed for the TBD August and November 2011 Council meetings.

In closing, Dr. Ford thanked the Council members for their participation. He thanked the Council's Executive

Director Diane Rausch and the Council's support staff. He gave special thanks to JPL's Nora Mainland and everyone else at JPL for hosting the excellent meeting.

The meeting was adjourned.

# NASA ADVISORY COUNCIL

NASA Jet Propulsion Laboratory  
4800 Oak Grove Drive  
Pasadena, CA

## PUBLIC MEETING

August 5-6, 2010  
Von Karman Auditorium

### Agenda

#### Thursday, August 5, 2010

8:00 – 8:02 am	Call to Order, Announcements	Ms. Diane Rausch, Executive Director NASA Advisory Council, NASA HQ
8:02 – 8:10 am	Remarks by Council Chair	Dr. Kenneth Ford, Chair NASA Advisory Council
8:10 – 8:30 am	Welcome to NASA Jet Propulsion Laboratory	Dr. Charles Elachi, Director NASA Jet Propulsion Laboratory
8:30 – 9:15 am	Remarks by NASA Administrator	Mr. Charles F. Bolden, Jr. NASA Administrator
9:15 – 9:45 am	NASA Near-Earth Object (NEO) Program Overview	Dr. Donald Yeomans, Head NEO Program Office, JPL
9:45 – 10:15 am	NEO Orbital Dynamics & Deflection	Mr. Rusty Schweickart Co-Chair, Ad-Hoc Task Force on Planetary Defense, NASA Advisory Council
10:15 – 10:30 am	Break	
10:30 – 11:15 am	JPL Workforce: Recent JPL Hiring Patterns	Ms. Cozette Hart, Director Human Resources Department, JPL
11:15 – 12:00 pm	Aeronautics Committee Report	Ms. Marion Blakey, Chair
12:00 – 12:45 pm	Lunch (Council only)	
12:45 – 1:30 pm	Audit, Finance, and Analysis Committee Report	Mr. Michael Montelongo, Vice-Chair
1:30 – 2:15 pm	Commercial Space Committee Report	Mr. Brett Alexander, Chair
2:15 – 3:00 pm	Education and Public Outreach Committee Report	Mr. Miles O'Brien, Chair
3:00 – 3:15 pm	Break	

3:15 – 4:00 pm	Exploration Committee Report	Mr. Richard Kohrs, Chair
4:00 – 4:45 pm	IT Infrastructure Committee Report	Mr. Charles Holmes, Vice-Chair
4:45 – 5:00 pm	Public Input	
5:00 pm	Adjourn	

**Friday, August 6, 2010**

8:00 am	Call to Order	Ms. Diane Rausch, Executive Director NASA Advisory Council
8:00 – 8:02 am	Announcements	Dr. Kenneth Ford, Chair NASA Advisory Council
8:02 – 8:45 am	Science Committee Report	Dr. Wesley Huntress, Chair
8:45 – 9:45 am	Cost-Growth in NASA Earth and Space Science Missions: National Research Council Study	Dr. Ronald Sega, NRC Study Chair Professor of Systems Engineering Colorado State University
9:45 – 10:30 am	Space Operations Committee Report	Col. Eileen Collins (Ret.), Chair
10:30 – 10:45 am	Break	
10:45 – 11:30 am	Technology and Innovation Committee Report	Ms. Esther Dyson, Chair
11:30 – 11:45 am	Public Input	
11:45 am – 12:00 pm	Final Wrapup	All
12:00 pm	Adjourn	

**NASA ADVISORY COUNCIL MEMBERS**  
**August 2010**

<p><b>Dr. Kenneth M. Ford</b> Council Chair <i>Founder and Director, Florida Institute for Human and Machine Cognition (IHMC)</i></p>	<p><b>Mr. Richard Kohrs</b> Chair, Exploration Committee <i>NASA (Ret.)</i></p>
<p><b>Ms. P. Diane Rausch</b> Executive Director <i>Designated Federal Official NASA Headquarters</i></p>	<p><b>Dr. Wesley T. Huntress, Jr.</b> Chair, Science Committee <i>Director Emeritus, Geophysical Laboratory, Carnegie Institute of Washington</i></p>
<p><b>Ms. Marion Blakey</b> Chair, Aeronautics Committee <i>Chief Executive Officer, Aerospace Industries Association</i></p>	<p><b>Colonel Eileen M. Collins, USAF (Ret.)</b> Chair, Space Operations Committee <i>NASA Shuttle Pilot and Commander (Ret.), Aerospace Consultant, President of Space Presentations, LLC</i></p>
<p><b>Mr. Robert M. Hanisee</b> Chair, Audit, Finance and Analysis Committee <i>Managing Director, Trust Company of the West</i></p>	<p><b>Ms. Esther Dyson</b> Chair, Technology and Innovation Committee <i>EDventure Holdings</i></p>
<p><b>Mr. Brett Alexander</b> Chair, Commercial Space Committee <i>Executive Director, Commercial Spaceflight Federation</i></p>	<p><b>Dr. Raymond S. Colladay</b> Ex-Officio <i>Chair, Aeronautics and Space Engineering Board, National Academies</i></p>
<p><b>Mr. Miles O'Brien</b> Chair, Education and Public Outreach Committee <i>Miles O'Brien Productions</i></p>	<p><b>Dr. Charles F. Kennel</b> Ex-Officio <i>Chair, Space Studies Board, National Academies</i></p>

**NASA ADVISORY COUNCIL  
Jet Propulsion Laboratory  
Pasadena, CA  
August 5-6, 2010**

**MEETING ATTENDEES**

***NASA Advisory Council:***

Ford, Kenneth, *Chair*

Rausch, P. Diane, *Executive Director*

Alexander, Brett

Blakey, Marion

Colladay, Ray, *Ex-Officio*

Collins, Eileen

Dyson, Esther

Holmes, Charles

Huntress, Wesley T, Jr.

Kennel, Charles F., *Ex-Officio*

Kohrs, Richard

Montelongo, Michael

O'Brien, Miles

Florida Institute of Human and Machine  
Cognition

NASA Headquarters

Commercial Spaceflight Federation

Aerospace Industries Association

Aeronautics and Space Engineering Board,

National Academies

Space Presentations, LLC

EDventure Holdings

Representing Albert Edmonds

Carnegie Institute of Washington

Space Studies Board, National Academies

NASA (Ret.)

Representing Robert Hanisee

Miles O'Brien Productions

***NASA Attendees:***

Ameche, Nicole

Bachman, Brian

Berisford, David

Boyd, Walter

Cooke, Doug

Emond, John

Flores, Sarah

Fosse, Elyse

Fredrickson, Rachel

Friedl, Randall

Gebow, Daniel

Getto, Connie

Gillis, Jason

Graczyk, Indrani

Green, Mike

Gustafson, Eric

Hand, Kevin

Hart, Cozette

Hofmann, Doug

Howard, Tom

NASA/JPL

NASA/JPL

NASA/JPL

NASA/JPL

NASA HQ

NASA HQ

NASA/JPL

NASA/JPL

NASA/JPL

NASA/JPL

NASA/JPL

NASA/JPL

NASA HQ

NASA/JPL

NASA HQ

NASA/JPL

NASA/JPL

NASA/JPL

NASA/JPL

NASA/JPL

Johnson, Lindley	NASA HQ
Kassaie, Parvin	NASA/JPL
Kenig, Sivan	NASA/JPL
King, Marla	NASA HQ
Kinnett, Ryan	NASA/JPL
Kulczycki, Stephen	NASA/JPL
Landau, Damon	NASA/JPL
Lewis, Leslie	NASA/JPL
Liewer, Pavlett	NASA/JPL
Liles, Kaitlin	NASA/LaRC
Michael, Brian	NASA/JPL
Minor, Susan	NASA HQ
Mittal, Nimisha	NASA/JPL
Nesnas, Issa	NASA/JPL
Oveisgharan, Shadi	NASA/JPL
Pardmanablhan, Sharmila	NASA/JPL
Rogers, Lindsay	NASA HQ
Schiller, Zack	NASA/JPL
Seidel, David	NASA/JPL
Short, Kendra	NASA/JPL
Siegel, Bette	NASA/HQ
Srinivasan, Jeff	NASA/JPL
Stalder, Julia	NASA/JPL
Tan, Ian	NASA/JPL
Urquiza, Eugenio	NASA/JPL
Vargo, Bob	NASA/JPL
Vick, Erika	NASA HQ
Weaver, David	NASA HQ
Weitl, Raquel	NASA/JPL
Yeomans, Don	NASA/JPL
Yuzzie, Aaron	NASA/JPL
Zuffada, Cinzia	NASA/JPL

*Other Attendees:*

Aldrin, Buzz	StarBuzz LLC
Barry, Diana	Ciber
Baffat, Jonathan	StarBuzz LLC
Levack, Dan	Pratt & Whitney Rocketdyne
Lindstrom, Kurt	APL
Rybacki, Jacqueline	Deloitte
Schweickart, Rusty	NAC Ad-Hoc Task Force on Planetary Defense
Sega, Dr. Ronald	Colorado State University
Siazer, Frank	Northrop Grumman

**NASA ADVISORY COUNCIL  
Jet Propulsion Laboratory  
Pasadena, CA  
August 5-6, 2010**

**LIST OF PRESENTATION MATERIAL**

- 1) Welcome and Innovation at JPL [Elachi]
- 2) NASA's Near-Earth Object Program Overview [Yeomans]
- 3) NEO Orbital Dynamics and Deflection [Schweickart]
- 4) JPL Hires Analysis [Hart]
- 5) Aeronautics Committee Report [Blakey]
- 6) Audit, Finance, and Analysis Committee Report [Montelongo]
- 7) Commercial Space Committee Report [Alexander]
- 8) Education and Public Outreach Committee Report [O'Brien]
- 9) Exploration Committee Report [Kohrs]
- 10) Information Technology Infrastructure Committee Report [Holmes]
- 11) Avionics, Software, and Cybersecurity Subcommittee Report [Holmes]
- 12) Science Committee Report [Huntress]
- 13) Controlling Cost Growth of NASA Earth and Space Science Missions [Sega]
- 14) Space Operations Committee Report [Collins]  
Technology and Innovation Committee Report [Dyson]