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EARTH SCIENCE SUBCOMMITTEE

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MEETING MINUTES

Byron Tapley, Chair

Lucia Tsaoussi, Executive Secretary

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Prepared by Elizabeth Sheley
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Opening Remarks

Dr. Lucia Tsaoussi, Earth Science Subcommittee (ESS) Executive Secretary, opened the meeting. She began by welcoming two new members, Dr. J. Marshall Shepherd of the University of Georgia and Dr. S. Prasad Gogineni of the University of Kansas. ESS members Ms. Kathleen (Kass) Green and Dr. Gregory Jenkins were participating by phone.

Meeting Charge

Dr. Byron Tapley, ESS Chair, reviewed the agenda. He explained that the data center presentation to be given that afternoon was important, but a portion of the briefing would have to occur at a later time. He also noted that ESS had had a teleconference in which the members received a briefing on the National Research Council's (NRC's) mid-term review of NASA's Earth Science Division (ESD) Decadal Survey (DS). At the time of the teleconference, the discussion of the review was deferred until this meeting. As suggested by some of the Subcommittee members at a previous meeting, the agenda included additional time for discussion.

Earth Sciences Division Update

Dr. Michael Freilich, Director of ESD, presented an update on Division activities.

On-Orbit Constellation and Science Update

The research missions have not changed since the last ESS meeting. Many of the 16 missions are old, and most involve international cooperation. Dr. Freilich noted four changes in the on-orbit constellation. The Suomi National Polar-orbiting Partnership (NPP) was launched in October 2011. NASA launched Aquarius in June 2011. With the Agency's French partners, NASA moved the Jason-1 down to a lower orbit and began a new mission. Finally, CloudSat had been having some battery difficulties. It is now operating on about 10 percent battery power, and its power configuration has been re-optimized to acquire about 55 percent of the available data. It is now back on the "A-Train." The Quick Scatterometer (QuikSCAT) is also having battery problems, which were being addressed at the time of the meeting.

Every 2 years, ESD conducts a Senior Review in which the Division takes a look at all of the missions that are close to or beyond their baseline lifetime. The Review determines how the mission operations budget will be allocated among the active missions and which missions, if any, are appropriate for termination. The upcoming Review will follow the same process as the previous Reviews. Other parts of the government that use data from ESD's research missions will have an opportunity to participate in a Needs Panel and formally present their needs and explain their uses of the missions to the Review panel. Dr. Freilich explained that when another agency comes to rely on a NASA mission that has never been intended to be permanent, it is the other agency's problem to solve; NASA maintains the prerogative to shut down the mission. NASA has never actually faced this situation, however. The Federal government initially funds the missions for a research purpose; past that, useful data from the missions become an added value for the taxpayers.

Dr. Freilich next gave a brief update of the A-Train constellation. He noted that CloudSat was dropped out of the A-Train while NASA was working on its power problems. Another mission joined the A-Train in June, the Japanese Space Agency (JAXA) GConW1. The A-Train demonstrates the advantages of constellation flight over long periods of time and with integrated data from the various missions, expanding their capabilities and products.

In answer to a question, Dr. Freilich noted that the expected lifecycle for the Aqua mission, which is the oldest mission in the A-Train, depends on fuel and the satellite's continued ability to maintain its position in the orbit. Current information indicates that it could last about another 10 years, substantially beyond its original design life. Aqua is a multi-instrument mission, so there is the question of the continued function of its individual instruments and how many warrant keeping the mission on the A-Train orbit. The Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar (PARASOL) mission had been on the A-Train but was moved to a lower orbit.

Dr. Freilich presented a couple of science highlights. Using the JAXA Greenhouse gases Observing SATellite (GOSAT), investigators were able to make space-based observations of megacity carbon dioxide, an analysis of which has been published in Geophysical Research Letters, a peer-reviewed journal. The Orbiting Carbon Observatory 2 (OCO-2) mission will be capable of making substantial carbon dioxide measurements that were developed and refined using GOSAT data and algorithms. JAXA in turn used the OCO-2 work to further calibrate its measurements from GOSAT. The measurements can detect human-induced changes over a small distance. The collaboration between JAXA and NASA has been strong and substantive.

Another science highlight had to do with the data from the Tropical Rainfall Measuring Mission (TRMM) satellite and Suomi NPP, as applied to Super-Storm Sandy. NASA makes its data available to investigators and others, particularly under the circumstances of a weather event like Sandy. TRMM took unique and frequent measurements of the storm's precipitation, and NASA made those measurements available to the Federal Emergency Management Agency (FEMA), first responders, and others. TRMM indicated that the greatest precipitation occurred over the ocean. Suomi NPP provided mission agencies with important data on Sandy-induced blackouts. In an area with fewer means of measuring the effects of the storm, these data could be even more critical. The NPP information is also available quickly. It may be valuable to do a retrospective study to determine how the data were used.

Venture Class Update

ESS and the DS panel advised ESD to pursue the Earth Venture (EV) class program, which is a science-driven, Principle Investigator (PI) led, competitively selected, cost- and schedule-constrained, regularly solicited, orbital and suborbital class of missions, investigations, and instruments. ESD subsequently established Venture Class with three separate solicitation strands:

- EV-1: suborbital/airborne investigations of 5 years duration;
- EV-2: small complete missions, Class D, with 5 years development; and
- EV-Instrument: spaceborne instruments for flight on Missions of Opportunity (MoO), with 5 years for development.

ESD put out solicitations and made selections in all three strands. For EV-1, ESD solicited in 2009, selected five missions in 2010, and launched the five missions in 2011. Solicitations will take place on a 4-year cycle. Solicitations for EV-2 went out in 2011, and will also be issued on a 4-year cycle. The result of this solicitation was the Cyclone Global Navigation Satellite (CYGNSS), a constellation of eight micro-satellites, which was selected in July 2012. In February 2011, ESD solicited for the EV-Instruments strand. The selection was just made, of the Tropospheric Emissions: Monitoring of Pollution (TEMPO) mission taking a geostationary hosted payload to make measurements related to air quality.

ESD allowed proposals up to the point of cost constraint. While the Division selected one mission for each science area, that was not by design. The intention was to select the best proposals, which is what happened. Submissions spanned the spectrum; the criteria did not weigh any science area more than the others, though Dr. Freilich had told Congress that the selection could be tailored to evolving science in the future if desired. He had expected to see more proposals, but noted that they are costly, representing significant up-front investments. Some potential investigators might prefer to use their time and funds in other ways. ESD was happy with the selected proposals and did not to select any that were less than what the Division sought. This is not a field in which there is a great deal of expertise at the PI level for doing large spaceborne missions. NASA saw this with EV-1 suborbitals, most of which went to the centers, which had the ability to manage big investigations that other investigators could then join. The key to Venture class is to prove that this program will produce solicitations on a regular basis, which makes it fairly simple to manage. The next round of solicitations is due soon, and is on schedule and funded.

EV-1 is going quite well, with four of the five investigations scheduled to have completed at least one sustained field campaign by early 2013. The least mature of the investigations is AirMoss, but it has now acquired the science data as designed, and has completed a difficult engineering development phase.

The three EV strands are separate and were not intended to build on each other. Previously, ESS discussed with ESD the best way to implement the program, which led to the three separate strands. However, it is important to note that, with a $90 million cap on EV-Instrument and a $100-150 million cap on EV-2, it is not a small stretch for those whose proposals are not selected to join in with another mission or solicitation. As for keeping disciplinary balance, the program will always provide a small sample size. Dr. Freilich does not see the value of adding on more requirements that will constrain what ESD can select. This is really a PI-led competitively selected program in Earth Sciences, which is broad, and he would like to see how it works.

Other Missions

The Cyclone Global Navigation Satellite (CYGNSS) went to a non-NASA center and is taking slightly longer than anticipated due to contract issues that were close to being settled. CYGNSS uses GPS and reflections from the sea surface as part of an effort to take multiple measurements from multiple satellites. It can measure wind speeds and various surface characteristics on the eye walls of hurricanes. In terms of class, it is a Class D, with a cost cap and some risks.

The TEMPO mission will measure air quality. This is a hosted payload in Geostationary Orbit (GEO); TEMPO will be a programmatic pathfinder to using additional hosted commercial payloads from GEO. The $90 million cap was written in fixed year dollars and, as is true for other missions, the mission funds

must be spent in real years, not spent in a single year. NASA has yet to fly a mission on a hosted GEO and must determine how to do so.

Budget

Dr. Freilich next discussed ESD's budget approach and status. He had nothing new to report on the Fiscal Year 2013 (FY13) budget, which was still with Congress. ESD is committed to maintaining a balanced program that advances Earth System Science, supports applications development, provides needed global space-borne measurements, develops the next generation of technologies, and is coordinated with activities of other agencies and international partners.

A chart illustrating ESD's recent budget history indicates that there is stability between FY12 and the likely FY13 budget, which is important and positive. Dr. Freilich expects that Congress will approve a budget close to what the President is seeking. He noted that the front page of NASA's budget submission mentioned ESD. In answer to a question, Dr. Freilich said that it is too soon to determine if the impact of Hurricane Sandy would have any effect on the budget, though that could appear in succeeding years. While ESD is operating under a Congressional Resolution, this is not a bad thing since the proposed budget was flat to begin with. ESD's total budget is almost $1.8 billion. It was tracking much lower in the previous administration.

Orbital flight portfolio

ESD's orbital flight portfolio for the next 10 years is both full and realistic. Between the time of the meeting and 2014, ESD will launch five missions, one in February 2013 and four in 2014. These include the Landsat Data Continuity Mission (LDCM), which will be the first to launch. At the end of November, it had just come out of final environmental tests. The Global Precipitation Mapping (GPM), a joint mission with JAXA, is on schedule to launch a year later, in February 2014, though that date could move up a bit. The official commitment date is June 2014. OCO-2 is a recovery mission slated to go up in July 2014. Stratospheric Aerosol and Gas Experiment III/International Space Station (SAGE-III/ISS) is an instrument designated for the ISS that will launch in August 2014 in conjunction with NASA's Human Exploration and Operations Mission Directorate (HEOMD) and the European Space Agency (ESA). ESD will get the benefit of a satellite and launch vehicle paid for by others. The Soil Moisture Active-Passive (SMAP) mission will launch in October 2014 and is the first of the Decadal Survey (DS) Tier 1 systematic missions.

These five missions are all very far along in development. The next missions to launch, starting in 2016, are Ice, Cloud, and land Elevation Satellite 2 (ICESat-2), CYGNSS, Gravity Recovery and Climate Experiment Follow-on (GRACE-FO), and others. OCO-3 is an instrument for which the Jet Propulsion Lab (JPL) found an affordable ride and a platform, the ISS. This is important, as there was never a budget for a launch vehicle or satellite. This allows ESD to move it forward now, and resolves the diurnal cycle issue. The fundamental science comes from being able to fly over a reasonable portion of Earth's population and have successive measurements. OCO-2 is a standard 3-year design mission, and there will be overlap.

In the area of continuity, Dr. Freilich explained that ESD is trying to solidify that the field needs long-time series, and that the Agency has a science imperative to minimize gaps that speaks to having orbit

overlap. In the FY11 budget, ESD was asked specifically to identify some areas in which it wanted to invest NASA funds to address pressing gaps for continuity issues. Prior to that, there was the perception that NASA did single missions and left the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS) to make long-term measurements in those areas. This approach led to gaps. The way ESD promoted the OCO-2 recovery mission was as a robustly spared mission with enough parts for another instrument. That resulted in OCO-3, which was thoroughly reviewed before it went to the Office of Management and Budget (OMB). Ten years from now, NASA will have a number of missions taking CO2 measurements.

Dr. Tapley asked for confirmation that NASA's position is that it takes measurements if they are important, and the Agency is also permitted to find a partner to take them over. Dr. Freilich agreed, noting that NASA is not prohibited from having a long-term series. The Agency may or may not have Landsat in the future. In answer to a question, he said that if OCO-2 were to fail, ESD does not have the funds or time to develop a replacement. The instrument can look at diurnal changes because the ISS goes through all the day times.

ESD is working out the acquisition strategy for some of the future missions, but Dr. Freilich was not at liberty to discuss that topic further. There are advantages to having the science definition team available for a smooth transition, depending on the acquisition strategy. No one on the teams will be forcibly recused if the acquisition strategy has competitive portions.

The L-band Synthetic Aperture Radar (SAR) mission is not the same as Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI). L-Band SAR is similar to the DESDynI radar, which was not funded. ESD had a choice between waiting for that funding or finding an L-band SAR mission that addresses portions of DESDynI. This choice accounts for the later launch date. OMB told ESD to excise DESDynI from the budget, but let the Division keep a funding wedge as long as it did not perturb the rest of the program. The DESDynI radar was projected to cost $1.2 billion.

There are no launches between 2017 and 2020. This is because ESD has attempted to reinvigorate its mission portfolio to drive the science and has no room for unidentified missions. The portfolio includes some costly missions, especially ones in development, where they are accounting for the entire available budget. The DS estimate that by now ESD would have over $2 billion in 2007 dollars did not occur, and its estimates of costs were understated. ESD therefore must come up with a program that is informed by DS priorities, responds to the Administration, and is realistic about the budget.

Dr. Tapley noted that had the budget followed the DS projections, it would now be up to $2.4 billion. There were a number of other cost mismatches between the DS and the reality of running the Division. The executive branch gave orders to reframe some of the missions in terms of costs, for example. Dr. Tapley repeated that ESD has been successful thus far in preserving funds for L-band SAR, and was prohibited in the FY12 budget from perturbing the rest of budget for the SAR. Pre-phase A, the costs are projected as being in the $800 million range.

The Advanced Composition Explorer (ACE) was a Tier 2 mission not included in the DS. The Pre-Aerosol, Clouds, and ocean Ecosystem (PACE) mission incorporates portions of ocean color, and

possibly aerosols. The order of the missions reflects what fits and Administration priorities. Dr. Freilich would be delighted if someone came up with a low-cost SAR that could launch sooner. If it happens, the S-band will be a contribution from an international partner. The Division is reviewing the quality of the NPP satellite products, including ocean color, but he has been told that it is still too early to assess.

Dr. Jean-Bernard Minster asked to have Tier 2 missions broken out from those of the climate initiative. Dr. Freilich identified GRACE and PACE as being part of the climate continuity initiative, as well as White House priorities. OCO-2 as recovery and SAGE III are climate continuity missions. ACE is in early reformulation.

The question ESD has been grappling with in regard to the orbital portfolio is that of launch vehicles, which have been acquired for all but two orbital missions. Regarding EV-Instrument missions, NASA's responsibility is to find a host for the instrument. It helps when the proposer demonstrates the difficulty or ease of getting an instrument into orbit. As it is, while they are not required to identify a specific partner or mission for the instrument, proposers must speak to the ease of accommodation. A unique orbit, for example, would have lower evaluation scores. While an instrument may sit on the ground if NASA cannot find a launch vehicle or mission, the EV-Instrument Announcement of Opportunity (AO) explains that there may be a hiatus between instrument delivery and the launch and operations. Therefore, the proposers must provide cost estimates for getting through those years. NASA has an ongoing activity with providers to define a set of interface characteristics that will make instruments more readily accommodated.

Technology highlights and investments
In the technology area, the focus remains on future missions. In the previous year, ESD sent up many instruments for their initial flights, and some are now active in the Airborne Science Program (ASP). Dr. Freilich discussed the aircraft used in this program and issues surrounding the authorization to fly. Especially with the Global Hawk program, ESD is running experiments that benefit from a high range but are primarily over global air space. Federal Aviation Administration (FAA) rules make it easier to fly on the west coast than the east coast. Unmanned Aircraft System (UAS) vehicles are not as inexpensive as many people think they are. FAA considers NASA to be a responsible user, but that does not make the program easy.

International Space Station
The ISS is an international lab that ESD is using in a variety of ways. The focus is on whether the Division can use it to make the needed measurements and, if so, is ESD supporting the analyses to use the measurements for its scientific purposes? There are three categories of instrumentation on ISS: projects that are already there, projects that are planned, and instruments approved and funded by ESD. The Hyperspectral Imager for the Coastal Ocean (HICO) was sent up in 2009, and ESD is funding some analyses. ISERV is a straightforward digital camera and telescope.

Planned instruments are funded by HEOMD, with Science Mission Directorate (SMD) input on their usefulness. HEOMD would like to make ISS as useful as possible and has a budget to do some of this work. There is a push to turn ISS into a national lab. The reason HEOMD comes to ESD with proposed projects instead of asking ESD for proposals has to do with funding exposure. ESD never uses the word

"requirement" for these projects, because use of that word would turn the proposed project into a funding issue that could perturb the Division's entire mission portfolio. HEOMD has a process, and ESD wants to leave it as it is. The ISS budget ends soon, though talks of extension are already occurring. ESD is getting a good deal from the HEOMD proposals; the Division does not pay for launch vehicles or spacecraft in these situations, and HEOMD does a good job.

The Inspector General (IG) has talked to him about the ISS. Dr. Freilich told the IG's office that there is nothing they could do to make the ISS better. The Division's exposure is now small, the need is nonexistent, and the benefits are large. There is a belief that no one is using the ISS, but SMD is making a good investment of resources there. Word needs to get out about this.

ESD Programmatic Summary: 2007 - 2013
The DS came out in 2007. At that time, ESD had missions under development, but only one had a realistic launch date with a realistic budget. The DS recommended reinvigorating the on-orbit constellation and launch legacy missions, and told ESD to preserve program balance, do 15 missions in three tiers, implement the Venture class, use ASP, increase the budget 30-40 percent, and implement missions using NASA institutional capabilities while being cost effective. This was a lot.

Thus far, ESD has launched five of its seven legacy missions, though two of the five had launch vehicle failures. The remaining two legacy missions will launch within 15 months. The Division also developed a climate initiative at the direction of the Administration, and three of its missions will launch in 2014. A mix of additional missions will launch by 2020. ESD has gone from launching a mission every couple of years to launching more than one per year, though there are gaps and clusters. In addition, the Division increased flight times by factor of 2.5. The Venture class has proven to be larger than the DS anticipated. ESD's budget has gone up, though not to the level recommended in the DS. When NRC looked at this, the Council found that NASA responded favorably and aggressively to the DS, and has made significant progress over the past 5 years.

<u>Discussion with SMD Associate Administrator</u>
Dr. John Grunsfeld, SMD Associate Administrator, joined the meeting for a discussion with ESS members.

The Earth science part of the SMD portfolio is very important. As an astronaut looking at Earth from a unique perspective for many years, he saw a lot of major changes, and he now wants to help facilitate better decisions about our planet. SMD is still awaiting the FY13 budget and looking at the fiscal cliff. Meanwhile, the Agency has submitted an FY14 budget that pushes a strong science agenda. Because of the Federal budget issues, there is more of a delay than usual on budget discussions this year.

The SMD mission selections are exciting. Over the next 5 years, people can expect new entrants into the space launch market. NASA has an important role in educating and informing its stakeholders in Congress, working with the Administration, interacting with the science community, and more. NASA does what it does because the taxpayers think it is important. The science community has a big impact in the dialogue with the public, but they can do more. Dr. Grunsfeld asked ESS members to encourage

scientists to talk to their neighbors, schools, community groups, and parents about the issues and the exciting science being done at NASA.

Discussion
Dr. Steve Running told of speaking to a graduate student at Carnegie Mellon who attended a talk about science by a NASA representative at the school's public policy program. That speaker said nothing about Earth science until the student asked a question. Even if it was not the right person from NASA, it does not speak well to the stature of Earth science at NASA.

Dr. Tapley said that he is looking at data processing and storage, and wondered about the advisability of moving to something more cloud-driven. Dr. Grunsfeld said that the Federal government is requiring that systems move to the cloud. From a science computing perspective, that falls within the realm of SMD. NASA moves from treating its science data centers as a science facility to an IT infrastructure facility at great peril. Yet SMD should review the optimal infrastructure for science. The concern is about treating it as a commodity that is beyond scientist control.

Dr. Shepherd noted that he is the President-elect of the American Meteorological Society (AMS), where the concern is with getting science into the field through meetings. Dr. Grunsfeld agreed that this is critical. He added that contrary to the impression many people have of Albert Einstein, he collaborated with an enormous number of scientists. Traditionally, science meetings have been an opportunity to learn, exchange information, and collaborate. However, a lot of jet fuel is burned getting people to and from the meetings, and he would like to see a better way emerge. NASA has experimented with its Astrobiology Institute using Adobe Connect, which enabled virtual meetings of various sizes, from dozens to a few hundred participants. In the end, however, people discover things, not the satellites or missions. Therefore, the focus must remain on the people.

<u>Earth Sciences Division Update continued</u>

NRC mid-decade review
Dr. Freilich resumed his presentation by discussing the findings of mid-decade review, in which the NRC assessed ESD progress since the 2007 DS. Overall, the NRC evaluators liked what ESD was doing and recognized the Division's efforts. Dr. Freilich reviewed seven specific findings, addressing the Division's efforts, the suborbital program, allocation of the available funds, the EV program, alternative platforms, international collaboration, and the Applied Sciences Program. All seven findings were positive.

Issues
Dr. Freilich identified three categories of issues faced by ESD:

- Launch vehicle cost and availability;
- The capabilities of the airborne program; and
- Budget issues, including sequestration, "fiscal cliff" deals, and others.

Regarding the budget, Dr. Freilich was not sure what would happen. Sequestration, if it were to occur, would take away 8.5 percent of the ESD budget. The Division's approach is that when these external

perturbations occur, if they can be handled by focusing them on a single mission, ESD will attempt to deal with them completely by excising that portion of the program. In other words, if the cost of a single mission were equal to the amount of the deleted funds, ESD management would review it. However, the gut reaction would be to take away the mission and leave the rest of the portfolio intact. This would hurt the program, but given ESD's imperative for balance and revitalization of the observing constellation, that is the approach. Dr. Freilich invited ESS to discuss this approach if they disagreed with it.

There are many negatives to re-optimizing and moving funds around in the various programs. First, ESD does not want to get into the situation of doing not very much because the Division cannot put up credible flights and launches. This happened in 2006. Second, it is very tempting for Congress to say that there is plenty of optimizing to do, then give ESD money to study that but not implement anything. Third, delays make the overall costs for individual missions go up dramatically, and Earth scientists then do not get the data they need. This is why ESD will handle any external perturbations with focused solutions.

In addition, this approach allows the Division to show its sponsors the impact of budget cuts. ESD would be saying, in effect, "We had Mission X before, and now we no longer have it." This is in contrast to letting stakeholders think that not much happened, or taking fewer proposals, or the like, then Congress believing that the budget cut does not seem like a big problem and trying to cut more. ESD managers have spent a lot of time thinking about this. He would appreciate ESS advice, but noted that the Division does have to make the decisions. Otherwise, OMB or Congress will do it for them. As for how far any cuts might go into the future, that is up to Congress.

Delays do not play out well. The interim report before the DS, as well as the DS itself, stated that ESD had an observing platform on the verge of collapse. The Division must move forward to advance the science. This is needed for credibility. NOAA moves forward broadly and slowly, which makes it hard for that agency to point to accomplishments that justify its budget. Delays increase overall budgets because not having funds at the right time is extraordinarily costly. The Global Precipitation Measurement (GPM) mission was confirmed around 1999, for example. In 2006, it still did not have a launch date, and NASA spent significant funds on it every year. Then the costs went up, and the choice was to drop the low inclination orbiter or delay other missions. ESD chose to drop the orbiter.

Dr. Tapley suggested that ESS might want to write a recommendation or finding endorsing the proposed approach. Dr. Freilich noted that he took a hypothetical case so that they could act on it by turning it into real principles. There are many hypothetical situations available.

Dr. Freilich next addressed the issue of launch vehicles, presenting a chart with data for small-, medium-, and intermediate-class launch vehicles. A number of these have been certified and could be used for ESD missions. CYGNSS, for example, qualifies as a small mission and could use any of five possible launch vehicles. The Pegasus has been flown, as has the Taurus XL, though the latter has not flown successfully for a while. Small Falcons and the Athena are not being made right now, and the Pegasus manifest is rather bare; CYGNSS is the next Pegasus mission. This goes beyond the loss of Delta II and the cost of the Evolved Expendable Launch Vehicle (EELV) class. ESD is asked to come up with innovative ways of obtaining data, but the data are acquired from space, and that means getting into space. The national

capabilities and requirements make it difficult. Use of international launch vehicles requires a waiver, which is hard to obtain.

Ethics Briefing

The Subcommittee had its annual ethics briefing.

Subcommittee Discussion

Because Dr. Freilich was called away, Dr. Tapley took up the issue of the NRC mid-decade review in his place. He sought an ESS response to the mid-decadal report, either as findings or recommendations. Dr. Tapley identified four specific NRC recommendations to revisit, with at least one requiring some discussion.

Dr. Running noted that although the NRC finding about the Research and Application (R&A) program was that the investment was healthy, ESS has not received any information on the program. He would like to know the success rate on proposal submissions. Dr. Tapley replied that ESS used to get that information and can ask for it again. He was not sure how ESS would evaluate the success ratio, given that the community is large. There was a presentation on the activities going out from R&A onward, which identified a healthy output. Dr. Tsaoussi pointed out that there is very little that is not supported by R&A. Dr. Tapley said that he would ask for a briefing on the program statistics. Funding information can be pulled from the budget, but the question is whether the funds are being used in the best way.

Pre-formulation Workshop Report

Dr. Stephen Volz, ESD Associate Director for Flight Programs, discussed the Division's flight program pre-formulation progress. He explained that mission funding does not present a complete picture, as support comes from many different sources.

Pre-formulation is part of the flight program and accounts for about 10 percent of mission costs. NASA has seven project lifecycle phases, from Pre-Phase A through Phase F. Currently, ESD has a portfolio of 15 missions in Phases E and F, the operations phases. There are 13 missions in Pre-Phase A, which is pre-formulation. At any given time, most missions will be in these three phases, but most mission costs are incurred in Phases A through D. All of the missions now in Phase F are legacy missions, while the Pre-Phase A missions include 12 DS missions and 1 climate plan mission. There are only two unlaunched legacy missions. Venture class missions begin with Phase A and do not go through pre-formulation.

The primary pre-formulation mission study objective has been to prepare mission concepts to move into the various development phases. Concepts in pre-formulation are subject to a great deal of documentation and a number of assessments and other activities. This phase requires both rigor and discipline. The program meets with each mission team about once a year, and presents them with their direct budget for the year and the probable budget for the next year. The program does not commit to a 5-year plan because the world in which these missions operate is not that precise. Budget changes happen, other ESD

activities come up, and technology changes or evolves. The result is that something that might have been attractive 3 years ago is now outdated. In addition, SMD or NASA policy may change.

Every year, Dr. Volz's team conducts a review to find mission concepts that are affordable, present the right level of risk, and produce the right science. For different sizes of missions, there are different processes and thresholds of reliability and performance.

For strategic missions, the objective is to ensure that the complete mission concept is mature before proceeding into formulation and development. This involves investments in technology, development of community consensus on the science scope, investigation of mission concepts, and development of cost and schedule assessments for missions that fit within the programmatic constraints. The program load for these activities is shared by Flight Programs, Earth Science Technology Office (ESTO), and R&A.

The challenge is how to plan without a long-term commitment. ESD's first commitment is to missions already in formulation, development, and operation. The Division also focuses on continued execution of the EV line, including regular and frequent calls. The Division has allocated resources to provide the greatest benefit with limited funds. Dr. Volz presented a graphic depicting ESTO investments. Research investments are harder to quantify; he gave some examples of R&A support.

Dr. Volz reviewed accomplishments and critical events from 2007 through 2010, noting where mission study activities occurred from 2008 forward. In 2011, the DESDynI and Climate Absolute Radiance and Refractivity Observatory (CLARREO) missions were deferred, while GRACE, SAGE III, and a number of other missions moved forward. That same year saw the Glory launch failure, as well as the earthquake that devastated Japan and affected activities in which JAXA was a partner.

ESD began pre-formulation work in 2008. Since then, the Division has learned the following lessons:

- Sustained investments have enabled ESD to graduate mission study teams into formulation, and have progressively improved the understanding of the remaining mission concepts;
- Mission readiness has been assessed for all Tier I and Tier II and Climate Continuity mission concepts;
- The budget for strategic missions allows for 1-2 graduations per year, with a mix of small and large mission investments;
- International partnerships are a key element of the mission implementation approach;
- While not all access to space issues have been solved, there are promising new options; and
- Responses to Earth System Science Pathfinder (ESSP) Venture AOs are providing good instrument and measurement candidates.

While some funding is done through Research Opportunities in Space and Earth Sciences (ROSES), much of the funding is directed to the most capable center. There are science working groups representing many different disciplines and weekly teleconferences that develop research proposals that his team assesses internally. From those, he gets an idea of what needs to be done.

Mission concepts have matured, allowing for more flexible implementation approaches, such as those used in GEO-CAPE and CLARREO. ESD is looking at options for those missions that could be split and

flown in other ways, like miniaturization or operations on the ISS. In most cases, the Division is not limited by technology readiness or mission concept immaturity – more money would allow ESD to move forward. Some DS mission concepts with multiple measurements can go to distributed solutions. The ESSP AO selections allow for measurements to be pursued that otherwise might not be affordable. The ISS program pays for some ESD instruments.

There are new opportunities and challenges. Among these is that ESD must manage mission science when the mission might combine a Venture piece and another element. The Division also needs to adapt to the increasingly significant role of the ISS in Earth science. In fact, the ISS could be a bridge platform for proving future measurement concepts, and currently manages the data stream back to Earth.

Data Center Study/ESD Data Centers

Dr. Martha Maiden, Program Executive, Earth Science Data Systems, discussed NASA's Earth Observing System Data and Information System (EOSDIS), an end-to-end system with data flowing from the satellite to the user. This distributed information network is enabled by an open data policy and operates with the data archives.

EOSDIS was initiated in 1990 and operational by 1994. In the system, data start with mission operations and data acquisition, move through a distribution function, and finally become accessible to users. Data from international archives are physically brought in, not just linked. For that and other data that are not totally NASA's, EOSDIS has set up a way for NASA investigators to get the data from the Agency. ESA has built a port into the NASA data-house, and NASA has done the reverse. The Agency's investigators prefer to get data from NASA, in part because the ESA archives are difficult to access.

The system was not perfect at the beginning, but EOSDIS has much more capacity now. If data are lost, the group will find it, but that rarely occurs. The EOS Clearing House (ECHO) is NASA's middle layer between Earth science data and users via a service-oriented architecture. There are other data holdings and search capacities allowing investigators to order data on Earth system science. There can be user-defined specialized clients to give data users access to data and services. The scale is due to NASA's huge repository of satellites, so that EOSDIS holds and delivers many different products.

An external advisory panel reviewed EOSDIS in 2005-08, and developed a vision and recommendations. The resulting system costs 30 percent less than previously, is closer to science needs, has good interfaces, and is easily upgraded. Continuous evolution investments are about 10 percent of the multi-mission operations budget. ESS previously discussed and praised EOSDIS.

Dr. Maiden presented a list of vision goals developed for 2015, along with their status. Most were complete. She noted that there are different methodologies for back-up storage among the data centers. The archive holdings are being peer reviewed for scientific merit. Where there are data sets that are not being used, the policy is to keep them for 6 months.

Discussion

Data Storage and Archiving. Dr. Minster noted that there were large data sets that no one ever looked at. These took up much storage, and there became other better ways to access those data. In light of this situation, he was interested in any process for peer review of data holdings. Dr. Maiden replied that it is inexpensive to put these products online. EOSDIS always keeps data at Level 2 and above, but discards recalibrated data. This was done with a working group of scientists who spoke to their colleagues. Her team is also going back to old archives and has begun digitizing old pictures of the Arctic and Antarctic.

In response to a question about the possibility of working with the National Archives for long-term archiving, Dr. Maiden noted that her group had started that on an experimental basis due to mutual interest. The managers at the National Archives have other priorities, and wanted EOSDIS to archive in place and have a certification process, which USGS has done. The EOSDIS interest is in managing the data for Earth science communities.

Dr. Tapley observed that an important capability is the coming charge to look at what one might do to move data into a distributed system. Most of the presentation was about data, but there has been concern about where and how to hold it. Dr. Tsaoussi added that when the NAC Information Technology and Infrastructure Committee (ITIC) comes forward to explain the proposed study and what is being discussed at NASA in terms of data storage for the science centers, it will be important for ESS to understand what is needed for operations in the science community.

Control of Data. Dr. Maiden said that it does not matter where the data are if they are well-structured and well-managed. However, the issue is if the data are on the computer of a person or group that does not know how to manage it for science. The cloud has to be structured to allow the flow of metadata to scientists. Those who want to do data analysis need a structured data system that is managed for science data, rather than having it in one big bin. She presented some slides showing metadata flows, which are machine-to-machine. Looking at the Earth science measurements, it is clear that the data go directly into the data centers right away. On PI-led missions, the PIs might post their own data. Those data enter EOSDIS at the end of the mission life.

Her team track how much data and which data are used, but they aggregate users rather than tracking individual users. They also do a comprehensive survey, which has a good response rate. EOSDIS is highly rated, above the U.S. government average. The survey provides comprehensive information on the system's strengths and weaknesses, and that information is used as a management tool.

If the data were kept in the cloud, there would be concerns about security. Dr. Maiden understood from ITIC Chair Dr. Larry Smarr that he thought that if all the data were together, scientists could come up with new questions to ask. She had heard that the IT long-range planners are thinking in terms of data-led science. If all the data were put together, she was not sure that the structure would be compatible with all the scientific activities.

Dr. Tapley asked what would happen if EOSDIS did not physically store data but continued to direct its management. Dr. Maiden explained that the Office of the Chief Information Officer (OCIO) has been told to use less power and consolidate data centers. This makes sense for writing checks. However, if there is a lot of computing going on and that moves, it could downgrade the quality of the data. Dr. Minster

suggested contacting the Centers for Disease Control and Prevention (CDC) and the University of Pittsburgh, which are also addressing these issues. They have the same need to preserve privacy. Dr. Maiden explained that when she hears examples of success, she thinks of the need to share data. The cloud can make data more sharable, but EOSDIS data are already available. The purpose of having it in the cloud would be to allow one to look at it collectively.

Dr. Tapley thought that the issue was determining the logic of the various types of access needed for compatibility. The data do not need to be in a single source. The cloud is a variety of servers anyway, and EOSDIS already has that. Dr. Anna Michalak added that the cloud is just hardware. She did not see this as being that different from the decision to have NASA or commercial providers make launch vehicles. NASA wants to focus on what NASA does best, and she saw this decision in the same way. Could a private company build a system that could offer what NASA science now has? Yes. Is that the best choice? This is not clear, but the cloud is not magical.

Updating Data Control. Dr. Moghaddam said that in looking ahead, it might be outdated to separate the data system from the computational aspect, and it might make sense to co-locate all the science information, which is something to consider in the longer run. Dr. Maiden explained that if the SMAP data were all together, it would be SMAP-concentric. This was the system her group was advised to pursue. Another data point was that a study was done on the cloud. That study found that for someone using his or her computer 70 percent of the time or more, cloud computing does not pay. It only works for less intensive use.

Dr. Michalak said that they were really discussing the next system, and that two systems from now, data will be in the cloud. Dr. Moghaddam agreed, noting that Google handles more than NASA and remains fast. Eventually, the Agency might want to go there. Dr. Tapley observed that the question of where the data reside is less important than the intellectual control of the data. He needs high performance.

Dr. Maiden added that NASA does have a representative going to the White House meetings on high performance computing but is not involved in researching the area because NASA is a user, not a provider. Dr. Minster expressed concern about small data sets, which get lost. NASA has solved that issue by having giant files in some areas, and small files in a collection. Dr. John Christy said that he wants older data, because he wants to characterize land cover as far back as possible. He wondered if NASA could be the Google of the Earth, allowing people like him to see what has happened in a particular spot. Dr. Maiden said that this is something USGS would like to be able to do, but it is out of NASA's purview.

Dr. Tsaoussi explained that ITIC wanted a recommendation about replacing the NASA science infrastructure with new hardware. The hardware part is fine, but the science programs are not served by OCIO taking over science IT operations. SMD management has said the science data systems are part of the science programs and are needed to support science. Therefore, scientists need to weigh in on what the recommendations really are. There is a proposal for a data center study, and ITIC wants ESS to provide guidance or principles on the essential issues surrounding Earth science and the community's needs. It may be necessary to do a teleconference with ITIC at some point, but Dr. Maiden gave ESS a good background.

Dr. Judith Curry said that this was an issue of flexibility to take advantage of emerging capes in IT. Dr. Moghaddam added that ESS also needed to address joining the science process with the data archives. If the data are collocated or managed in unified way, it will be more efficient. She asked Dr. Maiden if her group interfaced with the IT program. Dr. Maiden replied that she does. Earth Science's small access program uses things developed at a low Technology Readiness Level (TRL) and matures them to operate as part of the data system.

Dr. Michalak agreed with Dr. Maiden, but said that she would state it differently. If data are located in different places, they can be anywhere. The problem occurs when there is a need to download from multiple sources. If there is an attempt to yank data away from users, they will get defensive. Those who keep it locally will opt to do so because that is what makes them most comfortable. She thought that this was too big of a problem for ESS to address. She advised stating what they would need if the data were moved to the cloud. That is what they needed to convey to those considering a change.

Earth Science Data Needs. Dr. Running pointed out that the data sets Earth scientists deal with are research data sets that generate a lot of user questions. It is important to realize that this is not canned data and that people need assistance in using it. Dr. Tapley asked if there might be a commercial vendor capable of taking this on. Dr. Maiden said that that was a difficult question to answer, but she suspected that it might not work. NASA has a large contract with Raytheon Corporation to do ECHO, for example. If the decision were made to go to the cloud, each data center, rather than refreshing the hardware, would let it decommission and go to the cloud. NASA has a wide area network that goes to the data centers. Dr. Tapley advised having that discussion with Dr. Smarr, and noted that this topic will be discussed by members of the community.

Dr. Maiden explained that NASA designed EOSDIS as an end-to-end system before there was even an Internet. Things happen quickly in IT, and setting up a roadmap is difficult. Things change, and to commit to only one way of doing things is not right.

Dr. Moghaddam asked Dr. Maiden about her vision for putting the algorithms on an open source platform. Dr. Maiden replied that the policy is to share source code for validation. Scientists often do not want to do that, and it was noted that many do not want to get involved at this level of working with code. NASA tries to encourage collaboration, however, and having open source code is one way to do that. The original EOSDIS concept had all of the processing inside the data centers, but some of the science teams came in at lower costs, which is how the shared code system was born.

Dr. Tsaoussi said that the IT team wants to understand the needs of different communities. Astrophysicists might have different needs from Earth scientists, for example. So it is important to know each community's issues. SMD wants every subcommittee to help develop guidelines for the future ITIC study. If this is turned over to NRC or some other group, the right people might not be involved.

Dr. Tapley asked if the Science Investigator-led Processing Systems (SIPS) were considered modeling activities. There is a large modeling activity and four or five modeling centers. Dr. Tsaoussi was not aware that modeling was seen as being part of the ITIC study, though it could be. Dr. Tapley explained

that that is a larger data storage distribution product, producing information that must be stored and assessed. Dr. Running observed that different communities and teams use modeling and model outputs at different levels of intensity. It was noted that an increasing number of analysis projects go through the centers, and that ESD has two super-computer centers that PIs visit in order to do data analysis.

ITIC Briefing and Future Approaches. Dr. Tapley suggested that ESS could not do much more without the ITIC briefing. They will have the briefing and move forward. ESS would also receive a report on security analysis. There is some data analysis that is computation-intensive, and some of this is done through the data centers. Much of the computation-intensive work is done with the PIs. Dr. Siegel asked if it would be help the planning efforts for ESS to do an exercise in looking at a blank sheet of paper. Dr. Maiden said that it would be useful to have clear objectives for a study, such as save money, use EOSDIS data in conjunction with other data, and so on. Some of this has been done within the science community. Her team is also looking at some systems for mobile processing and data.

Dr. Minster observed that saving money is a good question that is hard to answer in IT. It is possible that a new approach might save money. He had no strong feelings about the cloud, but noted that it might be standard in a few generations of IT. Dr. Tapley suggested that NASA might not want to lead in this area, as costs can be worse than expected. Dr. Michalak said that ESS must set its criteria, then gave an example of where the criteria were wrong. She advised looking broadly when setting criteria.

Dr. Maiden explained that there is a team at the Goddard Space Flight Center (GSFC) that is very interested in NASA science, including Earth science. They know the contents of the data system, they are excellent in dealing with observations, and it is their job. They are implementers, and they manage and provide funds to the data centers. There is a hierarchy of people who make decisions. The systems architect makes sure the pieces all play together and are easy to find. They are real data centers, and do not present a single solution for all situations, which is important to understand.

Dr. Curry observed that the system works in terms of data management, but there is still a problem with the data information piece, especially for the non-research user. She wondered if the whole effort might be overwhelmed by the intense user. Dr. Maiden explained that the current term is “fit for purpose.” Data quality is in the eye of the beholder. One of the reasons NASA is going to ISO9115 is that it has a strengthened quality level and is more robust, allowing the Agency to better address uncertainty. Different people want different things. Applied science wants data fast. Often, investigators must use documentation that is separate from the data. This is an area in which her group is trying to catch up. President Obama said that people should be able to get data, but she felt it was also important to take care in how that is accomplished. In some areas, this will require a lot of work, but NASA needs input from many different people. Dr. Curry thought that the next target audience is a level down from the scientists, not necessarily the “man on the street.” Dr. Maiden agreed that there are people who can use data but do not know that EOSDIS has it. Ms. Kathleen Green advised highlighting the “added value user,” as they get the data out to decision-makers, like brokers.

There was additional discussion about the need to have Dr. Smarr’s presentation, as it was not clear what he would be seeking. It was possible to develop a finding from the information ESS did have, specifically with the questions the Subcommittee wanted answered. Dr. Tsaoussi said that Dr. Smarr had already

given presentations to the Heliophysics Subcommittee (HPS) and the Astrophysics Subcommittee (APS). She thought the two presentations seemed very different from each other. She distributed the APS presentation, because that seemed more similar to what ESS would need. It was still possible that Dr. Smarr would tailor a presentation to ESS. She added that the ESS discussion was more extensive than that of either HPS or ESS. She thought that was a positive, because they would benefit from having more direction rather than less.

The meeting adjourned for the day at 4:58 p.m.

November 29, 20 12

Session Overview

Dr. Tapley reviewed the meeting objectives for the day, and advised reviewing budget balance and launch requirements, at a minimum. This meeting did not include a presentation on the Joint Polar Satellite System (JPSS), in which some ESS members are involved. Although ESS had not yet had a briefing from Dr. Smarr about the IT study, they might want to put out a cautionary statement. Finally, they had not fully discussed the findings and recommendations of the mid-decadal review.

Airborne Science Program Strategy/Overview/Near-Term Issues

Dr. Freilich was unable to join the meeting that day, so Dr. Jack Kaye, Associate Director of ESD and the R&A lead, sat in for him. Along with Mr. Bruce Tagg, he discussed ASP. Dr. Kay explained that airborne science can help enhance the satellite program, providing a path to space and ways to learn about Earth via a platform that carries many instruments. There is overlap between serving satellites and learning something about Earth. Airborne applications provide flexibility in obtaining the right observing platform, which can be difficult with satellites. The people who work on the aircraft get good career training and contacts, whether for airborne or satellite work.

Dr. Kaye showed the program's budget history, noting that the 2009 was particularly good, due in part to the stimulus program. He also described current capabilities of the aircraft, along with funding levels. Some aircraft are fully funded, while others are partially funded, reimbursable with partial ASP funding, and fully reimbursable. The fully reimbursable are not in the core program. An example is a partial funding arrangement with the Grumman Corporation, in which NASA and the company split the costs and usage time equally for two aircraft. There is some tension regarding access, but that is worked through. The access formula could be revised in the future so that each organization has its own aircraft instead of sharing two.

Dr. Kaye said that it is easy to talk about platforms, but ASP emphasizes sensors, systems, and people as well. The goal is to advance the science. The systems make the aircraft good flying laboratories. The airborne campaigns now are much more advanced than they were 20 years ago. Air crews and management are based at a number of NASA centers. Instrument integration build and operations expertise are at Ames Research Center (ARC), along with mission management, flight request system and web presence, and education and public outreach.

There is not much interest in the tiny Unmanned Aerial Vehicles (UAVs), though individual programs might. Mr. Tagg noted that the universities are doing some UAV work. In terms of qualified pilots, the program keeps 14 at Johnson Space Center (JSC), 25 at Dryden Flight Research Center (DFRC), 4 or 5 at the Wallops Flight Facility, and another 4 or 5 at the Langley Research Center. NOAA has qualified pilots as well, and is interested in some of ASP's projects.

Flying the Global Hawks requires 13 people on an 8-hour mission and 26 on 24-hour mission. Because crew need a day off, there must be 33 people total on a back-to-back mission. This does not include

scientists, mission scientists, or back-up crew. Dr. Gogineni noted that the training is extensive and must be factored in. He thought the crew numbers were minimums and suspected that the numbers for actual missions were higher.

While the Global Hawks and other aircraft are flying, the ground crew does not do a lot, but they are essential for take-off and recovery, they put in 8-hour shifts, and there is a crew chief in the control room. This staffing configuration could be optimized further. Currently, Wallops is more expensive than Dryden, but ASP is trying to build up the Wallops staff. It is expensive to deploy Global Hawks.

Dr. Kaye presented a graphic of the airborne science aircraft and their relative endurance and range. Mr. Tagg pointed out that the Falcon and Sherpa were added within the last year, and provide much needed flexibility. Dr. Kaye explained that ASP flight hours have increased a lot since 2009. Much of this is due to the IceBridge, which accounted for many hours in 2012. ASP is also tracking hours better, which may account for some increase. As for the budget impact of the hours increase, Mr. Tagg explained that these aircraft have capacity that is not well-defined. ASP funds the crew, and did increase funding with the ramping up phase, but that has leveled off. ASP is close to maximum capacity on several levels. Dr. Kaye added that ASP has tried to enable cross-training for pilots, which could lead to economies of scale.

Dr. Kaye and Mr. Tagg presented the following topics for discussion:

- Can increased demands for airborne science data collection be met with current funding?
- How do we capture science capacity across the Agency, including outside providers?
- What caused the Southeast Asia Composition, Cloud, Climate Coupling Regional Study (SEAC4RS) issues and delay?
- What is the best use of unmanned systems?
- Should ESD invest in small unmanned systems?
- How do we manage the fleet, including retire aircraft?

Dr. Siegel asked how much is spent on fuel, over-time, and travel to get personnel to the right place. Mr. Tagg said it was roughly $5 million for IceBridge alone, and there was $30 million for infrastructure. Some of this comes from the various programs, and while ASP does not actually track all the hourly fees, it is possible to determine it. Dr. Kaye explained that the SEAC4RS campaign was to have been based in Thailand, but the Thai parliament did not respond to the NASA timeframe. Therefore, the project is now looking at Singapore, where it is more expensive, as much as three times more than in Thailand.

The UAVs and UASes are not technically unmanned, as they are well-staffed and the staff must be paid. They account for much atmospheric chemistry and physics. Scientists want comprehensive measurements that are accurate and traceable, which leads to bigger, heavier sensors, which is a limitation on UAVs. However, there are other uses for UASes.

There is a disincentive to retire aircraft. The WB-57 is being set aside in case anyone needs it, but no one was using it. The CD-8 will require $4 million in heavy maintenance after 2013. It presents a good lab that is easily deployable. If NASA disposed of it and had to reconstitute it, the cost would be $60-100 million, and that would take a lot of time. Some of these vehicles have useful holes and inlets that are well-suited for likely uses. It is therefore hard to let go of them since they provide versatility. The P-3

needs new wings after another 1,000 flight hours. Mr. Tagg added that the Sherpa is bigger, and has both a longer range and a bathroom, which important for anyone flying for 8 hours.

Dr. Kaye said that keeping all of the aircraft indefinitely will take more program resources, probably at the expense of something else. Dr. Minster asked what it costs just to keep an aircraft in a hangar. Mr. Tagg said that those were the costs given alongside capabilities. Those costs incorporate maintenance and related personnel costs.

Mr. Tagg asked for ESS input on the following questions:
- What should the program be?
- What is the right mix of assets and technology development?
- What are the best metrics to meet ESD requirements?

Discussion
Mr. Tagg said that ASP would be amenable to an independent review. A lot of the hours flown can be attributable to training time or travel time. As for collecting data in transit, they already do some of that. Mr. Tagg noted that for IceBridge, the PI is very specific about when the data collection starts. The P-3 is at the maximum for power, weight, and ports. A summary of science outcomes was available by mission.

Dr. Minster observed that with the ability to take aircraft anywhere on the planet, he could imagine transits designed to turn into portions of science missions, including those that follow the ground track of satellites. Dr. Tapley added that the analogue is that a lot of ocean data were picked up by ships in transit. So if an aircraft is going to fly certain hours, the question should be whether there is something that can be done beyond running the aircraft from Point A to Point B. Dr. Kaye said that atmospheric scientists do this type of thing, and it is possible that flights are already catching satellite overpasses. However, there might be additional possibilities.

Dr. Kaye asked whether, given the increase in platforms and sensors, ASP should be thinking about more applications to oceanography. Dr. Siegel explained that, as an oceanographer, he would not try to force this, as the ocean is dynamic and moves quickly. The NASA oceanography program must be on the water. When Dr. Minster suggested adding a hypothetical 2 hours to a flight in order to collect additional data, it was noted that to do that, someone must process the data, put it in the archives, and analyze it. There would have to be other elements involved to ensure that the added time offered value. Dr. Siegel pointed out that ESS members were concerned with filling down time if there is a need, use, or funding.

Dr. Kaye showed a map of the 2005-2012 airborne campaigns across the globe, noting that flights seldom travel over Russia or China. While the French, among others, have similar campaigns operating and planned, the size and range of the NASA platforms tend to exceed what others have. The U.S. size and scope exceeds that of the international partners, and are more comprehensive and capable. He and Mr. Tagg described some of the U.S. inter-agency work done with NOAA, DOD, NSF, and others. There is a lot of coordination at the inter-agency level, and some of the aircraft assets are exclusive to NASA. Some operations have constraints, however.

It was noted that NASA works with the Forest Service (FS) in support of wildfire activities, using airborne sensors. There are questions about the utility of the sensors and whether NASA and the FS want to continue. There is an effort to facilitate technology transfer in this area.

Other issues include the following:

- The Global Hawks were oversold and have under-delivered;
- Manned aircraft may require less staffing than unmanned aircraft;
- Maximum capacity is not well established at the centers, but ASP is close to its maximum capacity;
- ESD instrumentation strategy raises the question of how to go from the Instrument Incubator Program (IIP) to the Airborne Instrument Technology Transition (AITT) to becoming a real data collection asset.

Global Hawks. Dr. Gogineni observed that it will take time to get the Global Hawks to the right level, but it is important to target specific applications that can be done with them. Mr. Tagg replied that the budget for that is limited. Mr. Tagg presented a chart listing the Global Hawks' limitations. Among these was the fact that the payload must be distributed throughout the aircraft. Dr. Tapley was surprised by some of the limitations. Mr. Tagg explained that these are "low time" aircraft, and he was not sure ASP had enough reliability data. The Global Hawks are a reliable aircraft that go a long distance, but they were not ready, expectations were set too high, and too much was done with them too soon. It would be good to have a program assessment. Many scientists want to use the Global Hawks, but ASP also makes platform suggestions. The Global Hawk flies at high altitude and is the closest thing ASP has to a satellite. It is also long range and can cover more ground from higher up.

Dr. Jenkins if there had been any feedback from the science community comparing the P-3 to the Global Hawks. Mr. Tagg said that there was not, but noted that the P-3 provides more flexibility on preparing payloads. Dr. Kaye added that the Global Hawks and the ER-2 are the most closely related. The ER-2 flies a bit higher than the Global Hawk, though with less range. However, it has a greater payload capacity and it can use the Sun, which the Global Hawk cannot.

Earth Venture Class and other missions. Although ASP is prepared for the next EV, there are financial and time limitations, and concerns about personnel. The expectations on the proposals are rather high. Mr. Tagg said that he must be ready to determine capacity when proposals come in. Regarding the question of whether selections are based on resources or resources are based on science, Dr. Kaye explained that ASP might select fewer missions and invest in platforms, but relies on the structure of the budget. Overlapping missions should not be a problem. Dr. Moghaddam gave the example of AirMoss, where it was found that the existing G3 could not handle it as expected, as the aircraft was oversubscribed. She suggested that this be handled at the beginning of the process. Dr. Kaye agreed that the AirMoss situation could have been handled better. ASP must look at all the missions in development, and provoke the investigators to think more clearly ahead of time in order to identify their needs. There is a budgetary cushion to provide nimbleness.

Dr. Kaye said that there is less flexibility with EVs than previously. Most of the campaigns have not been multi-year, though there are more of those now. Dr. Curry asked how many good proposals are turned

down due to lack of facilities, and which disciplines are most affected by this. She also asked if ASP was supporting projects with marginal science payoff. Dr. Kaye explained that the EV-1 had some good science ideas that were not well implemented and less exciting science ideas that were well implemented. There are other issues, like field campaigns where the funding limitations are in the overall programs. ASP cannot always fund the campaigns like the Program did when it had deployable dollars. Another factor is that of logistics and personnel time. Dr. Curry suggested that flying less might make more sense because a lot of the data that are collected are not analyzed. Her faculty spend a lot of time in the field, but funds for analysis are less available. She wondered if the funding is skewed toward field work.

NRC DS Midterm Review

Dr. Tapley next discussed how to frame the response to the review. Dr. Freilich's information indicated that the flight programs in 2007 had a budget of about $1.45 billion. In addition to DS missions, the climate initiative was moved forward with OCO, SAGE, SMAP, and seven additional missions funded to launch by 2020. The budget increases have not met the DS goals, and there were additional costs associated with the OCO reflight and Glory failure. ESD has completed most foundational missions. The NRC review noted that the budget did not materialize and that mission costs exceeded those anticipated in the DS. Among the reasons for the cost escalations were higher launch vehicle costs and lack of launch vehicle access. DS "irrational exuberance and mission creep" presented cost issues with CLARREO, for example. Some of the missions were more challenging than anticipated and others envisioned synergies that were not readily achievable. Dr. Tapley noted that there were recommendations on partnering with NOAA, which has had its own problems. Regarding JPSS, for example, there were problems within NOAA and its decisions on measurement continuity. Many programs were underfunded, some of which were mentioned in the DS.

Dr. Tapley thought the most significant assessment was NRC's finding that NASA responded favorably and aggressively to the DS, given the budget situation and other limitations. NRC supported the Earth Venture class program, noted the flexibility brought by alternative platforms and flight formations, and acknowledged the positive development of international partnerships. NRC also praised the progress with the Applied Science Program (ASP), stating that NASA has enhanced that program while maintaining healthy investment in R&A.

Additional findings that were problematic include NOAA's greatly diminished ability to implement the baseline and recommended program, and the lack of reliable, affordable, and predictable access to space. The latter finding was specific to launch vehicles, and NRC stated the need for a medium class launch vehicle in order to secure programmatic robustness.

Dr. Tapley next reviewed the recommendations. The first stated that ESD should interpret DS estimates of mission costs as an expression of the relative level of investment that the DS committee believed appropriate to advance the intended science, and should apportion funds accordingly, even if all of the desired science objectives for the mission may not be achieved. The second recommendation was that ESD should implement its missions via a cost constrained approach, requiring that cost partially or fully constrain the scope of the mission such that realistic science and applications objectives can be achieved within a reasonable and achievable future budget scenario.

A discussion of costs followed, with Dr. Tapley observing that ESD gets both optimistic funding numbers and realistic numbers. Dr. Running added that when he was on a DS panel, they never did any kind of detailed cost analysis. Dr. Gogineni said that he has found more realistic costs modeled independently, and they were much higher than the DS figures. The centers also had realistic numbers. Dr. Tapley thought that the figures in the DS might come in part from the science community, which sometimes does not distinguish well between needs and wants. He agreed with the first recommendation. Regarding the second recommendation, he thought it better to get a mission into orbit rather than not flying it at all. ESS previously supported this recommendation, but he wanted to confirm that.

The third recommendation is that ESD should establish a cross-mission Earth system science and engineering team to advise NASA on execution of the broad suite of DS missions within the interdisciplinary context advocated by the DS. Dr. Running was not sure he agreed. With single missions now not under the scope of a separate committee, he was not sure where this was done. Dr. Siegel said that the manifest of what is going forward included things that were new to him, and it was not clear where advice was going. A NASA representative explained that the flight to ISS was an opportunity that came along suddenly. A NASA priority is to fly payloads on ISS, and given the launch vehicle situation and ISS expense, these are golden opportunities that ESD cannot turn down. It was also explained that OCO-3 is an extension of OCO-2, which only has a 3-year mission.

Dr. Siegel noted that the systematic review could make things more complicated. Dr. Michalak noted that, in general, it is not clear if there is a common, systematic process for making these decisions. It was also not clear whether such a process should involve ESS or some other group. In the case of OCO-2 and OCO-3, the concern was more about the process than anything. She understood why the opportunity for the flight to ISS was taken, but the community was surprised by it. She wondered if ESS should have input into the process to make sure it is done well. Dr. Tapley pointed out that that could occur between the NRC panel and the ESD director. Dr. Tsaoussi explained that the recommendation advocated a panel that would have to be legally set up to provide feedback that the Agency could consider. That would be under NASA, not NRC.

Dr. Moghaddam said that this bordered on the peer review process, and she was not sure how useful such a panel or committee would be. Her interpretation was that this group would select missions to go forward, which might not be desirable. Dr. Tapley thought that the tasks ascribed to the cross-disciplinary advisory group were done by single-purpose groups. Dr. Siegel said that he was on one of the latter, and it was brief. As he read through the NRC text, he saw continued discussion about keeping scientists reasonable on costs, and he was not happy with that.

Dr. Gogineni did not see how the new panel would address the fact that cost estimates are off, although he understood that to be the panel's purpose. Dr. Running thought this was redundant to what already happens. Dr. Christy added that when the DS first came out, it said that all these of measurements were needed, but the second recommendation said not to let implementation of any one subvert the rest. Dr. Tapley observed that much the experience has been in pushing the envelope on the science, but sometimes the science is best served by less precision over a longer timeframe. Dr. Kaye explained that

the DS gave continuity missions to NOAA and single missions to NASA. This cast NASA as the innovator and provided little focus on continuity outside of NOAA.

Dr. Running noted that the point on whether to continue improving a sensor or keep continuity is always being debated. The crosswalk to the next sensor is sometimes an issue, and sometimes continuity is best served by not going to the next state of the art. Ms. Green wondered if this discussion needed more time, perhaps at the next meeting. She has heard this issue discussed at NASA a lot. As science depends more and more on sensors, the scientists want more balance, and she did not think the balance existed yet. Dr. Siegel observed that the nation's science depends on NOAA for continuity, which is a problem because NOAA's continuity is an issue.

Dr. Tapley said that while ESS could endorse the first two recommendations, it did seem that Ms. Green was right in advising more time to think about and discuss the third recommendation. Dr. Curry asked what others thought of skeleton missions versus more complete missions. Dr. Tapley thought that depended on NASA's focus. The process studies are extremely important, and serious climate work requires long-term measurements. Dr. Curry said that while that may be true, there are not many variables required with climate. NOAA is useful with the climate data record, but the community does not present a coherent, practical program. Dr. Running advised a serious review of the array of data products.

Dr. Christy said that there had been a review of NASA and NOAAs programs about 15 years ago. Dr. Minster cautioned against creating unintended consequences. Continued measurement of the same points would not necessarily equate to stable costs, which could go up. Dr. Shepherd gave a best-case example of precipitation trends, in which the data record is continuing while the field also advances technologies. Dr. Tapley said that in considering budget issues, it was not clear that science is best served by doing the best possible on each measurement.

Ms. Green said that another issue is that while NASA will say the Agency wants continuity of measurement to go to another agency, Congress does not always trust other agencies as much as it trusts NASA. This means that if NASA does not do the continuity measurements, they might not get done. It is an institutional issue. Landsat is an example. The President gave that to the Department of Interior, but Congress gave it to NASA. Dr. Running pointed out that the issue is the continuity of the data record rather than the instrument. He would like to see instrument capabilities evolve, but the existing climate data records must be kept in mind. Compatibility of data is an important consideration in developing new sensors. Dr. Curry agreed, citing an example of lack of compatibility.

Dr. Tapley determined that the recommendation would remain under consideration until the next meeting.

The fourth recommendation was for NASA to ensure the availability of a highly reliable, affordable medium-class launch capability. The fifth stated that, consistent with available budgets and a balanced Earth observation program from space that is based on the DS recommendations, NASA should consider increasing the frequency of EV stand-alone/space-based missions.

Dr. Siegel thought the fifth recommendation seemed premature. No one knows if the system works, because there are not yet any data. Dr. Moghaddam added that this has to come at a cost, so increasing the

EV missions would necessitate reductions elsewhere. An alternative would be to implement some original DS missions through competing EV missions. Dr. Running said that he would not endorse it without knowing what is given up. Dr. Tapley agreed that information on the track record is necessary, and said that ESS would put this recommendation on hold and continue to monitor the EV missions.

Dr. Tapley said that ESS also needed to discuss the Suomi NPP mission, where the specific instruments are noted. There are five altogether, and NOAA will use four. Only one has already flown in space. There is a question about the actual science yield. The bigger issue is with JPSS after NPP. The budget is a concern, as is the number of instruments. There is also the question of what NOAA will do. Calibration and validation issues remain, and this is all very uncertain.

There was discussion about what the options were, with a NASA representative stating that NASA cannot control this situation. Dr. Shepherd said that he is on a NOAA advisory board that met the previous week and had a presentation related to this issue. There is an independent review team report now available. NOAA is doing a gap risk study. Dr. Tapley asked him to be the liaison, which Dr. Shepherd agreed to do if there is no conflict of interest. He emphasized that he did not speak for NOAA. Dr. Running observed that he had been on that same advisory board, and believed that NOAA does not feel it has ownership of climate data records. Dr. Tapley said that that was important to know.

Dr. Running said that every sensor should be looked at specifically, and while JPSS must keep going, it is important to distinguish which sensors are just interesting research tests and which contribute to ongoing data flows. This will come up at some point due to budgeting. Dr. Tapley asked Drs. Running and Shepherd to write something on the scope of the problem. ESS will hold that as the action on this topic.

Without knowing the budget, it is hard to address the issue on program balance. Dr. Tapley thought it was in good shape, though he knew that there were some in the community with concerns about the balance of the flight program and the delay in the microwave mission, although the latter is in the queue. Dr. Siegel said that he saw balance but not continuity, and was unsure how to articulate that as part of the balance discussion. Dr. Tapley suggested calling out continuity regarding JPSS, and Dr. Running agreed to write something.

It was noted that there was nothing specific about natural hazards, although “societal benefit through applications” might cover that. There is also an issue with the technical program, and the gap between outcomes and actual instruments. Dr. Kaye expressed concern that the instruments cannot be kept going. The presumption is that they will go into R&A, but that remains to be seen.

Applied Sciences Advisory Group

Ms. Green and Dr. Lawrence Friedl, of ESD’s Applied Science Program (ASP), discussed the Applied Sciences Advisory Group (ASAG). ASAG is a Congressionally mandated group advising ASP.

ASAG is still building its membership. At a recent meeting, the Group discussed Earth sciences data access, data latency, assessment of the ASP capacity-building program, applications value in satellite missions, market research for water resources applications, and grand challenges. The recently introduced

Application Readiness Levels (ARL) range from 1 to 9 and have proven to be extremely valuable in evaluating the applications. The annual performance goal for 2012 was more than achieved. Two thirds of the applications increased at least one ARL, 40 percent increased by at least two levels, and 23 percent increased by at least three.

Findings at the meeting include that applications play a pivotal role in the migration of NASA Earth science results into operational decision-making and other end uses, and that applications are critical to the continued support of ESD. Ms. Green gave some examples of applications that had migrated into the real world. Dr. Shepherd said that some scientists are looking at Tropical Rainfall Measuring Mission (TRMM) observations of Hurricane Sandy, noting that skeptics will ask if this was used in an applications mode. The NASA graphics looked like they were developed after the fact. Ms. Green said that she will bring additional information next time.

One of the more specific ASAG findings was that the ARLs are very effective in evaluating the success of applications projects and for tracking the migration of NASA science into operational decision-making. The program should consider tracking publications as well. There is a need to track data users and their applications in order to understand their needs. Methodologies are needed for determining the value of the applications and to identify approaches for communicating that value to the public. Determination of benefits and the value of applications is an unsolved intellectual and fundamental problem.

ASP is productive and effective, with many examples of success. However, key positions are not permanent or are vacant, and this needs to be addressed. There are also some very interesting organizations that understand NASA science and can formulate solutions, so ASP should establish that kind of translation through those groups to get the data more used and more institutionalized.

ASAG developed the following recommendations:

1. Increase consideration of applications in mission planning. This is very important in communicating the value of NASA Earth science.
2. ESD should pursue research that develops methodologies to determine the value of applications. This is the most important recommendation, Ms. Green said.
3. NASA should quickly staff the Disasters Program manager position as permanent.
4. The responsibilities of the Distributed Active Archive Centers (DAACs) should be broadened to include providing access to pre-launch test data for applications research supporting mission development.
5. ASP should better characterize users and grand challenges in the applications areas, which can enhance applications planning and users' engagement in mission planning.
6. ASP and other ESD programs should work together to develop and implement methods for tracking data users and their applications to better understand user needs and requirements.
7. ASAG strongly encourages ASP to fill the vacant Communications Manager position.
8. ASAG encourages the Program to diversify its communications and outreach approach by providing ways for the community to showcase successful applications.
9. ASAG encourages ESD to make more use of ASP's Annual Report and ASP's successes.

Discussion

Dr. Siegel said that since two-thirds of the applications had advanced through the ARLs, he wondered how technically calibrated they were. Perhaps nine was too many and they only needed six. Ms. Green thought that some of the groups might have been ambitious in their initial assessments. Dr. Friedl explained that initially, ASAG was trying to help investigators understand how to judge themselves. He agreed there was some gaming of the system so that PIs would look good. ASAG would like to run this for another year or two, then assess it again. There are criteria for the ARLs, but they first allow PIs to assess themselves, then an associate at NASA reviews the assessment.

Dr. Minster said that the mission of the DAACs to distribute the prelaunch test data has been a requirement from the first day. Ms. Green thought that could be a perception problem. Dr. Freidl added that regarding access to data sets, NASA is making the data available to early adapters of SMAP, which Dr. Tapley thought might be too early. Dr. Running explained that before launch, a PI has very little confidence in his or her algorithm and does not want it passed around by being posted on a DAAC. Dr. Tapley agreed that the prelaunch test data should not include just anything that is being done.

He added that the first recommendation was a policy that Dr. Freilich had mentioned, but it does not seem to be universally applied. He wanted to know if, in mission implementation, applications were brought in at the same time as the science team. Dr. Freidl said that ASAG had discussed the EV program and the role of applications. Dr. Moghaddam pointed out that EVs are highly cost capped, which meant that the addition of applications would lead to giving up something else. Ms. Green said it should be part of the decision process.

Dr. Tapley agreed with the second recommendation, but Dr. Siegel was unclear on its intent. He asked whether it meant that ASP would determine the value of applications research for the public, or that the research agenda would reflect the value of information to the public. When told it was more the latter and involved methodologies for communicating the value, he asked how they might use a satellite to forecast a hurricane. He had compared operating with and without a given asset, which led to a dollar value. Ms. Green said that the recommendation advised communicating processes that people value along with that.

Dr. Tapley agreed with the third recommendation but noted that it depended on resource availability. He also agreed with the fourth recommendation. Dr. Friedl noted that NASA has decided to restructure ASAG as an advisory committee, though it will continue to maintain its status as subordinate to ESS, and will have a member on the Subcommittee.

Findings and Recommendations

ESS members were given Dr. Running's piece on products the Subcommittee would like to define for climate continuity. Dr. Tapley asked them to read it over, and he would incorporate their comments into a draft. Similarly circulated was Dr. Minster's draft on the health of ESD and measurement products. Dr. Tsaoussi was to send out additional paragraphs for review. Dr. Tapley wrote an analysis of the balance of the program, in which he noted that the data centers should stay as they are for now, adding that if there is ever a decision to change, ESS wants to protect certain properties.

The airborne program presented the potential problem related to partnering on SAAs. ESS also wanted to understand the cost benefits through an external review. Dr. Siegel said that this should be similar to what was done with the satellite program. He volunteered to write a recommendation on that. Dr. Tsaoussi explained that ASP has a fixed budget line in the research program. The other R&A funding depends on the campaigns that are done in a given year. Some is competed, some is not. Some of the funding is steady and some is not. The funds are not available to do campaigns across all of the programs. The last two fiscal years are not necessarily representative. It is important to be more flexible, especially with flight hours. It would be possible do a retrospective to see how much of that is competitive, however.

Dr. Tapley said that there was, in general, agreement with the mid-decadal review, with the caveat that ESS is still looking at the cross-disciplinary and Venture class recommendations.

There was additional discussion about the potential cuts ESD would experience in the event of sequestration, and whether to cut the budget vertically or horizontally. Dr. Tapley said that it sends the wrong message to make it appear that the cut could be done without pain, but he thought ESS should at least discuss what might be cut. This could be done via teleconference once they had more information. Dr. Gogineni offered to write something about the cost versus benefits of UAV operations, and would write a recommendation that the program be reviewed.

There was discussion about the scheduling of the next meeting. Dr. Tsaoussi offered to poll the members. She added that NASA had received nominations for new ESS members, as four members were about to rotate off. She would look at the dates they were to leave and see if it might be possible to meet before then, though that would not determine the next meeting date.

Adjourn

Dr. Tapley thanked the meeting participants and adjourned the meeting at 2 p.m.

Appendix A
Attendees

Subcommittee members

Byron Tapley, ESS Chair, University of Texas
John Christy, University of Alabama, Huntsville
Judith Curry, Georgia Institute of Technology
S. Prasad Gogineni, University of Kansas
Gregory Jenkins, Howard University
Anna Michalak, Carnegie Institution for Science
Jean-Bernard Minster, University of California, San Diego
Mahta Moghaddam, University of Michigan
Steve Running, University of Montana
J. Marshall Shepherd, University of Georgia
David Siegel, University of California, Santa Barbara
Lucia Tsaoussi, Executive Secretary, NASA Headquarters

NASA Attendees

Mitra Dutta, NASA Headquarters
Michael Freilich, NASA Headquarters
Lawrence Friedl, NASA Headquarters
Steve Hipskind, NASA Headquarters
Ken Jucks, NASA Headquarters
Jack Kaye, NASA Headquarters
George Komar, NASA ESTO
John LaPrecyre, NASA Headquarters
Allison Leidner, NASA Headquarters
Peg Luce, NASA Headquarters
Martha Maiden, NASA Headquarters
Peter Meiser, NASA Headquarters
Marian Norris, NASA Headquarters
Mike Seablom, NASA Headquarters
Bruce Tagg, NASA Headquarters
Kathleen Teale, NASA Headquarters
Justin Tilman, NASA Headquarters
Leslie Vann, NASA Headquarters
Stephen Volz, NASA Headquarters
Amy Walton, NASA ESTO
Diane Wickland, NASA Headquarters
Cheryl Yuhas, NASA Headquarters

Non-NASA Attendees

Patnef Besha, OIIR
Don Blick, Raytheon
Kaitlin Chell, Caltech
Dom Conte, Orbital Sciences
Richard Dissly, Ball Aerospace
Mike Fox, Raytheon
Matt Jones, Boeing
Bill Mackey, CSA
John McCarthy, Orbital Sciences

Mike Moore, OIIR
Elizabeth Sheley, Zantech IT

Appendix B
ESS Membership

Byron Tapley, ESS Chair
Director, Center for Space Research
University of Texas

John Christy
Earth System Science Center
University of Alabama, Huntsville

Judith Curry
School of Earth and Atmospheric Sciences
Georgia Institute of Technology

Efi Foufoula-Georgiou
National Center for Earth-Surface Dynamics
University of Minnesota

S. Prasad Gogineni
Center for Remote Sensing of Ice Sheets
University of Kansas

Kathleen O. Green
Kass Green and Associates
Berkeley, California

(GOV) James Hansen
Goddard Institute of Space Studies
NASA

Daniel Jacob, ESS Vice Chair
Department of Earth and Planetary Sciences
Harvard University

Gregory Jenkins
Department of Physics and Astronomy
Howard University

William Large
Oceanography Section
National Center for Atmospheric Research

Patrick McCormick
Center for Atmospheric Sciences
Hampton University

Anna Michalak
Department of Global Ecology
Carnegie Institution for Science

Jean-Bernard Minster
Institute of Geophysics and Planetary Physics
University of California, San Diego

Mahta Moghaddam
Radiation Laboratory
University of Michigan

Steve Running
Department of Ecosystem and Conservation Science
University of Montana

J. Marshall Shepherd
Department of Geography/Atmospheric Sciences
University of Georgia

Hank Shugart
Department of Environmental Sciences
University of Virginia

David Siegel
Department of Geography/Institute for Computational Earth System Science
University of California, Santa Barbara

Mark Simons
Division of Geological and Planetary Sciences
California Institute of Technology

Konrad Steffen
Cooperative Institute for Research in Environmental Science
University of Colorado, Boulder

Appendix C
Presentations

1. Earth Science Division Update; *Michael Freilich*
2. Ethics Briefing for Special Government Employees Serving on NASA Advisory Committees; *Kathleen Teale*
3. ESD Flight Program Pre-Formulation Progress; *Stephen Volz*
4. NASA Earth Science Data Systems Program; *Martha Maiden*
5. Airborne Science Program Strategy/Overview/Near-Term Issues; *Jack Kaye, Bruce Tagg*
6. Applied Sciences Advisory Group; *Kathleen O. Green*

Appendix D
Agenda

NAC Earth Science Subcommittee
NASA Headquarters 300 E Street SW, Washington, DC.

November 28, 2012

8:30-8:35	Opening remarks	L. Tsaoussi
8:35-8:45	Meeting charge	B. Tapley
8:45-9:50	Earth Science Division Update	M. Freilich
9:50-10:00	Coffee Break	
10:00-11:00	ESD Strategy Issues	M. Freilich
11:15-12:00	EST Strategy Discussion	ESS Members
12:00-1:00	Lunch	
1:00-2:00	Ethics Briefing	K. Teale
2:00-2:30	Pre-formulation Workshop Report	S. Volz
2:30-3:00	Data Center Study/ESD Data Centers	IT Committee/M. Maiden
3:15-3:30	Coffee Break	
3:30-5:00	Discussion	ESS Members
5:30	Adjourn	

November 29, 2012

8:30-8:45	Session Overview	B. Tapley
8:45-9:30	Airborne Science Program Strategy/Overview/ Near-Term Issues	M. Freilich/J. Kaye/B. Tagg
9:30-10:20	Discussion	ESS Members
10:20-10:30	Coffee Break	
10:30-11:00	NRC DS Midterm Review	B. Tapley
11:00-12:00	Discussion	ESS Members
12:00-1:00	Lunch	
1:00-1:30	Applied Sciences Advisory Group	K. Green
1:30-2:00	Findings & Recommendations	ESS Members
2:00-3:00	Letter Writing/Next Meeting	ESS Members
3:15	Closing Remarks /Adjourn	