National Aeronautics and Space Administration

Earth Science Subcommittee

of the

NASA Advisory Council

November 17-18, 2010

NASA Headquarters
Washington, DC

MEETING SUMMARY

Lucia S. Tsaoussi	Byron D. Tapley
Executive Secretary	Chair

NASA ADVISORY COUNCIL

EARTH SCIENCE SUBCOMMITTEE

NASA Headquarters
Washington, D.C.
November 17-18, 2010

MEETING SUMMARY
TABLE OF CONTENTS

Meeting Report Prepared By:
David J. Frankel
Consultant, Zantech IT Services

NASA ADVISORY COUNCIL

EARTH SCIENCE SUBCOMMITTEE

NASA Headquarters
Washington, D.C.
November 17-18, 2010

Wednesday, November 17, 2010

Call to Order, Opening Remarks

The NASA Advisory Council (NAC) Earth Science Subcommittee (ESS) meeting was convened by Dr. Lucia Tsaoussi. She announced that the meeting was a Federal Advisory Committee Act (FACA) meeting open to the public. At her request, the ESS members introduced themselves.

ESS Meeting Charge

Dr. Tsaoussi introduced Dr. Byron Tapley, ESS Chair. Dr. Tapley described the objectives for the meeting and reviewed the agenda for the day. He explained that the ESS has been asked by the Earth Science Division (ESD) to evaluate the Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) mission. The mission is planned for launch in 2017 in order to enable overlap and synergy with other Earth observation satellites, including other Tier 1 missions identified by the Decadal Survey. The ESS is being asked to find "yes" or "no" to the following: *Does the DESDynI mission so defined represent a scientifically viable mission? That is, will its measurements likely enable advances in our scientific understanding commensurate with the cost and schedule of the mission?* Dr. Tapley reported on the results from the last NAC Science Committee meeting.

ESD Update

Dr. Tapley introduced Dr. Michael Freilich, ESD Director. Dr. Freilich provided the ESS with an update on the Division. He reviewed the Division's proposed budget and explained that the President's FY11 Proposed Budget is the second large infusion to the Division. It will enable the Orbiting Carbon Observatory-2 (OCO-2) mission to be developed and launched by February 2013. It accelerates the Earth Science Decadal Survey systematic missions. All four Tier-1 missions are now planned for launch between 2014 and 2017. These are: Soil Moisture Active-Passive (SMAP); Ice, Cloud, and land Elevation Satellite-2 (ICESat-2); DESDynI; and the Climate Absolute Radiance and Refractivity Observatory (CLARREO). The President's budget expands and accelerates the Venture-class program. It develops selected Climate Continuity Missions: Stratospheric Aerosol and Gas Experiment III (SAGE III); Gravity Recovery and Climate Follow-On (GRACE-FO); and the Particles, Atmosphere and Chemistry Experiment (PACE). It accelerates all Tier-2 Decadal Survey missions, with two launches in 2019-2020: Surface Water Ocean Topography (SWOT) and Active Sensing of Carbon dioxide Emissions over Nights, Days and Seasons (ASCENDS). The FY 2011 budget augmentation enables key research, applications, technology, and education activities to be initiated or greatly expanded. These non-flight activities both enable the new space missions and provide scientific and societal benefits from space-borne measurements. Dr. Charles Vorosmarty asked how ESD was preparing for anticipated congressional austerity. Dr. Freilich responded that ESD has a clear strategy for the present and is working towards the President's proposed budget. When Congress passes the budget, ESD will reevaluate the program to give the Administration the best possible guidance under the circumstances. Dr. Vorosmarty asked whether there was any contingency planning. Dr. Freilich responded that it would not be an effective way to use resources because it would be difficult to develop realistic scenarios.

Dr. Freilich described foundational near-term missions. The Glory spacecraft is planned to launch in February 2011. Aquarius, a joint mission with the Argentine National Space Activities Commission (CONAE) is scheduled for June 2010. Global Precipitation Measurement (GPM), a joint mission with the Japan Aerospace Exploration Agency

(JAXA) is scheduled for July 2013. Landsat Data Continuity Mission (LDCM), a joint mission with the United States Geological Survey (USGS) is scheduled for December 2012. The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP), a joint mission with the National Oceanic and Atmospheric Administration (NOAA), is scheduled for October 2011.

NASA cannot, by itself, afford to do everything that is needed. This makes it important to collaborate with other nations and sister Federal agencies. Dr. Freilich described collaborations with the European Space Agency (ESA), India, France, Canada, Argentina, Japan, Germany, and Brazil, and he remarked that NASA is in a very successful collaboration mode with NOAA. He observed that ESA has eased its data exchange policy and he expressed appreciation to the European Union for helping to make that possible. Due to the change, ESA-supported science campaigns may be established in the future.

The Joint Agency Satellite Division (JASD) has been established within NASA's Science Mission Directorate (SMD) to manage reimbursable satellite and instrument development. Dr. Freilich described the NPP mission status and the Joint Polar Satellite System (JPSS) status. JPSS is in an unusual transition from the NPOESS program. Risk is minimized by making JPSS an NPP clone. NASA and NOAA have successfully completed the Global Hawk Pacific (GloPac) campaign, the first Earth Science mission to be conducted on the Global Hawk unpiloted aircraft. The Global Hawk can fly autonomously to altitudes above 60,000 feet, approximately twice as high as a commercial airliner, and as far as 11,000 nautical miles, for up to 30 hours. There have been scientific and technical accomplishments from the Genesis and Rapid Intensification Processes (GRIP) mission, which involved using several aircraft in coordination with NOAA. The Impacts of Climate change on the Eco-Systems and Chemistry of the Arctic Pacific Environment (ICESCAPE), a multi-year NASA ship-borne project, has been studying sea ice in the Chukchi Sea. Dr. Freilich discussed the Division's assistance in responding to natural disasters like the Haitian hurricane, the Chilean earthquake, and the Gulf oil spill.

Dr. William Large remarked that NASA has a modeling forecast capability and he asked whether there was a program to review whether those forecast systems are using NASA data optimally. Dr. Freilich responded that there is not a formal program for doing so. ESD is developing a disasters strategy and will consider incorporating Dr. Large's suggestion. Dr. Raymond Hoff reported that the Federal Aeronautics Administration (FAA) recently awarded a $1 billion contract for flight coordination and is interested in using NASA's real-time data for rerouting aircraft. Dr. Mark Simons asked whether there was an integrated program for responding to disasters that leverages all the resources within NASA. He suggested that this could attract new clients. Dr. Freilich explained that this would be included in the overall strategy for responding to disasters and that ESD was actively engaged in ensuring that the data acquired from providing disaster assistance was used to the maximum extent possible.

Dr. Tapley thanked Dr. Freilich for his presentation.

Ethics Briefing

Dr. Tapley introduced Kathleen Teale, NASA Senior Attorney, who briefed the ESS members on the legal requirements pertaining to ethics. Each ESS member is a Special Government Employee (SGE) and the government's ethics laws apply to all SGEs. Ms. Teale described the standards of conduct and the criminal statutes on ethics. Any ESS member having a specific issue should notify Dr. Tsaoussi and obtain legal advice from the General Counsel's office. Mr. Hoff stated that he would recuse himself from participating in the DESDynI discussion. Mr. Simon stated he would be consulting with Ms. Teale about a possible conflict of interest that might prevent him from participating in the DESDynI discussion.

Dr. Tapley thanked Ms. Teale for her presentation.

SMAP Mission Status

Dr. Tapley introduced Mr. Eric Ianson, SMD Program Executive and Dr. Jared Entin, Program Scientist, SMAP Mission. Mr. Ianson provided an overview on the mission. SMAP is a first-tier mission recommended in the 2007 National Research Council (NRC) Earth Science Decadal Survey. Its primary science objective is a global, high-

resolution mapping of soil moisture and its freeze/thaw state using a combined radiometer and high-resolution radar. Launch is scheduled for November 2014. It is compatible with a several launch vehicle options. Dr. Entin described SMAP's science objectives. Its measurements data will be used in applications that range from agriculture to human health. SMAP will enable a better understanding about the processes that link the terrestrial water, energy and carbon cycles. It will be used to estimate global water and energy fluxes at the land surface. It will quantify net carbon flux in boreal landscapes. It will be used to develop improved flood prediction and drought monitoring capability. Dr. Entin described SMAP's Level 1 science requirements and their derivation. SMAP will provide returns for both science and applications. Its data will be vital for climate and global change science. It will provide data to test model forecasts for future water availability. Those models currently disagree on whether there will be more or less water in the future compared to today. SMAP will complement Aquarius and ESA's Soil Moisture and Ocean Salinity (SMOS) mission.

Dr. Entin discussed the strategy for mitigating the effects from radio frequency interference (RFI) on SMAP's radar and radiometer. Extensive surveys and simulations were conducted to understand the RFI environment. The radar was redesigned to minimize interference to FAA radar. Dr. Entin reviewed charts on SMAP's science organization and data products. A primary goal for the SMAP mission is to engage SMAP end-users and build broad support for SMAP applications through an inclusive and transparent process. An applications workshop was held and provided the basis for a draft SMAP Applications Plan, which is currently undergoing review at NASA Headquarters. All Decadal Survey missions are now required to have increased focus on Applications or Applied Science. The SMAP radiometer, provided by the Goddard Space Flight Center (GSFC), will be L-band, 1.4 GHz and provide 40 km resolution. The SMAP radar, provided by the Jet Propulsion Laboratory (JPL), will be L-band, 1.26GHz and provide 1-3 km resolution in Synthetic Aperture Radar (SAR) mode and 30 x 5 km resolution in real-aperture mode. The two instruments will share a 6-meter diameter mesh antenna with a deployable reflector rotating at 14.6 rpm. The swath and orbit will enable a two to three day global revisit.

Dr. Entin described the mission's current status. Most major planned contracts are in place. There is some launch vehicle selection risk and selection is expected after the Project Preliminary Design Review (PDR), which is scheduled for March 2011. The SMAP Flight System design and implementation has been simplified to stay within cost allocation. Phase C/D planning is nearly complete. The ESS discussed the effect from a possible reduction in mission duration to 18 months from three years. In response to a question from Dr. Foufoula-Georgiou, Dr. Entin explained that soil moisture would be measured from the top five centimeters of soil. In response to a question from Dr. Vorosmarty, Dr. Entin indicated that data flags would be used to account for canopy interference. In response to a question from Dr. Daniel Jacob, Dr. Entin noted that there has been some demonstration that the two instruments see the same moisture values.

Dr. Tapley thanked Dr. Entin and Mr. Ianson for their presentation.

DESDynI Mission Concept and Design

Dr. Tapley introduced Dr. Stephen Volz, who briefed the ESS on the DESDynI mission. Dr. Simon recused himself from discussion on this item due to a conflict of interest arising from his employment. Dr. Freilich explained that ESD has defined Baseline and Threshold mission science requirements for DESDynI. The requirements are based on capabilities, cost, risk, and schedule. The Baseline performance defines the full mission that NASA plans to implement. The Threshold performance defines a reduced but acceptable mission that NASA will implement if unexpected difficulties arise in the baseline mission development. The ESS evaluation must be based on the Threshold mission. The ESS is asked to find "yes" or "no" to the following: *Does the DESDynI Mission so defined represent a scientifically viable mission? That is, will its measurements likely enable advances in our scientific understanding commensurate with the cost and schedule of the mission?*

Dr. Volz described DESDynI's history. DESDynI is part of an integrated Climate Plan that ESD developed following direction from the Administration. It began with the 2007 Earth Science Decadal Survey. A science study group, with representatives from the Cryospheric, Ecosystem, and Solid Earth science communities, has worked with the DESDynI engineering design team to define mission capabilities and an engineering solution for achieving them that is consistent with ESD's budget and schedule guidelines. DESDynI uses two spacecraft, each with a different sensor. The mission combines the data from the two sensors to provide observations important for solid-

Earth (surface deformation), ecosystems (terrestrial biomass structure), and climate (ice dynamics). The sensors are an L-band Interferometric Synthetic Aperture Radar (InSAR) system, and a multiple beam Light Detection and Ranging (Lidar) system. The mission is planned for launch in 2017. Dr. Volz reviewed a chart showing the DESDynI Mission costs. ESD has allocated $1.67 billion ($1.45 billion for the project plus $220 million in reserve) for the mission. Three independent cost estimating methods will be used to assess the mission cost.

DESDynI Science Requirements

Dr. Volz introduced Dr. John LaBrecque, who briefed the ESS on the science requirements for the DESDynI mission. Dr. LaBrecque described the DESDynI Working Group's organization and its Science Study Group's membership. DESDynI's unique Lidar-radar fusion will provide new direction in surface change science. Charts were presented summarizing the mission's general Threshold and Basic science requirements. DESDynI will provide velocity and elevation data to help understand the rapid changes in the coastal ice sheets in Antarctica and Greenland. The data will be used to develop predictive models for accurate sea level projections. Dr. LaBrecque reviewed charts showing the dynamics of ice Threshold and Baseline requirements. He explained how DESDynI would provide an essential complement to ICESAT and international missions. The near simultaneous observations of thickness using Lidar and ice deformation using SAR will resolve the contribution of dynamics and thermodynamics to the distribution of ice thickness. DESDynI's relationship to existing and planned radar missions was described. For the first time, comprehensive ice flow sampling will be possible.

Dr. LaBrecque described the mission's primary goal and science objectives relating to the ecosystem structure. The current state of the art for global characterization of 3-D canopy structure is inadequate to address pressing environmental concerns. Science and policy need a high spatial resolution canopy structure data set and consistent framework suitable for answering critical questions about the effects of climate and land use change on carbon dynamics, habitat suitability and biodiversity. Using the radar-Lidar fusion approach, DESDynI enables global mapping of forest structure, biomass and disturbance at spatial scales far beyond current global capabilities. It would enable global carbon modeling and studies on biodiversity and habitat. Charts describing the mission's Threshold and Baseline requirements for the ecosystem structure were presented.

Dr. LaBrecque described the mission's primary goal and science objectives relating to deformation and solid Earth. It will help understand the physics of earthquakes and volcanoes, and help monitor and manage water and hydrocarbon use. Frequent temporal sampling will help understand earthquake mechanisms. DESDynI will extend EarthScope GPS temporal coverage of deformation as a fourth element. It will reveal processes never seen before and improve our models of earthquakes, volcanoes, and other hazards many-fold. Charts describing the mission's Threshold and Baseline requirements for deformation were presented.

Dr. LaBrecque discussed potential science partnerships. The DESDynI mission will allow a wide range of products for three distinct science communities: global ice; global biomass, carbon and biodiversity; and tectonic and volcanic geohazards. The USGS is interested in developing and operational hazard monitoring capability based on DESDynI's data. The U.S. Forest Service is interested in integrating DESDynI data into their forest inventory and monitory. The NSF's Directorate for Geosciences believes that DESDynI is a mission that will be transformational for science and society, and is interested in finding ways to support and partner with NASA in the mission. In response to a question from Dr. Jean-Bernard Minster, Dr. LaBrecque explained that the NSF may contribute the science data system.

Dr. Volz described Phase A activities that will begin next Spring. Interagency and international partnership opportunities will be pursued to reduce mission and implementation risk and enhance the mission's science return. Mission design trade studies will focus on risk mitigation and design refinement for the radar and Lidar. Dr. Volz explained that the launch vehicles for the missions will not be selected for a few years and is a program risk. NASA's Launch Services Program is providing estimated costs. The Falcon 9's development is an important element for cost containment.

Dr. Robert Schutz asked about the need for two platforms. Dr. LaBrecque explained it was necessary to give the Lidar system sufficient global coverage to satisfy the ecosystem requirements. Lidar will be a two year mission and the radar will be a three-year mission. Dr. Paul Rosen added that a single platform would not necessarily be less

expensive. The difference in cost between the Threshold and the Baseline missions is less than $100 million. The ESS discussed the mission's various instrument measurements and capabilities. Technical tradeoffs were discussed. Dr. Volz noted that there is not much margin in the project, but there are ample reserves. The problem will be building what has so far been tested.

Dr. Tapley thanked Dr. Volz and Dr. LaBrecque for their presentation.

Discussion

Dr. David Siegel asked whether C-band instruments on the Sentinel missions had been considered. Dr. Rosen explained that the C-band is more sensitive to smaller objects like leaves blowing on tree tops and tends to be compromised with respect to interferometry. Dr. Foufoula-Georgiou added that the sensitivity to the leaves prevents C-band from providing more information about the trees and the rest of the biomass. Dr. Labrecque noted that the U.S. is not currently flying any SARS missions, and that having DESDynI would be a game changer giving the U.S. tremendous bargaining power. Dr. Jacob stated that the Threshold mission is a viable and high-quality mission, although it is very expensive. Dr. Konrad Steffen expressed concern over the mission's length. He explained that a single season cycle would be insufficient and that it would be very important to have more than one year overlap. Dr. Vorosmarty observed that the program is much further along in risk and cost assessment than usually happens at this stage in the development cycle. Dr. Tapley obtained a consensus from the ESS to approve the Threshold mission. Dr. Freilich expressed his appreciation to the ESS for its assistance. He explained it is important to understand the constraints for capability, cost, risk, and schedule as early as possible in a mission's development. This is a change in ESD's culture that will be applied to future projects.

The meeting was adjourned for the day.

Thursday, November 18, 2010

Call to Order

Dr. Tapley called the meeting to order and reviewed the agenda for the day.

Applied Sciences Program (ASP) Update

Dr. Tapley introduced Dr. Lawrence Friedl, ASP Acting Director. Dr. Friedl described the ASP's goals and planned actions. The first goal is to advance the use of NASA Earth science in policymaking, resource management and planning, and disaster response. The key actions for this goal are to identify priority needs, conduct applied research to generate innovative applications, and support projects that demonstrate uses of NASA Earth science. The second goal is to establish a flexible program structure to meet diverse partner needs and applications objectives. The key actions for this goal are to pursue partnerships to leverage resources and risks and extend the Program's reach and impact. The third goal is to ensure that NASA's flight missions plan for and support applications goals in conjunction with their science goals, starting with mission planning and extending through the mission life cycle. The key actions for this goal are to enable application identification early in the satellite mission life cycle and facilitate effective ways to integrate end-user needs into satellite mission planning.

Dr. Friedl described recent ASP products. NASA provides near real time (NRT) information on volcanic sulfur dioxide (SO_2) and ash aerosols through NOAA's Volcanic Ash Advisory Centers (VAAC). Dr. Tapley stated that this is an impressive data application. Another product is NRT information that is provided to conservation managers and firefighters around the world through the Fire Information for Resource Management System (FIRMS) and the Global Fire Information Management System (GFIMS). Active fire locations are processed by NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) rapid response system. Text messages are sent to help groups identify illegal clearing, poaching, and fires. Dr. Simon expressed concern that NASA often does not receive credit for its products. Dr. Friedl discussed Applications Readiness Levels (ARL), a new methodology adapted from Technology Readiness Level (TRL). ARL will be used to assess Earth science application project

maturity and to track Earth science integration into decision making. He presented a chart comparing the Program's current applications and Decadal Survey Missions with the nine Societal Benefit Areas (SBAs) designated by the U.S. Group on Earth Observations (USGEO), established under the White House Office of Science and Technology Policy (OSTP). Dr. Jacob expressed an interest in learning how the ASP could partner more with the private sector, which, he believes, is prepared to provide funds to develop applications. Dr. Freilich cautioned that this entails procurement issues and might be viewed as giving a competitive advantage to one commercial entity over another. Dr. Friedl described how the Research Opportunities in Space and Earth Sciences (ROSES) solicitation is including applied research. Dr. Hoff commented that this is a new concept to get more application attention into the science teams.

Dr. Tapley thanked Dr. Friedl for his presentation.

Applied Sciences Advisory Group (ASAG) Report

Dr. Tapley introduced Dr. Hoff, ASAG Chair. Dr. Hart explained that the ASAG is a standing advisory subcommittee that was mandated in the 2005 NASA Authorization Act and reports to the NAC through the ESS. The ASAG met on October 21-22, 2010. He noted that the changes within the ASP over the past year, under Dr. Friedl, have been "transformational."

Dr. Hoff reviewed the ASAG's Findings, Observations, and Recommendations:

- Finding: The Applied Sciences Program is a critical part of ESD.
- Observation: The Director and Program Managers are complimented on the remarkably improved degree of visibility into the program.
- Observation: The willingness to share details of the program funding and direction with the ASAG helped us dramatically understand the issues facing ASP.
- Finding: Identified in our letter to Administrator Bolden in 2009, the Program continues to be understaffed and financially challenged for the breadth of societal benefit areas it needs to address. While the out-year funding in the President's Budget is attractive, NASA must continue to increase resources for ASP.
- Finding: This is especially true in light of the expectations of the 2010 Authorization language.
- Finding: Having the Applied Sciences Program leadership in an Acting position encourages a perception of lack of commitment to the Program. Partners take "wait and see" attitude.
- Recommendation: The Committee recommends that NASA seek a permanent line for the Associate Director of the Applied Sciences Program.
- Finding: The Associate Director has begun to state metrics for the program.
- Finding: The ASAG believes that:
    - The ARL or index is a good method to attack performance of applications
    - The "skin-in-the-game" metric is important
    - The development of fundamental knowledge needs to be emphasized
    - The sustainability of the application after NASA funding ends should be included
    - A NASA Attribution requirement (i.e. does the NASA Logo need to follow the product?) is not necessary but the ASP should track this metric.

Dr. Hoff opined that it is advisable to refrain from imposing attribution requirements when transitioning to an operational environment. Dr. Judith Curry noted that NASA's investment in the ASP is producing high results and could have a "halo" effect on the entire ESD program. She cautioned against excessive concern over whether NASA continues to receive attribution because NASA budget will not be reduced for products that become essential. Dr. Jacob advised that NASA should find a way to track how its products are being used. Dr. Hoff agreed and stated it is important to know when products have gone into an operational environment in another agency. Dr. Freilich concurred and noted that until the last two years, NASA has not done a very good job in tracking and articulating its contributions. Dr. David Siegel cautioned that attribution could become a problem if NASA is unable to provide data. Dr. Freilich concurred and observed that NOAA has issued public statements on NASA's failure to provide data.

Dr. Jacob congratulated the ASP for developing its vision and stated it is necessary to look more into partnerships with the private sector. Dr. Schutz opined that it is very important to have applications areas in new science teams. This has to be factored in early because it could have an impact on space hardware. Dr. Hoff noted that NRT is generally required for real world applications. Dr. Minster observed that the capability to disseminate data immediately is needed when there is a disaster. Dr. Freilich noted that NASA has been developing a disasters plan. Dr. Simon cautioned that imposing requirements for NRT data could add significant additional expenses that ASP will not have the funding to support.

Dr. Tapley thanked Dr. Hoff for his presentation.

Meeting with SMD Associate Administrator

Dr. Tapley introduced Dr. Ed Weiler, SMD Associate Administrator. Dr. Weiler stated that it has been a good year for Earth science and complemented Dr. Freilich and his staff for their good work. He discussed the budget situation. His meetings with NASA's four congressional oversight committees went well. NASA is currently operating under a Continuing Resolution (CR) that ends in December. The "lame duck" Congress is not likely to adopt authorization bills for individual agencies. A CR may be used to carry over to the next year or Congress may adopt an omnibus authorization bill. DESDynI is not a new program and, therefore, would not be precluded under a CR. NASA may not be given the budget that it is planning on, and cuts across the board may need to be implemented. Dr. Freilich should continue to develop plans based on the existing budget. While these are uncertain times, Earth science enjoys high priority in the Administration.

Dr. Jacob asked whether there was a way to engage international partners at the strategic level. He noted that the international partners are not flying the optimal mix of satellites and sensors at the right time. Dr. Weiler stated that NASA has decided that it cannot afford the Mars program by itself, and that ESA has made the same decision. Astrophysics is moving in the same direction. Working groups are being established at a lower level, and it is time to recognize that there are not many affordable small missions. Dr. Weiler agreed to discuss with the NRC a joint Decadal Survey concept with ESA. He observed that it would be wonderful to have an "Atlantic" decadal, but advised that it would be best to establish the architecture for this with one international partner. Dr. Minster noted that together NASA and ESA capture 85 percent of the data. Dr. Hoff requested a briefing from NOAA on NPP's status and the quality of its data. Dr. Jacob reported that BP, Inc. would provide funding to NASA to produce desired data. Dr. Hoff offered to have the ASAG explore how to bridge commercial requirements for data with NASA's products. Dr. Weiler suggested having the NASA office responsible for commercialization and a procurement lawyer brief the ASAG at a future meeting. Dr. Minster noted the need for a midterm review on the Decadal Survey, and Dr. Weiler indicated that it is in process. Dr. Freilich clarified that the review is an analysis and evaluation on ESD's progress on the Decadal Survey, recognizing ESD's administrative priorities and budgetary realities. Dr. Weiler stated that he intends to contract out for assistance in performing cost analysis. Dr. Tapley agreed that bringing in contractors for that function is a good idea.

Dr. Tapley thanked Dr. Weiler for his comments.

NRC Geodetic Networks Study

Dr. Tapley introduced Dr. Minster, who briefed the ESS on the NRC's Committee on National Requirements for Precision Geodetic Infrastructure. The Committee's task is to assess the benefits to the nation that are dependent on high precision geodetic networks, review scientific objectives that are dependent on geodetic networks, describe the infrastructure needed for the objectives, assess the opportunities for technological innovation from investment in geodetic infrastructure, and recommend a national plan for the infrastructure. Dr. Minster described the Committee's membership. Geodesy is a science for accurately measuring and understanding three fundamental properties of Earth--its geometric shape, its orientation in space, and its gravity field--and the changes of these properties with time. Geodesy benefits society in real-time positioning, autonomous navigation, precision agriculture, surveying and floodplain mapping, forest mapping and biomass estimation, monitoring and early warning for natural hazards, and sea level change. The geodetic infrastructure includes ground-based networks, Earth observation satellites, data collection, and national and international services. Geodesic systems include Very Long Baseline Interferometry

(VLBI), Global Navigation Satellite System/Global Positioning System (GNSS/GPS), Satellite and Lunar Laser Ranging (SLR and LLR), Doppler Orbit Determination and Radio Positioning Integrated by Satellite (DORIS), ground and airborne gravity, and tide gauges.

The geodetic infrastructure is in danger of collapse. Nobody has overall long-term responsibility. The U.S., to maintain leadership in industry and science, and as a matter of national security, should invest in the geodetic infrastructure through network design upgrades, modernizing observing systems, deploying improved observing capabilities, and funding opportunities for research, analysis, and education in global geodesy. The U.S. should construct the next generation SLR tracking systems and install the next generation VLBI systems. Maintaining the data history is essential for reference frame stability. The U.S., with its international partners, should deploy additional stations in order to reach at least 24 fundamental stations. The U.S. should maintain a high-precision GNSS/GPS network able to stream high-rate data in real-time. All data from this network should be available in real-time without restrictions, and at no cost or at a cost not to exceed the marginal distribution cost. The U.S. should support the international geodetic services and make a long-term commitment to maintain the International Terrestrial Reference Frame (ITRF). A federal geodetic service should be established. A quantitative assessment on the precise geodesy workforce should be conducted under a study focused on the long-term prospects for geodesy and its applications.

Dr. Tapley thanked Dr. Minster for his report.

Geodetic Network Plans

Dr. Tapley introduced Dr. Labrecque who briefed the ESS on what is being done to meet the geodetic challenge in the NRC's Decadal Survey. He described the foundation documents that guide space geodesy's development. Space missions costing $2.4 billion depend upon capable geodetic science, technology, and infrastructure. According to the NRC Decadal Survey, the geodetic infrastructure is in danger of collapse, and improvements in both accuracy and economic efficiency are needed. NASA supports a Geodetic Study Group to develop the requirements for the Next Generation Geodetic Network. Dr. LaBrecque presented a slide summarizing the NRC Study Committee's recommendations. He described the Global Geodetic Observing System (GGOS). Its data products come from the International Association of Geodesy (IAG) and depend upon international cooperation and investment. More than 250 institutions in over 90 countries contribute to the IAG services. Scientific and societal requirements for GNSS-based space geodesy are growing. Improvements to the GDL and the ITRF are critical to understanding sea level change impacts. The GGOS is not meeting measurement goals. The reference system accuracy is currently 1 cm and user requirements are for 1 mm. The GGOS challenge is to obtain 60-90 high precision radio sources within the next decade. The signals must be interoperable. The scientific geodetic community must have access to the precise signals, and the relevant codes must be available in real time. ITRS requirements can be achieved through satellite laser ranging to GNSS. Dr. LaBrecque discussed a chart showing how a 16 station SLR network tracking a GNSS constellation could provide 4mm/yr origin and .02mm/yr scale accuracy. He described the ILRS retro-reflector standard for GNSS satellites. Russia's Global Navigation Satellite System (GLONASS) is the first to comply with this standard. He reviewed a slide on the Organization of International VLBI Service (IVS) Working Group 3 Report on VLB12010 and a slide on a GGPS2020 recommendation to co-locate four space geodesy techniques in fundamental stations so that measurements can be related to sub-mm accuracy. He described the Goddard Geophysical and Astronomical Observatory (GGAO) Fundamental Station, which has four techniques on site: Legacy SLR, VLBI, GPS, and DORIS. The station is being upgraded to GGOS2020 standards.

NASA is developing a prototype next-generation geodesy observatory at the Goddard Spaceflight Center (GSFC). International contributions will be essential to developing the next generation GGOS network. Dr. LaBrecque reviewed charts showing the sites that are planned or proposed for the network. The highest latitude geodetic observatory will be in Ny-Ålesund. Its latitude is important for global coverage. It will cost $300-$500 million to build and maintain the global network. The U.S. will need to contribute $50-$70 million for its stations, and many countries cannot afford their own stations. Dr. Tsaoussi observed that this is a unique role for NASA. Dr. Tapley reported that the laser at NASA's station is deteriorating dramatically. Dr. Labrecque stated that they are looking on eBay for parts. Dr. Minster asserted that the defense agencies are not enormously interested in precision, and that the FAA is not interested in the scientific accuracy. Dr. Shutz commended Dr. LaBrecque and his program for taking the lead in this issue.

Dr. Tapley thanked Dr. LaBrecque for his presentation.

Discussion, Findings, and Recommendations

Dr. Tapley identified three issues requiring action by the ESS: (1) a finding on the DESDynI mission, (2) a decision on forwarding the ASAG recommendations, and (3) a response on Geodetic Networks. Dr. Large noted that there is a movement towards the continuity missions and he requested more information on the non-space flight budgets. Dr. Schutz observed NASA has been criticized in the past for getting into operational areas and he expressed concern that continuity implies operational. Dr. Freilich stated that rather than using the word "operational," he would prefer to use the words "long-term data acquisition." He noted that NASA now has direction for the first time to address climate continuity needs. Dr. Simon commended the initial steps that ESD has taken for disaster response. He noted that funding a new activity in response to a natural event is different than building an infrastructure. In response to a suggestion from Dr. Large regarding having a small line item for disaster response, Dr. Freilich stated that NASA would always be able to find funds to respond to an unexpected disaster. In response to a question from Dr. John Christy, Dr. Freilich explained that Congress is able to give directions subtly without using earmarks. Dr. Tsaoussi advised that ESD has issued a remote sensing call and responses have been received to look at algorithms and future data streams. Dr. Minister expressed strong disappointment over the data system planned for the NPOESS. Dr. Freilich discussed budgetary strategy among sister agencies. Dr. Tsaoussi advised that there is a NOAA advisory board for Earth observing systems, and that the science community could provide comments to it. Dr. Freilich explained that NASA is spending $150 million per year on data systems and has the ability to make sure that data is not lost. Dr. Siegel described an advisory problem at JPSS. Dr. Tapley asked Dr. Siegel to prepare a brief letter requesting a response to an earlier ESS recommendation on this matter and for information on the status of the NPOES program and JPSS. Dr. Tsaoussi stated that she would obtain status information on NPP.

Dr. Hoff discussed the ASAG Recommendation for NASA management to find a mechanism to make Applied Science's acting director a permanent position. Dr. Tsaoussi advised that it would need to become an ESS recommendation to go forward. Dr. Tapley advised that it would be useful for the NAC to learn about the Applied Sciences program. Dr. Freilich concurred. The ESS approved the Recommendation.

Dr. Tapley discussed the DESDynI question. The ESS consensus was to answer the question affirmatively.

Dr. Tapley discussed the Geodetic Network presentation. He expressed appreciation to the NRC for its report. There was no question presented, however, for consideration by the ESS.

Dr. Hoff proposed an Observation to encourage Dr. Labrecque and the laser ranging service to contact stations currently serving other purposes and seek to leverage those sites for Lidar stations. The ESS approved this Observation by consensus.

Dr. Jacob proposed a Recommendation for NASA to increase the staffing level at ESD. Dr. Hoff observed that downsizing is a good strategy for Congress but a bad strategy for the Agency. Dr. Minster expressed concern that NASA was managing 100 missions with only 160 people. Dr. Jacob opined that NASA's program managers are inefficient because they are overworked. Dr. Tapley suggested rephrasing the Recommendation as an Observation and asking the NAC to ascertain whether other areas were experiencing the same problem. The ESS approved this Observation by consensus.

Dr. Jacob proposed a Recommendation for more bilateral international cooperation with ESA at the strategic level. He explained that this could be expanded to include other nations once it proved successful. At Dr. Tapley's suggestion, the ESS decided to request a briefing on this issue at the next meeting.

Letter Writing/Next Meeting and Closing Remarks

Dr. Tapley stated that a date for the next ESS meeting in early March would be determined after the budget has been finalized. He issued writing assignments. A draft letter will be composed and circulated for comments before being finalized.

Dr. Tapley thanked the ESS members for contributing their valuable time. He thanked Dr. Tsaoussi for her assistance.

The meeting was adjourned.

Appendix A

NAC Earth Science Subcommittee

NASA Headquarters
300 E Street SW, Washington, DC.

Agenda

17-November-2010 @ MIC 3 (3H46)

8:30	8:35	Opening remarks	L. Tsaoussi
8:35	8:50	Meeting charge	B. Tapley
8:50	9:50	Earth Science Division Update	M. Freilich
9:50	10:00	Coffee Break	
10:00	11:00	Ethics brief	K. Teale (General Council)
11:00	12:00	SMAP Mission status	Ianson/Entin
12:00	*1:00*	*Lunch*	
1:00	2:00	DESDynI Mission Concept Design	S. Volz
2:00	3:00	DESDynI Science Requirements	J. LaBrecque
3:00	3:15	Coffee Break	
3:15	5:30	Discussion	All
5:30		Adjourn	

18-November-2010 @ MIC 6 (6H45)

8:30	8:45	Session Overview	B. Tapley
8:45	9:10	Applied Sciences Program Update	L. Friedl
9:10	9:30	ASAG Report	R. Hoff
9:30	10:00	Discussion	All
10:00	11:00	Q&A with SMD AA	E. Weiler
11:00	11:20	NRC Geodetic Networks Study	B. Minster
11:20	11:40	Geodetic Networks Plans	J. LaBrecque
11:40	12:00	Discussion	All
12:00	*1:00*	*Lunch*	
1:00	2:00	Findings & Recommendations	ESS Members
2:00	3:00	Letter writing/next meeting	ESS Members
3:15		Closing remarks / Adjourn	

Appendix B

EARTH SCIENCE SUBCOMMITTEE

Membership List – November 12, 2010

Byron D. Tapley *Chair*	University of Texas, Austin – Center for Space Research
Lucia S. Tsaoussi *Executive Secretary*	NASA Headquarters, Science Mission Directorate – Earth Science Division
Daniel Jacob *Vice Chair*	Harvard University – Department of Earth and Planetary Sciences
John R. Christy	University of Alabama, Huntsville – Earth System Science Center
Judith Curry	Georgia Institute of Technology – School of Earth and Atmospheric Sciences
Efi Foufoula-Georgiou	University of Minneapolis, Twin Cities – St. Anthony Falls Laboratory
James Hansen	NASA Goddard Institute for Space Studies
Raymond M. Hoff	University of Maryland, Baltimore County – Joint Center for Earth Systems Technology and Goddard Earth Science & Technology Center
Gregory S. Jenkins	Howard University – Department of Physics and Astronomy
William Large	National Center for Atmospheric Research – Oceanography Section
Patrick McCormick	Hampton University – Center for Atmospheric Sciences
Anna M. Michalak	University of Michigan – Department of Atmospheric, Oceanic, and Space Sciences
Jean-Bernard Minster	University of California, San Diego – Institute of Geophysics and Planetary Physics
Mahta Maghaddam	University of Michigan – Electrical Engineering and Computer Sciences Department
Steve Running	University of Montana – Department of Ecosystems and Conservation Science
Robert Schutz	University of Texas, Austin – Center for Space Research
Hank Shugart	University of Virginia – Department of Environmental Sciences
David A. Siegel	University of California, Santa Barbara – Department of Geography and Institute for Computational Earth System Science
Mark Simmons	California Institute of Technology – Division of Geological and Planetary Sciences
Konrad Steffen	University of Colorado at Boulder – Cooperative Institute for Research in Environmental Science

Charles Vorosmarty	City College of New York at the City University of New York – Environmental CrossRoads Initiative

Appendix C

NAC Earth Science Subcommittee Meeting

November 17-18, 2010
NASA Headquarters
Washington, DC

Attendees

Subcommittee Members:

Tapley, Byron (Chair)	University of Texas, Austin
Tsaoussi, Lucia (Executive Secretary)	NASA Headquarters
Jacob, Daniel (Vice Chair)	Harvard University
Christy, John	University of Alabama, Huntsville
Curry, Judith	Georgia Institute of Technology
Foufoula-Georgiou, Efi	University of Minneapolis
Hoff, Raymond	University of Maryland, Baltimore County
Jenkins, Gregory	Howard University
Large, William	National Center for Atmospheric Research
Minster, Jean-Bernard	University of California, San Diego
Running, Steve	University of Montana
Schutz, Robert	University of Texas, Austin
Seigel, David	University of California, Santa Barbara
Simons, Mark	California Institute of Technology
Steffen, Konrad	University of Colorado at Boulder
Vorosmarty, Charles	City University of New York

NASA Attendees:

Adamec, David	NASA Goddard Space Flight Center
Albertson, Randy	NASA Headquarters
Allen, Marc	NASA Headquarters
Al-Saadi, Jay	NASA Headquarters
Avery, Melody	NASA Headquarters
Ballard, Stephen	NASA Headquarters
Black, Scott	NASA Headquarters
Blair, Bryan	NASA Goddard Space Flight Center
Burgess-Herbert, S.	NASA Headquarters
Carter, David	NASA Goddard Space Flight Center
Connerton, Robert	NASA Goddard Space Flight Center
Considine, David	NASA Headquarters
Cox, Lucien	NASA Headquarters
Dress, Andre	NASA Goddard Space Flight Center
Eckman, Richard	NASA Headquarters
Entin, Jared	NASA Headquarters
Feeley, T. Jens	NASA Headquarters
Freilich, Mike	NASA Headquarters
Friedl, Lawrence	NASA Headquarters
Graf, Jim	NASA Jet Propulsion Laboratory
Hall, Forrest	NASA Goddard Space Flight Center

Hirskind, Steve	NASA Headquarters
Ianson, Eric	NASA Headquarters
Jurand, Deirdre	NASA Headquarters
Kakar, Ramesh	NASA Headquarters
Kaye, Jack	NASA Headquarters
Kellogg, Kent	NASA Jet Propulsion Laboratory
LaBrecque, John	NASA Headquarters
Leete, Stephen	NASA Goddard Space Flight Center
Leidar, Allison	NASA Headquarters
Luce, Peg	NASA Headquarters
Minder, Martha	NASA Headquarters
Moore, Michael	NASA Headquarters
Neil, Doreen	NASA Headquarters
Norris, Marian	NASA Headquarters
Ranson, Kenneth Jim	NASA Goddard Space Flight Center
Rosen, Paul	NASA Jet Propulsion Laboratory
Scheidlinger, Vera	NASA Goddard Space Flight Center
Schurr, David	NASA Headquarters
Seablom, Mike	NASA Headquarters
Teale, Kathleen	NASA Headquarters
Turner, Woody	NASA Headquarters
Valenia, Azita	NASA Goddard Space Flight Center
Volz, Stephen	NASA Headquarters
Walton, Amy	NASA Headquarters
Webb, Frank	NASA Jet Propulsion Laboratory
Weiler, Ed	NASA Headquarters
White, Nick	NASA Goddard Space Flight Center
Williams, Greg	NASA Headquarters
Woods, Dan	NASA Headquarters
Wreleland, Diane	NASA Headquarters
Zellar, Ron	NASA Goddard Space Flight Center

Other Attendees:

Bartels, Ernesto	UDC
Blankenship, Terry	Booz Allen Hamilton
Bordi, Francesco	Ace Aerospace
Braatz, Lena	Booz Allen Hamilton
Charley, Lea	NRC Mapping Science
Conte, Dom	Orbital Sciences
Cook, Carol	[self]
Criscione, Joe	Stellar Solutions
DeCola, Phil	Sigma Space
Frankel, David	[consultant, Zantech IT]
Goldstein, Ed	Orbital Sciences
Hoff, Ray	University of Maryland, BC
Jonglin, Ian	University of Washington
Lavaque, Rodolfo	Booz Allen Hamilton
Mackey, Bob	Lockheed Martin
Neale, Virginia	Lewis-Burke Associates
Petry, Shelley	Ball Aerospace

Quintal, Mieriam	California Institute of Technology
Rowan, Linda	AGI
Springer, Cory	Ball Aerospace
Turner-Valle, Jennifer	Ball Aerospace

Appendix D

NAC Earth Science Subcommittee Meeting
November 17-18, 2010
NASA Headquarters
Washington, DC

LIST OF PRESENTATION MATERIAL

1) NAC Earth Science Subcommittee – Committee Charge [Tapley]
2) Earth Science Division Update [Freilich]
3) Project Overview to the Earth Science Subcommittee [Entin & Ianson]
4) DESDynI – Deformation, Ecosystem Structure and Dynamics of Ice [Volz]
5) DESDynI Science [LaBrecque]
6) DESDynI Path Forward [Volz]
7) Draft Level 1 Science Requirements [LaBreque and Volz]
8) ESD Applied Sciences Program [Friedl]
9) Applied Sciences Advisory Group [Hoff]
10) Precise Geodetic Infrastructure [Minster]
11) Meeting the Geodetic Challenge of the NRC's Decadal Survey [LaBrecque]