



NATIONAL SPACE-BASED POSITIONING, NAVIGATION, AND TIMING (PNT) ADVISORY BOARD

Second Meeting


Doubletree Hotel

1515 Rhode Island Avenue, NW

Washington, D.C. 20005

October 4 & 5, 2007

MEETING MINUTES


James R. Schlesinger
Chair


P. Diane Rausch
Executive Director

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POSITIONING, NAVIGATION, AND TIMING (PNT)
ADVISORY BOARD**

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**MEETING REPORT
TABLE OF CONTENTS**

October 4, 2007

Board Convenes	3
Welcome & Opening Remarks	3
Introductions, Announcements, & Agenda	4
Update on GPS, PNT Policy & PNT EXCOM	4
International Member Feedback & Regional Reports	5
<i>Panel 1 – Leadership: Fact-Finding Report</i>	7
<i>Panel 2 – Strategic Engagement & Communication: Fact-Finding Report</i>	8
Options for Promoting GPS to Vendor, New User & Global Communities	11
<i>Panel 3 – Future Challenges: Fact-Finding Report</i>	12
Update on GPS Performance Standards: DoD Perspective	13
Update on GPS Performance Standards: Civil Perspective	14
Afternoon “Wrap-Up” & Announcements	16

October 5, 2007

Chair Feedback – “What We Want the PNT Board to Accomplish”	16
Future of E-LORAN: GPS Alternative & Backups – Timing	17
Future of Nationwide Differential GPS (NDGPS): Infrastructure & Funding Status	18
GPS Constellations & Support for Separation Standards	19
Board Member Feedback – “Round Table”	21
Board Assignments & Future Taskings	23
Adjournment	23

APPENDICES:

- Appendix A Agenda
- Appendix B Board Membership
- Appendix C Meeting Attendees
- Appendix D List of Presentation Material and Other Distributed Material

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Board Convenes

Ms. P. Diane Rausch, Executive Director, National Space-Based Positioning, Navigation and Timing (PNT) Advisory Board (the "Board"), NASA Headquarters, convened the meeting at 8:30 am, and welcomed members back for their second meeting. The first meeting was held on March 29-30, 2007. She noted that the Board is a Presidential advisory committee mandated by the President's PNT Policy announced in December 2004, and stated that NASA is pleased to be the official sponsor of the Board on behalf of seven Federal agencies: the Department of Defense (DoD), Department of Transportation (DOT), Department of Commerce (Commerce), Department of State (State), Department of Homeland Security (DHS), Joint Chiefs of Staff (JCS), and the National Aeronautics and Space Administration (NASA). The results of the Board's work will be in the form of findings and recommendations to the National Space-Based PNT Executive Committee (EXCOM), co-chaired by the Deputy Secretary of Defense and Deputy Secretary of Transportation. Ms. Rausch reminded the attendees that the Board is a Federal advisory committee under the Federal Advisory Committee Act (FACA), and the minutes for the meeting would be published and posted for public review on the U.S. Government web site (www.pnt.gov). Ms. Rausch introduced the NASA support team for the PNT Advisory Board, including Global Positioning System (GPS) subject matter expert James Miller and policy analyst Barbara Adde. She noted that three panels had been appointed at the last Board meeting: *Panel 1 - Leadership; Panel 2 - Strategic Engagement and Communication; and Panel 3 - Future Challenges*. Ms. Rausch also reviewed the ethics briefing that had been given to the Board at the last meeting. She reminded members that Special Government Employees (SGEs) are appointed due to their expertise; however they are subject to ethics laws and must recuse themselves from the meeting if a potential conflict of interest arises. Representative members, on the other hand, are expected to present the positions and views of the respective organization or entity they were appointed to represent. Ms. Rausch then introduced Dr. Scott Pace, Associate Administrator, Program Analysis & Evaluation (PA&E), NASA Headquarters.

Welcome & Opening Remarks

Dr. Pace welcomed every one to the meeting and conveyed greetings from the NASA Administrator, Dr. Michael Griffin. He briefly described how everyone is becoming increasingly dependent on the GPS, and described recent discussions among PNT EXCOM members to ensure GPS remains robust and accessible to all, even as budget priorities are reexamined in tighter fiscal environments. To this end, EXCOM members have been receiving many good ideas on ways to do this, and the EXCOM welcomes the Board's ideas and recommendations in determining priorities and making the most of current and expected resources. This is similar to advice given by the National Academy of Sciences, and he believes that the Board can provide similar assistance in setting national priorities for GPS. Dr. Pace described the upcoming International Committee on Global Navigation Satellite Systems (ICG) as an important

mechanism to bring GPS issues into the international arena. He then introduced the Board's Chair, Dr. James R. Schlesinger.

Introductions, Announcements, & Agenda

Dr. Schlesinger thanked Dr. Pace and welcomed everyone back to the Board's second meeting. He noted that it was the 50th anniversary of the launch of Sputnik that day. He recalled that the Sputnik launch on October 4, 1957, had preceded the launch of the U.S. Vanguard spacecraft, much to the chagrin of the U.S. Navy. He stated that we are here today to discuss the future of the 25-year old GPS system, with a goal to provide the EXCOM with actionable recommendations backed by solid rationales. He thanked everyone for the work that has been accomplished since the first meeting. He thanked Dr. Brad Parkinson for providing an initial list of priorities to the Board members, and expressed appreciation for the letters he received from some Board members on issues that the Board might want to consider. He noted that Mr. Chet Huber recommended the subject of the ongoing review of the GPS Standard Positioning Service (SPS) Performance Standards (PS) for the civilian users. Mr. Charles Trimble had expressed concern about the future of Nationwide Differential GPS (NDGPS), and Ms. Ann Ciganer had expressed concern about the military's Flex Power testing and its impact on L2C and semi-codeless receivers.

Dr. Schlesinger indicated that as Board members work through the agenda over the next two days, they will see that their recommendations have been followed, and time has been allotted for discussion and updates from key government players who directly deal with these issues. He acknowledged Dr. Robert Hermann for handling his particular task. He noted that the Board has yet to address some of these important issues and hopes that the Board can build upon what it has started as we work toward fulfilling a national purpose of setting goals for future GPS services from a user perspective. Dr. Schlesinger stated that his goal for the meeting was to obtain two or three recommendations for consideration and action by the EXCOM at its next meeting scheduled for November 8. The recommendations will require a strong intellectual basis and should be capable of being implemented in the near term. He added that there is additional work to be done by the Board's panels within their respective areas of expertise.

Dr. Schlesinger informed the Board that he was pleased to report on the clear success of the Board's recommendation regarding elimination Selective Availability (S/A) on the next generation of GPS spacecraft known as GPS III. That recommendation has been implemented and S/A will be removed from all future programs for satellites, monitoring equipment, and military user equipment. He observed that removing S/A has been an 11-year quest upon which we can now close the book. Time should be taken to discuss what the final elimination of S/A might mean for us in the future. He presented several questions for future discussion. How can we leverage this decision that reduces GPS system costs and complexities? What are some near-term actions? Are there some residual issues that need to be addressed? Dr. Schlesinger then introduced the Board's co-chair, Dr. Brad Parkinson.

Dr. Parkinson spoke to the Board briefly about the impact from the elimination of S/A. He observed that it meant that civilians can move ahead with the assurance that they do not have to include S/A in error calculations. Mr. Keith McPherson, speaking on behalf of the Australian government, congratulated the Board and Dr. Schlesinger on achieving this result. Professor Gerhard Beutler described it as a great achievement. Dr. Schlesinger acknowledged Deputy Secretary of Defense England for making it happen. Dr. Parkinson noted that Dr. Schlesinger had worked towards this goal for over 10 years and is owed a debt of thanks. Mr. Trimble questioned whether anything else could be accomplished if it took 10 years to accomplish something so obvious as the elimination of S/A.

Update on GPS, PNT Policy & PNT EXCOM

Dr. Schlesinger introduced Mr. Michael Shaw, Director of the National Space-Based PNT Coordination Office. Mr. Shaw introduced Col. Tony Russo, the new Deputy Director of the National Coordination Office. Mr. Shaw briefed the Board on the activities of the EXCOM. The EXCOM is meeting regularly and will next meet on November 8, 2007, at which time it will conduct a budget review. Recent items addressed by the EXCOM are: Selective Availability (S/A), Interference Detection & Mitigation (IDM), the National 5 Year Plan for Space-Based PNT, the National PNT Architecture, and the EXCOM 2008 Work Plan.

Mr. Shaw also briefed the Board on the status of major GPS programs. He reported that the GPS constellation is robust, with 30 operational satellites. The first GPS IIF satellite is projected for launch in early 2009. An update to the GPS SPS PS is in progress and should be completed by April 30, 2008. A contract award to upgrade the GPS ground segment is at the Request for Proposal (RFP) source selection stage and contract award is anticipated by the end of October. The next generation of GPS satellites – GPS IIIA – is also in source selection and an award is anticipated in January, 2008. The Wide Area Augmentation System (WAAS) has recently expanded service into Canada and Mexico. The DOT is working to complete an assessment of the need for the inland component of the NDGPS by the end of January, 2008. The maritime component will not be affected by this assessment. A notice about the assessment was published in the *Federal Register* in August and the comment period ended on October 1, 2007.

Mr. Shaw also briefed the Board on recent international developments. He expects that space-based PNT service providers will grow from two countries (U.S. and Russia) to six or more countries by 2020. He noted that China launched its COMPASS medium earth orbit satnav satellite on April 16, 2007. He reported that the U.S. is actively engaged in diplomatic efforts to promote GPS. He described the ICG, which held its second meeting in Bangalore, India, in September 2007. The participants included Global Navigation Satellite System (GNSS) providers the U.S., European Union (EU), Russia, China, and Japan. He announced that the U.S. would host the third ICG at NASA JPL/Cal Tech on December 8-12, 2008. There have been ongoing discussions with Russia, while the U.S. and Japan conducted their 5th annual consultation on May 24, 2007. The U.S. and India issued a Joint Cooperation Statement on February 28, 2007, the purpose of which was to ensure interoperability between WAAS and India's GPS-Aided Geo Augmented Navigation (GAGAN) system. The U.S. and Australia also issued a Joint Cooperation Statement on April 19, 2007. On July 26, 2007, the U.S. and the European Union (EU) adopted a new improved civil signal structure (MBOC). The EU on June 8, 2007, abandoned its plan for funding through a Public/Private partnership and is now examining governmental funding opportunities.

In summarizing, Mr. Shaw noted that implementation of the President's 2004 PNT Policy is progressing with very active senior U.S. Government leadership. International cooperation is a top priority for the government and it is actively engaged in both multilateral and bilateral consultations. He reiterated the theme that as new space-based GNSS emerge globally, interoperability is the key to "success for all."

In response to a request from Board member Mr. Terence McGurn, Mr. Shaw described the current budget status for GPS. Gen. Lance Lord contended that 20 consecutive miracles will be needed to make it work and that a sustained funding line is needed to protect the resources to assure continued linkage between the ground stations and the constellation. Mr. Shaw explained that the budgets will be reviewed to assure continued operations. Dr. Schlesinger recalled there had been a recommendation years ago to open up the discussions to international members and, he observed, that has come to fruition.

International Member Feedback & Regional Reports

The Board received briefings from its international members. Dr. Gerhard Beutler, President, International Association of Geodesy (Switzerland), described the role of the GPS and GNSS in geodesy and geodynamics. He explained that geodesy is based on and provides information for geometry and the kinematics of and on the Earth and its environment, Earth orientation and rotation, and the Earth's gravity field, including its variability. This makes it necessary to define, realize, and maintain unique reference systems on Earth and in the sky, and to monitor the transformation between them. The space age brought about a revolution in geodesy and led to the creation of several important services, including the International Earth Rotation Service, the International GPS Service for Geodynamics (IGS), and the International Laser Ranging Service (ILRS). There are currently 30 GPS satellites in six orbital planes, but that independent precision ranging should continue to be refined through techniques such as laser ranging. He noted that there are a varying number of satellites in the Russian system (GLONASS), while Galileo has one prototype satellite in space sending out test signals (Giove-A). He suggested that the Galileo system's lack of funding stability is a problem.

Dr. Beutler then described the history of the IGS. It was initiated in 1989 and became an official service in 1994. At first, it was a pure GPS service. Today however, the IGS is an interdisciplinary service providing support to all Earth sciences. Its Central Bureau is located in the United States and its Director is Board member, Ms. Ruth Neilan, who was one of its founders. In 1992, the IGS was based on 20 geodetic receivers, and has grown to over 400 receivers today. It started off as an orbit determination service for about 20 GPS satellites. Today it provides ephemerides (with an accuracy of 2-4 cm) for all active GNSS satellites, about 30 GPS satellites, and 10-17 GLONASS satellites. In addition, the IGS is providing products that are accurate, reliable and robust. These included serving as an archive of GNSS observations, satellite and receiver clock corrections, length of day monitoring, and atmospheric information. Dr. Beutler described how IGS enables great science. It has been instrumental in the new age of gravity field determination, participating in the launch of the German small satellite (CHAMP) in 2000 and the Gravity Recovery and Climate Experiment (GRACE) in 2002, exploring the use of inter-satellite measurements to study the time variability of the gravity field. The Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) in 2007 will make use of the 3-D gradiometer to derive the “best possible” stationary gravity field.

Dr. Beutler described the International Association of Geodesy (IAG)/IGS expectations concerning GNSS. He stated that the scientific community will not switch from one GNSS to another, but will combine the measurements from all systems. The community also assumes that at least the same information available from GPS today will be openly available without fees for all emerging GNSS systems, and be made available for use by the same receivers. He explained that the GNSS constellations differ considerably and that different systems improve the geometry, helping to understand systematic errors. Dr. Schlesinger thanked Dr. Beutler for his presentation.

Mr. Arve Dimmen, Director, Maritime Safety Division, Norwegian Coastal Administration (Norway), briefed the Board on E-Navigation, Galileo, and the Arctic challenge. He defined E-navigation as “the harmonized collection, integration, exchange, presentation, and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment.” The key elements of E-navigation are situation awareness, instant data sharing, the ability to act upon someone else’s data, robust networking, and a system of systems. Mr. Dimmen described the latest time schedule for Galileo. The second prototype satellite, which is fully financed, is scheduled for launch in 2009. He explained how full financing beyond this is currently delayed and is likely to be resolved. Mr. Dimmen expressed his belief that progress in Galileo is now beyond the point of no return and that the full system will be completed.

Mr. Dimmen next discussed the Arctic challenge. He noted that the ice is disappearing and that the Northwest Passage was free of ice in August of this year. There are two main drivers that make the Arctic area important. First, 25 percent of undiscovered oil resources are there. Second, supertankers and large container ships can now use the passage. It shortens the time to sail between the west coast of North America and Europe, and the trip from the East Coast to Japan. The time can be shortened by as much as 30 percent. The GPS is not used north of the Arctic Circle due to coverage limitations. This can create a precision navigation problem. They are trying to expand the usefulness of the GPS signal. There is very sparse infrastructure in the area, both in the way of harbors and navigational aides. The challenge will be in the area of international cooperation – how we can combine ground-based and space-based services from all service providers. He expressed his belief that this will occur within the lifespan of GPS III. In response to a question from Dr. Schlesinger, Mr. Dimmen stated that the information regarding undiscovered oil came from the U.S. Geological Service. Dr. Schlesinger advised that those reports are biased in the optimistic direction. Ms. Nielan commented that the benefits from opening the Northwest Passage could give a positive spin to global warming. She explained that this is why the IGS is so interested in using GPS to accurately measure sea-level rise and the disappearance of glaciers. Dr. Schlesinger thanked Mr. Dimmen for his presentation.

Mr. Keith McPherson, Manager GNSS, Airservices Australia (Australia), reported to the Board on developments in Australia. The Ground Based Augmentation System (GBAS) program is up and running. A certification process is underway and certified production systems are expected in late 2008. Better antennas are expected. All six runways at Sydney’s airport have been programmed and are using the

GBAS Cat-1. He explained the reasons for wanting flexible approaches. Community noise is a major consideration. Displaced thresholds can increase throughput, and provide shorter taxi-times. Multiple glide-slopes would also become available to help overcome environmental noise issues. The Ground-based Regional Augmentation System (GRAS) will work the same way as WAAS. GRAS is needed for several reasons. The WAAS footprint over the Pacific was moved 35 degrees further east in July, 2007. There are no wide area augmentation systems in the southern hemisphere and GAGAN does not cover the Sydney-Melbourne area on the east coast. They expect a certified production system in 2009. In addition, there are sovereignty issues. They have come up with the GRAS system so that one box in an airplane's cockpit will suffice. Mr. McPherson also discussed the forecast for major GPS outages. He explained that one problem is piggy-backing GPS satellites. Thirty satellites with "piggy-backing" leaves only 24 satellites in positions that are actually useful. During some periods, only five satellites are visible. Dr. Schlesinger thanked Mr. McPherson for his presentation.

Mr. Hiroshi Nishiguchi, Secretary General, Japan GPS Council (Japan), was introduced. He described the history of the GPS and noted that in 1992, Dr. Scott Pace first mentioned that GPS would become like a clock or a timing tool that everyone would need to have in the future. Since then in Japan, people without GPS cannot lead their routine lives anymore. Given the high level penetration of GPS into everyone's lives and the demands with respect to the safety of life, the need for GNSS assurance and reliability is continually increasing. In that regard, the announcement that S/A will be turned off for GPS III has generated an enormously favorable impact. A GNSS implementation plan has been generated and will come out in November. They are trying to achieve cooperation between the Japanese industry and government. The GNSS industries have been talking with the government, with the result that a new commanding body will be instated in the Japanese Cabinet. Dr. Schlesinger thanked Mr. Nishiguchi for bringing these matters to the attention of the Board.

Capt. Richard Smith, President, International Association of Institutes of Navigation (United Kingdom), briefed the Board on the International Association of Institutes of Navigation. He stated that they have institutes all over the world. The largest is in China and the smallest is in North Korea. Their role is to promote disseminating information on navigational matters and to promote cooperation. He reported that all institute members have received the Minutes from the Board's last meeting. The feedback demonstrates that there is a clear understanding of the role of the Board and a great appreciation for access to the public record. The members are grateful for the opportunity to contribute and admire the quality of the briefings. Capt. Smith remarked that this is an example of the Board's leadership. He stated that there has been a warm welcome to no S/A on GPS III. The message, however, has yet to percolate down to the public and there remains a misperception over the continuation of S/A. There is total agreement on support for a 30+ satellite constellation. A GNSS back-up system is still desired and the word LORAN (Long Range Radio Aid to Navigation) keeps coming up. There is no desire for any financial charging mechanism, as has been proposed for the Galileo system. He noted that the failure of the private finance element has thrown the Galileo budget into disarray. He stated his belief that Germany, the largest nation in the EU, is bargaining for a larger use of the satellites. Capt. Smith concluded that the EU may not have reached the point of no return on the Galileo system. Dr. Schlesinger thanked Capt. Smith for his presentation. He observed that critics formerly operating under misperceptions about S/A now say that we have agreed to discontinue SA because we are trying to preserve our monopoly.

The Board adjourned for a break and reconvened.

Panel 1 – Leadership: Fact-Finding Report

Dr. Bradford Parkinson, Chair of *Panel 1 – Leadership*, briefed the Board on the Panel recommendations. He was pleased to report that their number one recommendation, the elimination of S/A, had recently been implemented. It was removed by Deputy Secretary of Defense England at the urging of Dr. Schlesinger; the removal was officially announced on September 18, 2007. The Panel now has four remaining recommendations, which Dr. Parkinson described. The first is to place GPS III quickly under contract with early delivery. He noted that GPS III provides significant improvements over GPS IIF and provides insurance against "brown-outs" that could impact 150 million users. He noted that it is imperative to avoid GPS brown-outs. The current GPS average on-orbit life is 8.9 years. The first GPS III will not be available

for launch until December 2013. The second recommendation is to formally commit the U.S. to the current level of service. This would enable civilian users to take advantage of GPS's proven capabilities. It calls for 30 + satellites to be geometrically optimized for users. Dr. Parkinson explained how the masking angle affects the ability to use GPS because many users cannot see down to the horizon. The 30 + satellite constellation would insure military availability in impaired regions. It would compare to the projected capabilities of China's COMPASS and the EU's Galileo systems. It would also support worldwide use to reduce aircraft congestion under a program known as "Relative Receiver Autonomous Integrity Monitoring" (RRAIM). This is a new development that provides the integrity to allow aircraft to land at regional airports in bad weather and to use lightly instrumented developing-nation landing fields with safety. The third recommendation is to ensure affordability to enable service without brown-outs. A sensible fast-track approach should be utilized. Dr. Parkinson noted that expensive, complex satellites could threaten schedule as well as the constellation size. Non-GPS requirements, such as Nuclear Detection Sensors (NDS) should be avoided, as these add weight to the satellite and may prevent achieving savings from inserting two GPS satellites into orbit with one launcher. A dual launch saves \$50M per satellite. The fourth recommendation is to place the GPS signal specifications under a true national organization such as the RTCA (formerly, Radio Technical Commission for Aeronautics) to ensure transparent, technical excellence for all users. This would assure that the signal is truly compatible and help maximize its usefulness. It would call for strong participation by users as well as government agencies.

Gen. Lord observed that many people on Capitol Hill think that the status quo is sufficient. Mr. McPherson stated that geometry is the key thing in the Southern Hemisphere, where geometrical dispersion is extremely important and piggy-backing is a problem. He asserted that the right orbits are needed. Dr. Pace requested additional information about dual launches. Dr. Parkinson responded that we should start those tests now because the savings are tremendous. Dr. Schlesinger observed that if there is no dual launch for GPS III, then there will not be dual launch for the next group of GPS satellites. Mr. Trimble agreed that more satellites are more important than adding unnecessary functions or complexity. Mr. James Miller asked how a national committee process would differ from today's EXCOM deliberations. Dr. Parkinson replied that currently there is no representation from civil and commercial users. He asserted that their participation would help eliminate major mistakes from being made as usual requirements would be considered from the beginning. He conceded that working the details is difficult and offered that control is not needed, just transparency. Mr. Hall made a point that one aspect of affordability is the assumptions and methodology used to estimate a satellite's lifespan. He noted that different assumptions allow calculations showing a longer life of satellites than the mean lifespan. Dr. Parkinson agreed, but remarked that some form of operational risk assessment is needed. He noted that a large number of satellites is down to no back-up; a single string. Mr. Shaw stated it was 50 percent, although sometimes the last one lasts a long time. Dr. Parkinson responded that hope is not a strategy.

Gen. Lord recommended coming out strong on the affordability issue. He also recommended launching new satellites as soon as possible after they are delivered. The satellites are no good "in a barn," he said; they need to be in orbit. Dr. Schlesinger concurred with Gen. Lord. Mr. Kirk Lewis stated that a full operational risk assessment is essential. The track record must be taken into account, he said, and there is a need for a gap analysis. He added that more good data is needed; otherwise we can only express what we'd like. Dr. Parkinson agreed. He cautioned, however, that a severe GPS brown-out would affect most weapons systems and most civilian users. Gen. Lord advised that Deputy Secretary England should be informed about this issue. Dr. Schlesinger agreed and indicated to Mr. Kirk Lewis, Institute of Defense Analysis (IDA), that a paper on this subject is needed. Dr. Schlesinger advised that everyone who depends on the GPS System should "please continue to sleep soundly." Dr. Parkinson added, "at least for the next year or two."

Panel 2 – Strategic Engagement & Communication: Fact-Finding Report

Ms. Ruth Neilan, Chair of *Panel 2 – Strategic Engagement & Communication*, introduced Mr. James A. Slater, who is with the Basic and Applied Research Office, National Geospatial-Intelligence Agency (NGA). Mr. Slater briefed the Board about the benefits of having standardized reference systems. He first reviewed the objectives of a reference system. It answers the questions: Where am I? What is the location

of some object or someone else? For the military, it is used for missile launch sites, precision weapons, and land mines. For the general civilian, it is used for borders, car, ship, or plane navigation, and for mineral resources. For the scientific community, it is used to determine crustal motion and sea-level change. To do this, there is a need for a terrestrial reference system. To create a foundation and structure, we define a set of conventions, constants, models, and parameters, which form the mathematical basis for representing locations on, above, or below the Earth. Mr. Slater described what would happen if every country implemented a different version of a geodetic reference system and explained that much accuracy is lost in translating one system to another. Mr. Slater described the International Earth Rotation and Reference Systems Service (IERS), which maintains the standard and is located in France. The International Terrestrial Reference Frame (ITRF) is defined or rationalized to be a geocentric coordinate system. It is aligned to the mean equator of 1900 and Greenwich meridian.

Mr. Slater described the U.S. DoD World Geodetic System (WGS). This has been a global geocentric terrestrial reference system since the 1950s. It was needed because satellite tracking and inter-continental ballistic missiles (ICBMs) required global coordinate systems. Mr. Slater explained that there was a WGS 1960, 1966, 1972 and 1984. DoD world geodetic systems have always conformed to and adopted international standards. They are applied to all DoD products and services: maps, charts, airfields, features data, topography, satellite orbits, real-time positioning, etc. For DoD, this has to be applied across the board. Mr. Slater described the DoD WGS. He explained that the WGS 84 reference frame is defined or realized by the coordinates of a globally distributed set of reference points on the topographic surface of the Earth, constituted solely by a network of permanent GPS stations. The WGS 84 reference frame is periodically adjusted to maintain close alignment with the ITRF. The positions of the reference points (DoD monitor stations) are estimated using GPS observations. The result is DoD station coordinates and by definition WGS 84 reference frame is coincident with the ITRF within some level of uncertainty. He noted that the process accounts for plate tectonic motion. A slide was presented, showing the locations around the world of the DoD WGS 84 reference stations.

Mr. Slater discussed the exploitation of GNSS in the future and the need for standardizing multiple satellite constellations. He noted that we will have GPS III, GLONASS, Galileo, COMPASS, and space-based augmentation from India, Japan and the U.S. WAAS. He observed that users and manufacturers want interoperability, compatibility, and standardization. This leads to improved signal availability, improved integrity, and higher accuracy, which leads to real-time, seamless operations. In response to a question from Dr. Hermann, Mr. Stark stated the improvements are derived because each system uses different positions for its satellites. Dr. Hermann observed that the others might use satellites that simply trail our satellites and that would not help much. Dr. Parkinson stated that each system uses different phases. Mr. Slater stated that the user community wants to be able to tap into all of these systems. He noted that the Russians have had GLONASS up for a while and that their stations have been offset from the ITRF and WGS 84. Also, they only have tracking stations on Russian soil. The last few years, they have been trying to improve their orbit positioning and are trying to align with WGS 84.

Mr. Slater discussed the concerns in exploiting GNSS performance. These are quality assurance and enhanced performance for GPS III. He explained that there are four long-term geodetic objectives: achieve a stable geodetic reference frame; maintain a close alignment of the WGS 84 with the ITRF; provide an independent quality assessment capability independent of current radiometric measurements used to determine GPS orbit and clock performance; and ensure the interoperability of GPS with other GNSS systems. He stated that these objectives make the case for putting laser retro-reflectors on GPS III. He noted that they will be on GLONASS and Galileo. Mr. Slater concluded by stating that a Global Standard Terrestrial Reference System is critical to future positioning and navigation with Global Navigation Satellites. Multiple systems will need to be exploited to support the increased demands of a wide range of users. The WGS 84 reference frame has been and will continue to be periodically realigned to the ITRF.

Capt. Burns asked whether WGS 84 would be around for a while. Mr. Slater responded in the affirmative. In response to a question from Mr. Hall, Mr. Slater stated that he did not know whether COMPASS was moving to ITRF standard. Ms. Nielsen noted that Chinese are aware of the need for standardization and are pushing towards that objective. Mr. Miller asked whether Galileo would provide better performance if it

had retro-reflectors and GPS did not. Ms. Slater replied that DoD would not care, but it would have advantages from the scientific community's perspective. He explained that it deals with very small differences and high precision applications. Dr. Hermann asked what the burden would be to put on laser reflectors. Dr. Parkinson said it would be 10 to 20 pounds and require no wattage. A member in the audience advised that it would be less than 10 pounds. Mr. Slater explained that DoD is concerned because there is a payload that rides on the satellite and could conflict with the laser reflectors. Dr. Beutler offered that there is a need to have the reflectors. He explained that there are variations of one to two centimeters showing up that are very important to the scientific community, which is looking for the highest possible accuracy. It would be a big mistake, he opined, not to go for the highest accuracy possible.

Mr. Slater reviewed the biggest impediments to achieving conformity. He explained that China is an unknown and that India and Japan are also uncertain. He asserted that it would be useful if the international community could influence them to conform. The impediment on the laser reflectors is a U.S. agency decision to determine if there is a conflict with NDS. Mr. Trimble asked if it is a ground-based software issue and Mr. Slater responded affirmatively. Mr. Miller discussed concerns over putting lasers on the satellites. He asserted that situational awareness would be improved. He noted that there is an Interagency Forum on Operational Requirements (IFOR) managed by Space Command that has recommended that satellite reflectors be incorporated into the GPS CDD for the GPS IIIB block. Mr. Slater explained that his was a geodetic point of view. He added that we are now in the millimeter range. He recommended that we build-in the capacity that we can imagine now. Ms. Neilan thanked Mr. Slater for his presentation.

Ms. Neilan introduced Mr. Ron Beard, Chairman, International Telecommunications Union – Radiocommunications (ITU-R) Working Party 7A, U.S. Naval Research Laboratory. Mr. Beard briefed the Board on the topic: ITU-R's Role in Standard Time and Frequency Signal Services. The ITU is the leading United Nations agency for information and communication technologies. ITU-R is the radiocommunication core sector. Mr. Beard explained that the ITU-R is responsible for Standard Frequency and Time Signal (SFTS) services, both terrestrial and satellite. The goals of Working Party 7A are to develop and maintain ITU-R recommendations in the TF series and Handbooks relevant to SFTS activities, covering the fundamentals of the SFTS generation, measurements, and data processing. The ITU-R recommendations are of paramount importance to telecommunication administrations and industry, to which they are first directed. They also have important consequences for other fields, such as radio navigation, electric power generation, space technology, and scientific and metrological activities.

Mr. Beard described how Coordinated Universal Time (UTC) is developed. It originated as a common reference for coordinating time signals as a compromise between continuous atomic time and solar mean time (Universal Time). He discussed the future of the UTC timescale and proposals to modify the UTC definition. One modification would be to eliminate the leap second. He reviewed a chart showing international time links. He explained that more and more systems are adopting their own system time. This gives rise to concern that the increasing number of systems could potentially result in a multiplicity of system time scales. He believes that UTC should be the single common reference time. He noted that many GPS users assume that UTC is the global reference, but many use GPS time directly. GPS Time (GPST) is the system internal continuous timescale. It is primarily used for positioning and navigation. It is secondarily used for disseminating time. Mr. Beard noted that GPS has become the primary method of providing and coordinating time and frequency services worldwide. Its use in telecommunications is extensive, both civilian and military. These uses include public switched telephone networks, wireless mobile, paging services, the internet, NTP time servers, banking, financial transfers, sensor networks (geophysical and remote sensing), power generation, and power distribution. The full extent of utilization is difficult to determine due to the ready availability of off-the-shelf equipment. Mr. Beard concluded by noting that GPS availability and capability has greatly impacted the time and frequency industrial base and that the time and frequency users are the majority of the users of GPS.

Mr. Miller stated that he never used to think about "leap seconds" before coming to NASA. Now he does because the Earth's rotation varies and additional leap seconds will need to be inserted in coming years as NASA's space architecture is built and operated. In essence, preparing for leap seconds is like preparing for a mini-Y2K rollover event several times. He noted that a majority in NASA and DoD would like to see

the leap second eliminated, however there is not unanimous consent with the astronomy community. He described how Japan is developing “trusted time,” in which they just turn the system off for a second. Dr. Beutler asserted that astronomers cannot accept leap seconds, although it is debatable whether leap seconds are needed for the atomic time scale and the Earth’s rotation. Dr. Parkinson suggested that it might be more an emotional argument because one hour difference could take a thousand years to accumulate. Mr. McPherson asked about using optical clocks. Mr. Beard responded that it is coming and will be more accurate than atomic clocks. Ms. Neilan expressed the Board’s appreciation to Mr. Beard for his presentation.

Ms. Neilan presented to the Board the results of the deliberations by Panel 2 – Strategic Engagement and Communication. The Panel felt that there was a need to bring to the Board the results of fact-finding on three topics: the reference frame, timing, and promotion options. The Panel felt it would be important to consider system performance, a commitment to 30+ satellites, adding laser reflectors to GPS satellites, avoiding user fees, avoiding a mandate to use a specific GNSS, spectrum protection, and interference detection. They also will review the San Diego RFI event. In addition, the International Traffic in Arms Regulations (ITAR) must be dealt with. Those regulations are burdensome and stifle innovation. Ms. Neilan added that there is the need for a broader engagement with international organizations and standards bodies, and that interchangeability is a key factor to consider.

Mr. Miller asked if there is a need to transition from a six-plane to a three-plane constellation. Dr. Parkinson said it will not be necessary and that it is no longer a technical issue. Mr. McPherson added that there are other ways to accomplish accuracy and that Australia has no intention to rely on WAAS equipment. Dr. Schlesinger asked whether the issue on user fees will be addressed. Ms. Neilan responded that the compelling argument is that administering fees would be so complex it would drive people away from using the system. Dr. Enge asserted that the absence of user fees is helping to develop Galileo and that it is considered to be part of a global infrastructure. He opined that the private sector really cannot cover the cost and that it should be assigned to the public sector. Dr. Parkinson observed that the difficulty would be how to impose fees. If they were imposed at the point of manufacture, it would only affect the U.S. If they were applied to China or other emerging markets, there would be much resistance. Mr. Trimble noted that the user fee issue has been studied under different administrations and each time it was concluded that we would be better off paying for the service through taxes. Dr. Schlesinger advised that we should look at GPS benefits as “manna from heaven.” Dr. Hermann inquired as to how one would draw the line between users and non-users; in fact, he asked rhetorically: could you even find someone who is not a beneficiary of the GPS and timing functions? It would be difficult to calculate who the beneficiaries are and how to extract a toll for benefits. This, he concluded, makes the case for funding GPS like part of the infrastructure. Dr. Schlesinger drew an analogy to taxes paid on gasoline that go into the Highway Trust Fund. With respect to GPS, he noted, the U.S. taxpayer is paying for a service that is being used around the world. Dr. Hermann asked what percentage of highway expenses are paid by the Highway Trust Fund. Dr. Schlesinger explained that a substantial percentage ends up, in effect, going into the General Fund of the U.S. Treasury. Dr. Pace explained that GPS has an infinite number of users, so a marginal user does not affect cost. The military requirement leads to a global optimum so that the price for adding additional users equals zero. The Board adjourned for lunch and reconvened.

Options for Promoting GPS to Vendor, New User & Global Communities

Mr. Chet Huber, Member of *Panel 2 – Strategic Engagement & Communications*, briefed the Board on recommendations developed by the Panel for promoting GPS. To market GPS to the global GPS vendor community, there are four recommendations. First, reinforce commitment to preservation of the current civilian signal through performance, availability, reliability, usability, backwards compatibility, and cost, i.e., no user charges. Second, issue press and media releases to alleviate foreign doubts about the U.S. commitment to GPS as a global utility for the indefinite future. Board members could host interactive sessions at key GNSS forums. Third, increase the U.S. presence at foreign GNSS sessions and actively explore opportunities to augment and enhance GPS performance with other GNSS. Fourth, solicit feedback from the Board members prior to initiating any GPS signal changes or upgrades.

The Panel had four recommendations for marketing GPS to potential new users. First, promote the capabilities of GPS in leading U.S. and international magazines and journals as an excellent tool for real-time computation of location, speed and altitude; for accurate and precise source for timing; and as a free ubiquitous global utility. Second, identify niche areas to target for possible applications using GPS. These could include communication, transportation, construction, emergency services, agriculture, banking, and commerce. Third, encourage experts in the field to write technical articles about potential applications using GPS. Fourth, have Board members host town-hall style meetings on the web. Futuristic internet-based tools, such as You-Tube and Second Life, could also be utilized.

Mr. Huber noted that the elimination of S/A was a positive step towards expressing the U.S. commitment to GPS. He stated that GPS is a true public utility that the average American citizen ends up using many times a day for wireless cell phone networks, electrical power distribution, and for public safety and emergency services. Mr. Huber described GPS as a key enabler for many other services that make key contributions to the U.S. economy in aviation, transportation, civil engineering, navigation, trip guidance, and farming. Mr. Huber presented a case study focusing on the General Motors' OnStar program. He explained that GPS location and clock time are critical enablers for all OnStar services. He described how OnStar uses GPS to be an effective advocate against crime. It is used for targeted amber alerts with the National Center for Missing Children, for stolen vehicle locations, and to provide information to assist persons in crisis. He noted that OnStar will be standard in all General Motors retail vehicles in the U.S. and Canada. Mr. Huber concluded his presentation with a film showing how current research by General Motors is using GPS to prevent automobile accidents.

Dr. Schlesinger remarked that he has heard commercials about babies being rescued and returned to their mothers thanks to OnStar, but there is no reference to the GPS signal. Those advertisements could reference the GPS signal. Dr. Parkinson asserted that Congress has to get the perception that this is bigger than realized. In response to a question from Dr. Parkinson, Mr. Huber answered that General Motors is working on a fully self-guided system. Dr. Schlesinger observed that we have had two major technological revolutions: one is the internet and the other is GPS. The public fully understands the internet, but not GPS. He advised that this needs to be corrected. Ms. Neilan stated that her Panel still needs to work on crafting its recommendations. She liked Mr. Logsdon's suggestion for a GPS Capitol Hill Day. Ms. Ciganer suggested working with the American Electronics Association. Dr. Schlesinger counseled that the GPS Capitol Hill Day should involve the Congressional leadership. Capt. Burns stated that the Air Transportation Association would participate. Dr. Schlesinger thanked Mr. Huber for his presentation.

Panel 3 – Future Challenges: Fact-Finding Report

Mr. Charles R. Trimble, Chair of *Panel 3 – Future Challenges*, presented a fact-finding report on behalf of the Panel. He stated that GPS is the GNSS world standard and that it would be advantageous to the U.S. to maintain that position. The key is leadership and the Panel has four recommendations in that area. One, there should be a transparent evolution of GPS. This calls for policy stability and predictable change. For civil integrity, the transition from one set of capabilities to another has to be seamless. Two, there should be a commitment to the 30+ satellite constellation. This is valuable for the U.S. military; it is needed for the national air space; and it is important for the international community. Three, use of the EXCOM should be maximized. Its existing structure is adequate; it should provide for a national plan; and it should oversee the evolution of GPS. Mr. Trimble stated that the EXCOM should be urged to step up to a higher level, rather than simply providing supervision. Four, there should be international collaboration. As we transition, we should involve our international partners in testing the changes; involving partners would ease in solving problems.

Dr. Schlesinger observed that the organizations in the Executive branch are difficult to manipulate. He advised that we should talk about tasks the EXCOM may be willing to take on. He noted that the House of Representatives has cut \$150 million from the GPS budget. That, he asserted, is not conducive to policy stability or to the earliest possible deployment of GPS IIIA. Dr. Schlesinger concluded that the Congressional appropriation committees are going to have to go to conference and the damage may have to be mitigated. Mr. Trimble emphasized the importance of avoiding surprise. He suggested that reinstating the transparent Interface Control Document (ICD) deliberative process would be helpful for all parties. Dr.

Schlesinger asked, rhetorically, which would the Air Force object to most strongly to, a cut in the F-22 budget line or in the GPS budget line? Dr. Hermann opined that there is a need to describe to Congress what we are trying to do, and a need to apply discipline to make it a national effort. He questioned whether the Federal Government was up to the task. Ms. Neilan asked about the effectiveness of the EXCOM and how it was working. Mr. Shaw stated that Dr. Hermann was right about a five-year plan and agreed that there is a lot to be done. He explained that when plans are released, the EXCOM reviews them. There has been an exchange between the officials. The EXCOM members push things through. It is not a body that is directed towards any one department. Dr. Hermann stated that as an institution, the EXCOM is not directive. It will happen if they have a will, he asserted. If something does not get done, it is not for lack of authority. Mr. Shaw agreed with Dr. Hermann and explained that is why the EXCOM membership has been elevated to the Deputy Secretary level. At that level, he explained, they are more liable to understand the position of each department and they have a better national and global view.

Mr. Logsdon suggested that after both political party conventions are finished, the Board should put together an industry team that briefs the candidates on the importance of GPS and how it has enhanced the American bottom line. Mr. Shaw stated that there will be a briefing for the next Administration and added that Mr. Logsdon's suggestion could be made part of that effort. Mr. Trimble asserted that the EXCOM is too engaged in coordination and is not providing enough adult supervision. Dr. Schlesinger stated that he has been impressed with level of discussion and briefings at the EXCOM. He noted that Deputy Secretary of Defense England has been instrumental in increasing the level of discussion, particularly in regard to GPS III and in understanding the breadth of coordination that is required. Dr. Hermann asserted that the EXCOM needs to become a management tool, although performance will matter in due course. Mr. Trimble stated that Panel is encouraging Dr. Schlesinger to help the EXCOM go to the next level. Mr. Shaw noted that the EXCOM is not shy about receiving criticism; that is how it gets better. Dr. Enge cautioned that the GPS system is interconnected and that small changes may have unintended consequences. Ms. Neilan asked Dr. Parkinson to clarify his vision for a national committee. He responded that there needs to be an in-depth technical exchange that will generate a feeling of stability by giving the civil side an opportunity to provide input. That process would empower the committee by assisting it to understand what is needed. Mr. Trimble agreed. Mr. McPherson asserted that there is a need for guidance and leadership in going forward, and he recommended having an overarching group to look at the civil and military sides. He would like to see sustainability, and he encouraged efforts to stabilize the technical side. The Board adjourned for a break and reconvened.

Update on GPS Performance Standards: DoD Perspective

Dr. Schlesinger introduced Brigadier General Donald Alston, Director of Space and Nuclear Operations, USAF HQ. Gen. Alston briefed the Board on the GPS Performance Standards (PS) from the DoD perspective. Gen. Alston described the Precise Positioning Service (PPS) PS. It was published in February 2007, and defines the current service provided to military and authorized PPS users. It states the DoD commitments, i.e., what PPS users can count on, and it is the basis for military GPS safety certifications. Gen. Alston described the SPS PS, which was published in October of 2001. That document defines the standard service provided to non-military GPS users, and it states the current DoD commitments for the SPS users. The SPS PS is the basis for all civil GPS safety certifications. Gen. Alston explained the SPS PS upgrade process. He stated that a revised final document is expected in May 2008. He affirmed his belief that the updated SPS PS will be a significant step forward in the evolution of GPS performance.

Gen. Alston acknowledged the Board's interest in a 30+ satellite constellation and request for a commitment to current performance. While he supports the government's position on the budget, he also understands the context in which the Board views the requirements for GPS. He understands that if we fail to impress the international community, America and its allies would be at a substantial disadvantage. Gen. Alston stated that he is busy thinking about how to protect the GPS assets from hostile interventions, in addition to concerns over radiation and vibration. He is mostly concerned about the signal in space. Dr. Parkinson stated that the 30+ satellite parameter is also important to the Federal Aviation Administration (FAA). Gen. Alston stated that the 2001 PS calls for 31 meter accuracy, and currently they are looking at 10 meters. Dr. Parkinson stated that committing to the size of the constellation makes all the difference. He asserted that the difference is geometric, not linear, and that the extra satellites are necessary to support

integrity. Dr. Schlesinger observed that the Air Force is unduly modest. He counseled that it be less modest and more accurate. Mr. Lewis questioned the vision for the next document, noting that there will be three frequencies. Gen Alston stated that they have to preserve the backward compatibility. Mr. Trimble suggested that it would be easier to think about a pseudo range error. Gen. Alston remarked that it has been helpful to learn about the Board's concerns. Mr. Murphy noted that the process does not include consultations with the end users and asked whether there would be an opportunity for comments from people outside the government. Gen. Alston acknowledged Mr. Murphy's concerns. Mr. McPherson stated that not consulting with civilian end user puts them "behind the eight-ball". He asserted that it would save money to have the perspective of the maritime unions, the airlines, and other non-government users. Gen. Alston stated he would welcome recommendations on how to make sure that the appropriate input is obtained. Dr. Parkinson stated that it would be important to let users know what the standard will be. He added that the information currently being provided is not much use. He endorsed the recommendation to give non-governmental users the opportunity to help the Air Force shape the document.

Gen. Alston discussed the January 11, 2007, China anti-satellite event. He acknowledged that the Chinese have successfully proved their capability and stated that their achievement was not a surprise. He stated that as we work through and posture ourselves for what will follow in the coming years, it will be useful to understand how the combatant commanders will handle space combat. We have to go forward and demystify how they are depending on space. Broadly, folks have a great appreciation for how space helps, but they do not understand how it is done. A resulting protection and augmentation strategy would be brought forward. Understanding those dependencies is important. The combatant commanders have different priorities. He indicated that he feels good that the government is moving in a deliberative way; however, the targeting problem has to be made more challenging. Ways to mitigate risk are needed from platforms down to ground stations. Gen. Lord, who was formerly Gen. Alston's superior, suggested that Dr. Schlesinger bring to the next EXCOM meeting the two points made by Gen. Alston, observing that it gets it into an effects-based approach. Dr. Schlesinger stated that the Air Force has done a remarkable job, but more is wanted. The DoD has set up the Northern Command to deal with the protection of the country, among other things. The overall responsibility is to protect the U.S. and its allies. Dr. Schlesinger criticized the DHS for poorly articulating the importance of GPS. He expressed his belief that GPS is critical to the DHS mission and crucial to national security. Dr. Schlesinger reiterated that more is wanted.

Gen. Alston, in response to a question from Ms. Neilan, explained that "AOR" means "area of responsibility" and that the President tasks the four-star generals who are the combatant commanders. He described the newly established U.S. Africa Command (AFRICOM), a new military command of the Department of Defense excised from the U.S. European Command (EUCOM). Mr. Lewis cautioned Gen. Alston that wherever the military fights, it will have to depend on resources made available by civilian agencies, and that the GPS SPS should take that into consideration. Dr. Schlesinger suggested that the U.S. Air Force emulate the U.S. Marine Corps and stop being so modest. He thanked Gen. Alston for his presentation.

Update on GPS Performance Standards: Civil Perspective

Dr. Schlesinger introduced Mr. Hank Skalski, DOT's Liaison to Air Force Space Command. Mr. Skalski briefed the Board on the process for updating the GPS Standard Positioning Service (SPS) Performance Standard (PS). He referred to a tasking memo from Maj. Gen. Burg, which stated that the process was to "... include appropriate involvement from the GPS Wing and civil community." In May 2007, Air Force Space Command formed the GPS SPS PS Update Coordination Team to craft and informally draft an update of the 2001 SPS PS. Mr. Skalski noted that the basic ground rules call for informal coordination only, with formal coordination occurring after the update is sent to Air Force Headquarters. The update is to document the status and services to be delivered by the current GPS constellation; in other words, a snapshot in time. Unresolved issues are to be appropriately noted, documented, and sent forward for discussion and resolution during the formal review. Only U.S. Government civil agencies participated in the crafting and review of the draft SPS PS update. Those agencies included, among others, the Federal Aviation Administration (FAA), Department of Homeland Security (DHS), the U.S. Coast Guard, Commerce, State, the U.S. Geological Service, the Federal Highway Administration (FHWA), the National Oceanic and Atmospheric Administration (NOAA), and NASA. In addition, civilian comments were

solicited and 261 were received. Those comments were either accepted or adjudicated. Mr. Skalski reported that the informal review process was completed in late July 2007, and that, overall, the civil team was satisfied with the draft GPS SPS PS update. They are now waiting for DoD to establish the process and schedule for the formal government review.

Dr. Parkinson observed that the Board has not seen the document and expressed concern that it does not reflect the constellation that is currently flying if it reflects 21+3 satellites. Dr. Hermann declared that the decision-making process is unsatisfactory. Mr. Skalski responded that the document has to be a snapshot as of today. In response to a further comment from Dr. Hermann, Mr. Skalski stated that the document for the F-22 fighter plane was a different type of document. Dr. Herman rejoined that it is also an expression of what the institution wants to do and he asserted that the decision process is the reason there is a problem. Mr. Skalski suggested that there may be a need to reconsider what we want this document do. Mr. Trimble contended that what exists today is what we have in space; it is the performance today, and he asked whether that is what is in the document. Mr. Shaw answered that the performance standard is the committed level of performance that the U.S. Government will guarantee to provide. The actual level is much better. What will happen in the future also gets back to the piggy-back issue – when there is a satellite at risk, a satellite is put next to it. Right now, the performance standard can only reflect what the Federal Government is committed to provide. Mr. Trimble asked what purpose would be gained from using that as the performance standard. Mr. Shaw responded that it is not ignored and that actual performance is much better. Dr. Hermann opined that the process is an arcane process dealing with only what the DoD is interested in. In response to a question from Mr. Trimble on how to get to 30 certified satellites, Dr. Schlesinger counseled: with persuasion.

In response to a question from Ms. Neilan, Mr. Shaw stated that the operators were willing to sign up to better standards than in the document. Dr. Parkinson stated that the issue is where the commitment is and he asked: where is the lever? He stated that there is concern over what the budget cutters will decide and the fear that we will end up at 21+3 satellites in the constellation. He asserted that we are not well with respect to the commitment, and again asked how a lever could be found to make it a real commitment. Mr. Skalski responded that we need to start with the Capabilities Development Document (CDD), not this document. Dr. Parkinson stated that range error is not as important as having 30+ satellites. He asked where the steering is that will get somebody's attention. Mr. Shaw suggested that 30 satellites would have to be put in different terms. Dr. Parkinson stated that was unacceptable. He added that the payoffs have been shown and are not a single data point. Mr. Shaw replied that it must go through the process. Mr. Trimble asked whether anyone could move it through the process in a matter of months and Mr. Shaw responded that no one could do that. Mr. McPherson concluded that it was a useless document. Mr. Skalski observed that they were asked to describe what level of performance GPS is giving today. Dr. Pace contended that the SPS is intended to communicate a message to the global community and he asked if this is what the U.S. wishes to communicate, or if it is just helping an internal process.

Ms. Neilan asked Mr. Skalski to describe the CDD. Mr. Skalski stated that it starts with the Joint Requirements Oversight Council (JROC). The JROC polls the users, civilian and military, on their needs. Then there is an analysis, and they develop the CDD. That goes to the Joint Chiefs of Staff (JCS). Then it goes to the acquisition community. Mr. Trimble asserted that nothing new is required other than an acceptance that 30 satellites is what is needed. Mr. Skalski remarked that no one has provided Air Force Space Command with the proof that 30 is the number that is needed. Dr. Parkinson responded by stating that the highest advisory board is the Defense Science Board, and they brought it forward. Dr. Hermann declared that the authorities that need to speak up are, "the rest of the nation."

Mr. Hall observed that when setting in motion an acquisition program, the "elephant in the room" is the budget. He stated that the problem is that the Air Force has delivered more than was specified and the users got used to it. He predicted that a lot more than 30 satellites on orbit would be the result if the specification was 98% availability for 30 satellites on orbit. This would be especially true, he noted, if new satellites were launched on availability, regardless of the health of the constellation. Capt. Burns noted that there are two modes to the requirements process: the basic needs, and the bells and whistles. He observed that we are in a retreating mode when we look to not what we are to achieve, but what we have to retreat to. Dr. Schlesinger cautioned that some people pay less attention to this document than what it is worth; yet it

is America's commitment to the rest of the world. Mr. Trimble declared that it is not worth the time for private industry to participate in putting out a document that does not describe what exists. Dr. Parkinson analyzed that if you are talking about an extra 6 satellites, it is one half satellite a year if they last 12 years. In the greater scheme of things, this isn't a "break the bank" deal. What is on the table is the budget and the priorities. We don't understand how to influence the process. The people we need to influence are the representatives to the EXCOM. Mr. Shaw stated that we will struggle with a 30 satellite constellation. At the end of the day, it is a budget issue; 33 satellites will be needed for a 30 satellite constellation. Mr. Trimble recalled that it has been recommended to make the satellites simpler and send up two per launch; this will save enough to pay for the additional satellites. Mr. Shaw stated that this will be considered by the EXCOM.

Ms. Ciganer observed that we have an opportunity to affect the receivers, which come out faster than the satellite processes. Ms. Neilan opined that the requirements process is convoluted and flawed. Mr. Skalski replied that the basic premise is to identify the requirement and bring it forward; nobody has done that. Mr. Lewis noted that backward compatibility is an issue; sometime we have to say it can't be forever. Backward compatibility will create problems in the military, and it has an impact on the rate at which we can bring out the technology. Dr. Schlesinger observed that satisfaction can be at two levels: one is with a document that is meaningless; there is also what the civilian agencies want to achieve from the GPS system. That, he noted, is not being articulated. It goes to the JROC, and nobody at the JROC understands the problem. The civilian agencies should say that the process is flawed. Mr. Shaw agreed that it is becoming an irrelevant document. He asserted that our goal should be to make it a relevant document to indicate what we can depend on the U.S. Government to provide. He added that some buffer is needed and that, clearly, where it is now it is not relevant. Mr. Skalski advised that one needs to identify what is meant by "tomorrow." Ms. Ciganer stated that it is important to know that there is some degree of stability in the SPS document. Mr. Lewis observed that people are making economic decisions and are counting on what they will get tomorrow. Mr. Skalski noted that there are a lot of misunderstandings out there, and people will be pleasantly surprised by what the document will do.

Afternoon "Wrap-Up" & Announcements

Dr. Schlesinger offered end-of-the-day remarks. He reflected on the successful elimination of SA and thought it appropriate to craft a press release to remind the world of the excellent stewardship that the U.S. has demonstrated for some 25 years in providing a free Positioning, Navigation and Timing service to users around the world. Dr. Schlesinger noted that the U.S. recognized the need to include international input when it made provisions to include international members on the PNT Advisory Board. Their input on the concerns about the potential lingering effects of continuing to include S/A capability in the GPS design was key to the Board's recommending that any future GPS system no longer include that capability. For global users, this should be viewed to mean that the U.S. can be relied upon to continue to provide improved capability with continuous and reliable service for all. Dr. Schlesinger stated that it would be useful to have this press release out within the next week and to include comments from the international members. The Board adjourned until 8:30 am on October 5, 2007.

October 5, 2007

The Board meeting was reconvened by Ms. Rausch at 8:30 am.

Chair Feedback - "What We Want to Accomplish"

Dr. Schlesinger welcomed the members back for day two. He reminisced that on this day in 1942, President Harry Truman called for a system of rationing to help the War effort. Dr. Schlesinger noted that the Board, happily, was not similarly constrained by rationing in making comments during yesterday's meeting. He complimented the presentations that had been given at the meeting, noting that they had been excellent. He reiterated that his goal was to come away with two or three recommendations to take to the EXCOM meeting in November. He reminded the Board that anything conveyed to the EXCOM must have

a strong intellectual basis. He stated that the final segment of today's meeting would have two parts: first to develop the recommendations; second to give the Panels their assignments for the next Board meeting.

Future of E-LORAN: GPS Alternatives & Back-Ups – Timing

Dr. Schlesinger introduced Capt. Curtis Dubay, Chief, Systems & Architecture, U.S. Coast Guard (USCG), Department of Homeland Security (DHS). Capt. Dubay briefed the Board on the Enhanced Loran (eLoran) situation today. Congress first directed the program in 1999. Funds for improvements have been approved in the amount of \$160M to modernize and enhance the system. The Department of Transportation (DOT) and DHS have been tasked with the responsibility to make a decision on whether to continue to maintain it. Several steps have been taken. Last August, DOT and DHS commissioned an Independent Assessment Team (IAT) to assess the national need for continuing Loran. Dr. Schlesinger asked if it was organized by DHS. Capt. Dubay answered that it was initiated by DOT, and that DHS was brought in subsequently. Capt. Dubay stated that the Assessment Team received nearly 1000 comments; 92% favored retaining or expanding eLoran, and 80% thought it was needed as a backup to GPS. A decision was made to use existing PNT structures for the decision-making process. Capt. Dubay explained that both DOT and DHS have PNT Executive Committees, similar to the EXCOM on the national level.

Capt. Dubay described the eLoran system. It is based on Loran-C, which has existed for the past 50 years. It provides a back-up for frequency and timing and can be used as a backup or complement to GPS. It is terrestrially based, with high power and low frequency, the inverse of GPS, making it inherently less susceptible to deliberate interference. It is GPS-like, requiring digital user equipment. It presents position data in Latitude/Longitude coordinates. It provides maritime harbor entrance and approach accuracies from 10-20 meters. It meets aviation required navigation performance requirements of 0.3 nautical miles for non-precision approach and integrity. It provides coverage in many obstructed areas not served by GPS. The system is in a transitory state. New timing equipment has been installed but not yet turned on. There are 24 U.S. Loran-C stations; 19 have been updated and modernized to transmit the extra data services. The monitoring network has not yet been installed. Three new stations must be installed to expand coverage. Capt. Dubay reviewed a slide showing the locations around the world where Loran is available under the legacy Loran-C and where eLoran would be provided. He noted that five additional stations remain to be built, all in Alaska. In response to a question from Dr. Schlesinger, Capt. Dubay indicated that Sen. Stevens is interested in having this work completed.

Capt. Dubay stated that no funds were appropriated for 2007 and currently no funds for 2008. There is a need to make a decision on whether to continue to invest in the system. To get to a full eLoran system would cost up to \$400M. Dr. Schlesinger observed that the Executive Branch either does not want the system or knows that Congress wants it. Capt. Dubay stated that \$15-\$25M a year would be needed for system modernization or enhancement. The intent is to convert the sites to unmanned bases. De-staffing will lead to lower operational costs and those savings can be diverted to modernization and enhancement. The Loran data channel is the mechanism that enables the stations to transmit the enhanced signal. Only 5 stations are currently transmitting the Loran data channel and another is being tested in Boston.

Mr. Hall asked for the position of the Executive Branch on whether the expansion is needed. Capt. Dubay replied that Deputy Secretary Barrett has stated that the Administration is reviewing the recommendation to improve the system. DOT and DHS are reviewing the recommendations, and a joint announcement is expected by the end of the year. Mr. Trimble asked whether the Federal Aviation Administration (FAA) was willing to use eLoran receivers as a replacement for gyros. Capt. Dubay responded that he could not answer for the FAA. Mr. Trimble asserted that the cost of user equipment would be very high. Dr. Parkinson stated that cost had been looked at by the Assessment Team in their report and that it was their conclusion that the incremental cost could be affordable. He added that Mr. Jim Darvey, a real hero, had helped arrive at the conclusion that eLoran was a prudent, affordable back-up to GPS, and a real deterrent to terrorist actions. He noted that the report was unanimous.

Capt. Burns asked if any eLoran manufacturers were currently building the receivers. Capt. Dubay said that there were 12 companies that had developed prototypes for integrated GPS/eLoran receivers or eLoran/timing device receivers. He observed that it is a “nascent” industry. Mr. Trimble concluded that the FAA is a market that will provide a price umbrella for the receiver. Dr. Parkinson added that the cost is very small. Mr. Trimble stated that he was uncertain whether there is a commercial market. Dr. Parkinson stated that the interface for the user would cost very little more and that it was not a hard decision to make. He noted that it would be difficult to recover from discontinuing the service. Prof. Enge stated that the back-up role is important. He explained that it produces a megawatt signal; to defeat it you would need a 40 foot antenna and 40 watts. He added that the signal penetrates buildings.

Ms. Neilan requested a copy of the Assessment Team’s report and Capt. Dubay assured her that DOT would provide it. He added that the Assessment Team would provide a briefing, if requested. A DOT representative in the audience stated that other nations are looking for the U.S. to assume a leadership role for this technology. Dr. Schlesinger asked whether other countries are willing to extend their systems. Capt. Dubay explained that the eLoran system needs to be codified into a formal standards document and that other countries are looking for this. Dr. Hermann asked which countries are supporting this and whether there is a champion for making this occur. Dr. Parkinson responded affirmatively. Capt. Dubay stated that he expected that the DOT and DHS EXCOM members have clear direction to pursue eLoran and make it happen, and to prepare it for a formal Secretarial decision by the end of the year.

Gen. Lord asked for an estimate of the annual operating costs, assuming modernization. Capt. Dubay replied that it would be \$22M per year. Mr. Trimble stated that the operating costs are acceptable. His concern is that it would not be a back-up without users being willing to purchase the equipment and that the real problem is figuring out how to generate a market. He explained that the threat of eLoran as a back-up for GPS would not be realized unless there is a market. Dr. Parkinson stated that the incremental cost of adding this for the people for whom timing is important is so small that it would not be a problem. Mr. McPherson asked whether eLoran might expand to the Southern hemisphere. Capt. Dubay responded that it is currently being discussed only for the U.S. He explained that sovereign control is an issue. Mr. Trimble remarked that it is up to foreign governments to provide the system. He added that it is a great way to provide a terrestrial based navigation system. Mr. McGurn asked whether it would work with existing equipment. Capt. Dubay replied that it would be 100% backwards compatible. Old receivers can use the signal, but you would not see the upgraded accuracy or time. Dr. Schlesinger thanked Capt. Dubay for his presentation.

Future of Nationwide Differential GPS (NDGPS): Infrastructure & Funding Status

Dr. Schlesinger introduced Mr. Tim A. Klein, Senior Policy Advisor, Research and Innovative Technology Administration (RITA), U.S. Department of Transportation (DOT). Mr. Klein briefed the Board on the Nationwide Differential GPS (NDGPS) program. The NDGPS program is implemented jointly with the DOT (Federal Highway Administration, Federal Railroad Administration, Office of the Secretary of Transportation); the DHS (U.S. Coast Guard); the DOC (National Geodetic Survey, Forecast Systems Laboratory); and the DOD (U.S. Air Force, U.S. Army Corps of Engineers). He explained that NDGPS is an augmentation system. It consists of the U.S. Coast Guard maritime Differential GPS (DGPS) receivers for harbor/entry approaches at 39 sites, U.S. Army Corps of Engineers receivers for inland waterways at 9 sites, and DOT inland receivers for terrestrial applications at 38 sites.

NDGPS affords sub-meter accuracy in multiple terrestrial applications and provides accurate real-time positioning in all surface environments, including impeded environments, such as mountains, valleys, tunnels, and urban canyons. Post-processed data affords increased accuracy for resource management and mapping. There are multiple user communities. Parties currently relying on NDGPS data are national and cooperative Continuously Operating Reference Stations (CORS), NOAA, and the University Navstar Consortium (UNAVCO) (for tectonic plate monitoring).

In response to a question from Mr. Lewis, Mr. Klein explained that the terrestrial mode is used to facilitate train control, and also for farming and construction. There has never been a requirements document created for the inland DGPS. DOT is performing a complete assessment of the need for the inland component. If it finds that there are insufficient transportation requirements or other Federal user requirement, DOT intends to develop a decommissioning plan for that component. The assessment is due January 30, 2008. There have only been 50 responses to a Federal Register Notice seeking comments. In response to a question from Dr. Parkinson, Mr. Klein stated that the ACE is not part of the assessment. Mr. Trimble asked if there was any outreach to the States, and Mr. Klein responded in the affirmative. He stated that the current funding is \$5M for FY08, and that they have been funding the system with carryover funds from FY06 and FY07. He added that maritime coverage will be continued and operated by the USCG. In addition, the ACE will continue to operate and maintain the system for the Mississippi.

Mr. Hall requested that the systems' large supporters be identified. Mr. Klein stated that they were the Association for American Railroads and the State Governors' Association. Ms. Neilan asked whether the U.S. Geodetic Survey has been interested. Mr. Klein replied that he has heard from individual members. Prof. Enge noted that the equipment is essentially the same as eLoran and that the two signals can be issued from one antenna. Mr. Klein stated that that no one has suggested bringing eLoran and DGPS together. Capt. Dubai stated that they have looked at putting additional equipment on the eLoran towers. The towers are insulated, however, and multi-coupling would be required. The effect on the integrity calculation of the eLoran service would need to be calculated. Dr. Parkinson noted that there are water vapor sensors at these sites and asked whether the people responsible for those measurements have responded. Mr. Klein replied that he expects to hear from them.

Mr. McGurn asked what response would be sufficient to justify maintaining the system. Mr. Klein responded that they have never figured out who is using it. Mr. Trimble observed that the system is embarrassingly inexpensive. He does not believe it comes to the level of a recommendation to bring to the EXCOM, but would be a shame to lose. Mr. Klein explained that 92% of the area in the lower 48 states has single coverage and 65% has dual coverage. Canada provides the service for the St. Lawrence River. Mr. McGurn asked about the San Diego incident. Mr. Klein stated that the station in the area went down and that the source of interference was in the San Diego harbor. The DGPS signal was lost during a three-hour outage. Dr. Parkinson suggested broadcasting the eLoran corrections over the beacon system. Mr. Klein stated that the bandwidth for doing this was available. In response to a question from Ms. Ciganer, Mr. Klein stated that it would take 2-5 years to switch over to another system. Dr. Schlesinger thanked Mr. Klein for his presentation. The Board adjourned for a group photograph and reconvened.

GPS Constellations & Support for Separation Standards

Dr. Schlesinger introduced Mr. Richard L. Day, Vice President, En Route and Oceanic Services, Air Traffic Organization (ATO), Federal Aviation Administration (FAA). Mr. Day briefed the Board on the applicability of GPS to the FAA's separation standards. He stated that the MITRE Corporation had conducted a separation standards analysis. The objective was to determine the GPS constellation configurations that support various separation standards for the En Route and Terminal domains. He explained that the GPS SPS PS defines the minimum requirements for GPS performance. In support of the service availability standard, 24 operational satellites must be available on orbit with a 0.95 probability. At least 21 satellites in the 24 nominal plane/slot positions must be set healthy and transmitting its navigation signal with a 0.98 probability. He stated that GPS performance has historically exceeded the minimum SPS requirement. The current constellation has 31 satellites that are operational, with 28 usable as of August 29, 2007. Mr. Day explained that the availability of a defined level of integrity is the basis for determining the GPS constellation's ability to support FAA separation standards. The integrity is referred to as Navigational Integrity Category (NIC). Mr. Day discussed the current separation standards and the MITRE Close Approach Probability Model, which is the basis used for determining the integrity or NIC values that support a defined separation standard. The current system is today's radar environment. The goal is to push for lower separation standards. Mr. Day described the assumptions used for assessing the current specified 24 satellite constellation. He then reviewed several slides showing various satellite constellation configurations for two and five degree mask angles. The study showed that only the GPS constellations with 30 satellites provided an availability of >0.99999 to support all current separation

standards and provided a NIC that supports reduction of separation standards. In this constellation, a single satellite failure does not impact the availability of applying all current separation standards. Two satellite failures would reduce the availability of applying all separation standards.

Dr. Parkinson recommended the OnStar presentation to Mr. Day. He noted that it is important to reduce the separation standards due to the fact that new runways are unlikely to be added to legacy spaced airports to manage the risks. Dr. Schlesinger asked whether the FAA is happy with 21 satellites and that is all that is needed. Mr. Day responded that 21 satellites would not be adequate for the performance-based standards for the future requirements. In response to a question from Dr. Parkinson for the take-away, Mr. Day stated that an equivalent to the radar separation calls for a NIC value of 7 or 8, dependent on the satellites in view. Mr. Murphy noted that a NIC of 9 was dictated by the Notice of Proposed Rule Making (NPRM). Mr. Day stated that the NPRM talks about classes of airspace. The mandate, he explained, is higher in the major metropolitan areas. It was noted that the study assumed that S/A would be on.

Dr. Schlesinger asked what the FAA would regard as the appropriate number of satellites. Mr. Day responded that in order to provide separation standards equivalent to what radar affords would require 27 to 30 satellites. Dr. Schlesinger asked when the new national space design is to be initiated. Mr. Day replied that it has already begun. The standards and procedures are charted and in use today. They have had a demonstration project in Alaska since 1999. They are taking that project and are going to areas where they will prove the safety case to assure the signal and accuracy for separating aircraft. Once the safety case is proven, it can be deployed nationwide. By 2013, services will be provided in a few areas, and that will serve as the basis for expanding nationwide. In response to a question from Dr. Schlesinger, Mr. Day said that the full nationwide system, subject to funding, may be completed by 2016, and that the current system would not be adequate at that time. In response to Capt. Burns' observation that it is hard to make the investment decision without the satellite number, Mr. Day stated that there is an aviation rule-making committee that has been charted by the Administrator to identify incentives for early equipage.

Dr. Hermann observed that with increased traffic and the gains from spacing, it sounds inevitable that a contribution from the GPS will be needed that exceeds what is currently provided. Other people need to decide what to invest in during the interim. This is a utility that will require a long lead time and some continuity is needed. People need to know what the FAA will require in order to determine what to invest in. Mr. Trimble asked when they would feel comfortable to recommend to the FAA Administrator that the requirement is 27 satellites. Mr. Day responded that he would review the question. Additional information is not required to make the recommendation. Mr. Day noted that the separation standards were developed with the industry based on current performance standards. He added that the Acting Administrator is aware of the need for more satellites. Dr. Parkinson asserted that the U.S. should focus leadership in this area and that this is focused on the FAA, which has the ability to enable things for the future. He stated that the longest lead time involves getting the U.S. to realize that a 30 satellite constellation is required and he hopes that Mr. Day will recommend a 30 satellite constellation. Mr. Day replied that they are aware of the requirements. Mr. Trimble stated that the FAA has done a great job making the airspace over the U.S. a safe space. He added that what is needed is an expression at the national level that the FAA sees the need for a 30 satellite constellation. Mr. Daniel Salvano, FAA Navigational Services, stated that the former FAA Administrator had announced that the goal was to sustain the existing actual constellation – not the performance standard. The FAA now needs to get back to the EXCOM, but cannot do it by the November meeting. They are trying not to be myopic – there are surveillance pieces and navigation pieces that need to be addressed and integrated to come up with overall aviation requirements. Mr. Trimble asked when the FAA Administrator would have enough data to make a recommendation. Mr. Salvano responded that the number in orbit is meaningless if not properly located and that the study could be completed in 2008. Mr. Trimble asserted that the FAA needs to understand forward policy. He added that the FAA believes that dual frequency is critically important and has to weigh which services are on which satellites.

Dr. Schlesinger requested Mr. Salvano's reaction to the GPS performance standards and whether they were relevant with respect to future FAA requirements. Mr. Salvano stated that the FAA had to fight hard with the Air Force to get a 21 satellite guarantee. He noted that there are other documents in the Air Force system where they can change the performance standards without changing the 21 satellite commitment. Ms. Ciganer asked whether these are civilian concerns only. Mr. Day responded that much of the country's

air space is used only for military purposes, which affects capacity. Mr. McPherson asked whether the mandate for the 2020 introductory date could be advanced. Mr. Day responded that the lead time is needed to complete the rule-making process and for lead time to equip fleets of aircraft with new equipment. There is also the need to consider legacy aircraft. Mr. McPherson asked whether the FAA would provide services to RTCA DOC 260 fitted aircraft or only to DOC 260A fitted aircraft. Mr. Day responded that this is under consideration by the FAA. It involves concerns over how to stimulate equipage and how to permit a payback for having installed equipment. In response to a question from Mr. McGurn, Mr. Day attempted to clarify how NIC values were determined. He stated that it is a rich and complicated interface and there are fundamental issues that affect the values. Mr. McGurn questioned the wisdom in shifting integrity management to the aircraft. He asked why shift to the airplane the responsibility to determine the efficacy of the constellation status if we are just replacing radar surveillance with GPS surveillance. Mr. Murphy stated that congestion is a global issue and that the rest of the world looks to the FAA for leadership. He expressed the belief that WAAS receivers will be required and suggested that the FAA should try not to be parochial because they do influence the rest of the world. Dr. Schlesinger thanked Mr. Day for his presentation and for generating a lot of interest.

Board Member Feedback – “Round Table”

Dr. Schlesinger solicited comments from the Board for recommendations to bring to the EXCOM. Dr. Hermann asked for a list to work from and the Board decided to use the list from the *Panel I – Leadership* presentation. Dr. Schlesinger stated that this exercise would also help identify the tasks for the three Panels. Dr. Hermann offered that there was a need for an affordability paper to identify value-added from increasing the GPS constellation to 30+ satellites. Dr. Hermann also suggested that the Performance Standards might be useful to look at, noting that the planned level of performance over a period of time was important. He opined that the current performance specification document is vague in its utility. Dr. Schlesinger agreed with Dr. Hermann and stated that there is more than a gap between the performance standards and the future requirements for both the FAA and the military. Dr. Schlesinger noted that it is not a gap, it is a chasm, and suggested that attention should be called to the chasm. Mr. Logsdon suggested that the Board request the National Academy of Sciences (NAS) to perform a study on the ways in which GPS has become a public utility. Dr. Schlesinger recalled that the NAS had performed a study on GPS in the late 1990's, and he thought it would be worthwhile asking the NAS to get involved again.

Dr. Hermann stated that he had not yet seen a study clearly exploring the values added for the country or the world from the range of available GPS options and alternatives. Dr. Parkinson agreed with Dr. Hermann. Dr. Parkinson asserted that if that study had been made early on, it would have been accepted by no one. He explained that what has happened has depended on senior leadership deciding that something might work. The same argument, he suggested, would apply to the 30+ constellation. It is doubtful that a single argument would be persuasive; the naysayer would simply assert it is not an insurmountable problem. The leadership, Dr. Parkinson concluded, must be persuaded. Dr. Hermann stated that he understood this to be the “great champion” theory.

Mr. Trimble reminded members that the Board had to be thinking about what can be done before the middle of November. Dr. Schlesinger asked the Board to consider the number two recommendation from the Leadership Panel: *“Formally commit to current level of service”*. Mr. Hall observed that the current level needs to be clarified to distinguish diverse orbits versus satellites placed in piggy-back orbits. Dr. Parkinson stated that it should be changed to read: *“Commit to at least the current level of service.”* We need to commit to 30+. Mr. McPherson stated that the current level of service is poor in the rest of the world. He added that the Australian part of the world needs a better level of service and needs the satellite constellation to be geometrically optimized. Dr. Parkinson agreed to modify the Leadership Panel's recommendation to take into consideration the Board's comments. Dr. Schlesinger suggested that what was missed in yesterday's briefing is that we are already there and do not want to back track. Mr. McPherson stated that the requirement is no less than the current level of service. Gen. Lord recommended that this should be point number one. *“Assure affordability”* should be the second point, he said, and *“Place GPS III quickly under contract with early delivery”* should be number three. Dr. Parkinson explained that it is important to avoid redesigning the GPS III satellites. Dr. Hermann recommended a prioritization to trade more satellites for less sophisticated and less complicated satellites. Dr. Schlesinger

stated that the message to get GPS III quickly under contract has already been delivered. Dr. Hermann cautioned the Board to avoid sounding like it was whining. Dr. Parkinson argued that the Board can reinforce a prior recommendation.

Gen. Lord observed that within the corporate Air Force there has not been unanimous support for the larger GPS constellation, yet the Air Force accounts for 80% of the DoD fuel costs. He noted that those costs could be significantly lowered with reduced separations enabled by GPS, and suggested that this could be a way to get some buy-in from constituencies in the Air Force. Dr. Schlesinger agreed that this was a powerful point and noted that studies on the subject were underway. He counseled that it would help to get some numbers from the Air Force itself on these savings. Capt. Burns stated that United Airlines is currently engaged in performing that study. Dr. Schlesinger asked about the timeline for the study and Capt. Burns offered to check with the Air Force about releasing it. Capt. Burns indicated that the amount was substantial – well over hundreds of millions. Mr. McPherson noted that Qantas had also engaged in a similar study that could be useful. Dr. Parkinson asked him to see if Qantas would be willing to share it with the Board.

Mr. Hall stated that there is a need to determine whether the NDS will be riding on the GPS satellites. He asserted that there is a need to develop an argument on why GPS affordability is more important than NDS. He stated that it is nonsensical to include NDS. Dr. Schlesinger concurred and remarked that there is already have enough NDS capability on orbit to handle things through 2025. Dr. Parkinson stated that he would rework the order of the recommendations and rewrite the Panel's number one recommendation as an aside since it has already been presented to the EXCOM. Mr. Hall recalled the lack of opportunity for non-governmental users to provide meaningful input into the decision-making process. He asserted that national GPS users should have an opportunity to participate in the decision-making process early and often. Accordingly, the Board should not drop the Panel's fourth recommendation. Dr. Hermann requested that the EXCOM be informed that the entire country is not represented in the process. He stated that he believes that this is an urgent problem and that there is a need for a better decision-making process. Dr. Schlesinger recalled that former Secretary of Defense Robert McNamara had stated that he could only slay a limited number of dragons in one day. Dr. Schlesinger counseled that the JROC process might be avoided in this one case. What is really needed, he said, is something similar to the RTCA (the name for a requirements group), which would help to avoid the phase-in problems that have been described. He counseled that to move toward a more open national decision-making program would have to await the arrival of the next Administration. He cautioned that the EXCOM has enough on its plate and recommended against using the Board's political capital to say, "You federal officials are not properly informed and need more help." Mr. Trimble submitted that having the Air Force return to the ICD process would be the simplest method. Dr. Parkinson explained that up until several years ago there was a process that allowed outsiders to participate. He asserted that governmental agencies are not a good substitute for professional expertise from the private sector. Gen. Lord remarked, with respect to air traffic management, that the expanded use of unmanned aircraft should be taken into consideration. Dr. Parkinson suggested quantifying the problem in Afghanistan to show the value-added proposition. He and Dr. Hermann agreed to prepare a draft paper to expand on that.

Dr. Schlesinger observed that the Board has developed its recommendations for the EXCOM. Dr. Beutler stated that he would like to see the recommendations somewhere. Mr. Lewis reminded the Board that the Air Force will be putting laser reflectors on GPS IIIB, but not on IIIA. Mr. Skalski confirmed that IFOR had approved this requirement. Ms. Neilan stated it is important to keep the time schedule in mind. She added that Galileo will have reflectors and, as a result, laser reflectors may need to become a GPS IIIA requirement in order to keep GPS III competitive with the other new systems. Dr. Parkinson explained that the Air Force would not want to sign a procurement contract and then immediately issue a change order to add the reflectors. Mr. McGurn noted that common filter design would be affected by the addition of the laser reflector. Mr. Lewis agreed to look into this as an action item. Dr. Schlesinger asked the Board to bear in mind that more and more aircraft are flying into Beijing, even though the Chinese air traffic control system is less than desirable. He noted that the 30+ satellite constellation was going to impact much of the outside world, and he explained that we are doing this not for China, but for the air traffic flowing into China, and other areas with less than desirable air traffic control systems. Dr. Parkinson stated that he would revise the Leadership Panel's recommendations and circulate them to the Board and to Chairman

Schlesinger. Dr. Schlesinger asked whether anything should be done about the SPS Performance document, cautioning that it might have a pernicious impact. Dr. Parkinson questioned whether the Board should expend its political capital on that issue. Mr. McGurn opined that one problem is that the current performance as stated in the document is not the current performance – it is better than that. Dr. Parkinson stated that the concept is imbedded in Leadership Panel issue number two. He agreed to make it a sub-bullet so that it could be emphasized.

Board Assignments & Future Taskings

Mr. Miller informed the Board that the next EXCOM meeting after November would be scheduled for the February/March 2008 timeframe. Ms. Rausch suggested that the simplest approach to scheduling the next meeting of the PNT Advisory Board would be to use the same timeframe as the previous meeting – i.e., in late March. Dr. Schlesinger, after querying the Board members, announced that the next PNT Board meeting would be tentatively scheduled for the March 27-28, 2008.

Dr. Schlesinger noted that the tasks have already been identified for *Panel 1 – Leadership*. He asked about *Panel 2 – Strategic Engagement and Communication*. Ms. Neilan offered to take a look at the next steps. She endorsed the GPS Capitol Hill Day. David Logsdon stated that the GPS Capitol Hill day is critical. Mr. Hall suggested issuing a statement showing the importance of the 30+ satellite constellation to homeland security. Ms. Neilan replied that this has been discussed and that more homework needs to be done on how to develop that plan. Dr. Schlesinger asked Ms. Rausch to craft the press release he had mentioned earlier. He added that there is also an issue relating to ITAR to be dealt with. With regard to *Panel 3 – Future Challenges*, Mr. Trimble stated that *Panel 3* recommendations have been completely captured in the *Panel 1* recommendations. Dr. Schlesinger added that it would be helpful if *Panel 3* would continue to work on a vision paper with Dr. Hermann.

Adjournment

Dr. Schlesinger expressed his appreciation to the Board members for their service. The meeting was then adjourned.



NATIONAL SPACE-BASED POSITIONING, NAVIGATION, AND TIMING (PNT) ADVISORY BOARD

Second Meeting

Doubletree Hotel

1515 Rhode Island Avenue, NW

Washington, D.C. 20005

October 4 & 5, 2007

MEETING AGENDA

Thursday, October 4

8:30 – 8:35	BOARD CONVENES Call to Order	Ms. P. Diane Rausch, <i>Executive Director</i> <i>National Space-Based PNT Advisory Board</i> NASA
8:35 – 8:45	Welcome & Opening Remarks	Dr. Scott Pace, <i>Associate Administrator</i> <i>Program Analysis and Evaluation, NASA</i>
8:45 – 09:15	Introductions, Announcements, & Agenda <i>No Selective Availability (S/A) for GPS III</i>	Dr. James R. Schlesinger, <i>Chair</i> Dr. Bradford Parkinson, <i>Vice-Chair</i>
9:15 – 09:45	Update on GPS, PNT Policy, & PNT EXCOM	Mr. Michael Shaw, <i>Director</i> <i>National Space-Based PNT Coordination Office</i>
9:45 – 10:45	International Member Feedback & Regional Reports <ul style="list-style-type: none">• Dr. Gerhard Beutler (CH) President, International Association of Geodesy• Mr. Arve Dimmen (NO) Director, Maritime Safety, Norwegian Coastal Administration• Mr. Keith McPherson (AU) Manager GNSS, Airservices Australia• Mr. Hiroshi Nishiguchi (JP) Secretary General, Japan GPS Council• Capt. Richard Smith (UK) President, International Association of Institutes of Navigation	
10:45 – 11:00	BREAK	
11:00 – 12:15	<i>Panel 1 – Leadership:</i> Fact-Finding Report	Dr. Bradford Parkinson, <i>Stanford University</i> Mr. Martin Faga, <i>Former CEO, MITRE Corp.</i>
12:15 – 1:00	LUNCH	
1:00 – 2:15	<i>Panel 2 - Strategic Engagement & Communication:</i> Fact-Finding Report	Ms. Ruth Neilan, <i>Jet Propulsion Laboratory</i> Mr. David Logsdon, <i>U.S. Chamber of Commerce</i>
2:15 – 3:30	<i>Panel 3 - Future Challenges:</i> Fact-Finding Report	Mr. Charles Trimble, <i>Founder, Trimble Navig.</i> Dr. Robert Herman, <i>Global Technology Partners</i>
3:30 – 3:45	BREAK	

3:45 – 4:15	Update on GPS Performance Standards DoD Perspective	Brigadier General Donald Alston, <i>Director Space and Nuclear Operations, USAF HQ</i>
4:15 – 4:45	Update on GPS Performance Standards Civil Perspective	Mr. Hank Skalski, <i>Civil Liaison GPS, Air Force Space Command</i>
4:45 – 5:00	Afternoon “Wrap-Up” & Announcements	Dr. James R. Schlesinger, <i>Chair</i>
5:00	ADJOURNMENT	
	<u>Friday, October 5</u>	
8:30	BOARD CONVENES	
8:30 – 9:15	Chair/Vice-Chair Feedback “What We Want the PNT Board to Accomplish”	Dr. James R. Schlesinger, <i>Chair</i> Dr. Bradford Parkinson, <i>Vice-Chair</i>
9:15 – 9:45	Future of E-LORAN GPS Alternatives & Back-Ups - Timing	Capt. Curtis Dubay, <i>Chief Systems & Architecture, DHS</i>
9:45 – 10:15	Future of Nationwide Differential GPS (NDGPS) Infrastructure & Funding Status	Mr. Tim Klein, <i>Senior Policy Advisor Research and Innovative Technology Administration (RITA), DOT</i>
10:15 – 10:30	BREAK	
10:30 – 11:00	FAA National Airspace System (NAS) Modernization Automatic Dependent Surveillance-Broadcast	Mr. Richard L. Day, <i>Vice President En Route & Oceanic Services, Air Traffic Organization (ATO), FAA</i>
11:00 – 12:00	Board Member Feedback - “Round Table” Board Assignments and Future Taskings	All
12:00 – 1:00	WORKING LUNCH – PNT Advisory Board “Wrap-Up” Discussions	
1:00	ADJOURNMENT	

ACRONYMS

AU:	Australia
CH:	Switzerland
DHS:	Department of Homeland Security
DOC:	Department of Commerce
DOD:	Department of Defense
DOT:	Department of Transportation
E-LORAN:	Enhanced Long Range Navigation
EXCOM:	National Space-Based PNT Executive Committee
FAA:	Federal Aviation Administration
GPS:	Global Positioning System
IN:	India
JP:	Japan
PNT:	Positioning, Navigation & Timing
NAS:	National Airspace System
NDGPS:	Nationwide Differential GPS
NO:	Norway
RITA:	Research and Innovative Technology Administration
USAF:	United States Air Force
UK:	United Kingdom

**NATIONAL SPACE-BASED
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BOARD MEMBERSHIP

U.S. Board Members

Dr. James R. Schlesinger – *Chairman, Board of Trustees, MITRE Corporation*

Mr. Phil Boyer – *Aircraft Owners and Pilots Association*

Capt. Joe Burns – *United Airlines*

Ms. Susan M. Cischke – *Ford Motor Company*

Ms. Ann Ciganer – *U.S. GPS Industry Council*

Dr. Per Enge – *Stanford University, Department of Aeronautics and Astronautics*

Mr. Martin Faga – *Former President and CEO of MITRE*

Mr. Keith Hall – *Booz-Allen Hamilton*

Dr. Robert Hermann – *Global Technology Partners, LLC*

Mr. Chet Huber – *OnStar Corporation, General Motors*

Mr. David Logsdon – *Space Enterprise Council, U.S. Chamber of Commerce*

Gen. Lance Lord – *Retired USAF, Former Commander, Air Force Space Command*

Mr. Tim Murphy – *Boeing Corporation, Commercial Airplane Group*

Mr. Terence McGurn – *Retired CIA (currently private consultant)*

Gen. James McCarthy – *Retired USAF (currently professor)*

Ms. Ruth Neilan – *Jet Propulsion Laboratory*

Dr. Bradford Parkinson (Vice-Chair) – *Stanford University, Department of Aeronautics and Astronautics*

Mr. Charles R. Trimble – *Founder, Trimble Navigation (currently private consultant)*

International Board Members

Dr. Gerhard Beutler (Switzerland) – *President, International Association of Geodesy*

Mr. Arve Dimmen (Norway) – *Director, Maritime Safety Division, Norwegian Coastal Administration*

Dr. Suresh Kibe (India) – *Programme Director SATNAV, Indian Space Research Organization*

Mr. Keith McPherson (Australia) – *Manager GNSS, Airservices Australia*

Mr. Hiroshi Nishiguchi (Japan) – *Secretary General, Japan GPS Council*

Capt. Richard Smith (United Kingdom) – *President, International Association of Institutes of Navigation*

**NATIONAL SPACE-BASED
POSITIONING, NAVIGATION, AND TIMING (PNT)
ADVISORY BOARD**

Second Meeting

Doubletree Hotel

1515 Rhode Island Avenue, NW

Washington, D.C. 20005

October 4 & 5, 2007

MEETING ATTENDEES

Board Members

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Capt. Joe Burns	United Airlines
Ms. Ann Ciganer	U.S. GPS Industry Council
Prof. Per Enge	Stanford University, Department of Aeronautics and Astronautics
Mr. Martin Faga	Former President and CEO of MITRE
Mr. Keith Hall	Booz-Allen Hamilton
Dr. Robert Hermann	Global Technology Partners, LLC
Mr. Chet Huber	OnStar Corporation/General Motors
Mr. David Logsdon	Space Enterprise Council, U.S. Chamber of Commerce
Gen. Lance Lord	Retired USAF - Former Commander, Air Force Space Command
Mr. Tim Murphy	Boeing Corporation, Commercial Airplane Group
Mr. Terence McGurn	Retired CIA (currently private consultant)
Ms. Ruth Neilan	Jet Propulsion Laboratory
Dr. Brad Parkinson, <i>Board Vice-Chair</i>	Stanford University, Department of Aeronautics and Astronautics
Mr. Charles R. Trimble	Founder, Trimble Navigation (currently private consultant)

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Prof. Gerhard Beutler (<i>Switzerland</i>)	President, International Association of Geodesy
Mr. Arve Dimmen (<i>Norway</i>)	Director, Maritime Safety Division, Norwegian Coastal Administration
Mr. Keith McPherson (<i>Australia</i>)	Manager GNSS, Airservices Australia
Mr. Hiroshi Nishiguchi (<i>Japan</i>)	Secretary General, Japan GPS Council
Capt. Richard Smith (<i>United Kingdom</i>)	President, International Association of Institutes of Navigation

NASA Attendees

Ms. Barbara Adde	NASA HQ
Mr. James J. Miller	NASA HQ
Mr. Robert A. Nelson	NASA/SERC
Mr. A.J. Oria	NASA/Overlook
Dr. Scott Pace	NASA HQ
Ms. P. Diane Rausch	NASA HQ

Other Attendees

Abner, Milton	NSSO
Adkies, Bill	Adkies Strategies
Alexander, Ken	FAA
Andren, Carl	Institute of Navigation (ION)
Badbance, Anne	ESA
Basneyeki, Chaminde	General Motors R&D
Beard, Ron	NRL
Bocek, Robert	Boeing
Brancato, Richard	DOT
Clary, Milton R	ASD (NII)
Daniels, Charlie	NCO Washington, DC
Day, Rick	FAA/ATO
Dedz, George	Topcon Positioning Systems
Doherty, Jim	IDA
Dubay, Curtis	US Coast Guard
Frankel, David	Consultant
Jordan, Dan	Lockheed Martin
Karner, Julie	[self]
Kenagy, Randy	AOPA
Kim, Jason	DOC
Klepczynski, Bill	USNO
Klesh, Timothy	DOT/RITA
Lewis, L. Kirk	IDA
Madhavan, Sethu	GM/OnStar
Madison, Earl	Lockheed Martin
McNeff, Jules	OASD (NII) Overlook
Nagle, Tom	FAA
Narnon, Mitch	FAA
Nordwald, Frederic	ESA
Peterson, Eric	GPS Users Alliance
Russo, Anthony	PNT
Sapp, Joseph	Scitor Corp.
Shashok, Alexander	Air Attaché Russian Embassy
Shaw, Michael	NCO
Skalski, Hank	DOT
Slaker, James	NGA
Stear, David	SAF/USAL
Turner, Dave	Aerospace Corp.
Van Dyke, Karen	DOT/RITA/Volpe Center
Vicario, Jeff	NSSO
Williams, Michele	Boeing
Yamamoto, Yuki	Interpreter for Mr. Nishiguchi

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LIST OF PRESENTATION MATERIAL¹

- 1) U.S. Space-Based PNT Update [Shaw]
- 2) The Role of the GPS/GNSS in Geodesy and Geodynamics [Beutler]
- 3) E-Navigation; Galileo; The Arctic Challenge [Dimmen]
- 4) GBAS Cat-1 Sydney GRAS [McPherson]
- 5) Panel 1 – NPE CAB [Parkinson]
- 6) Panel 2 – Terrestrial Reference Systems for Global Navigation Satellite Systems [Slater]
- 7) Panel 2 – Standard Time and Frequency Applications and GPS [Beard]
- 8) Panel 2 – Options for Promoting GPS [Logsdon]
- 9) Panel 3 – Presentation [Trimble]
- 10) Global Positioning System (GPS) Performance Standards (PS) [Alston]
- 11) GPS Performance Standards Civil Perspective [Skalski]
- 12) Loran Transition [Dubay]
- 13) Update on DOT Nationwide Differential GPS (NDGPS) Program [Klein]
- 14) GPS Constellations and Support for Separation Standards [Day]

Other Material Distributed at the Meeting

- 15) Presenters' Biographies
- 16) National Space-Based PNT Advisory Board Membership
- 17) National Space-Based PNT Advisory Board Meeting Minutes, March 29-30, 2007
- 18) Federal Register Notice of Meeting
- 19) National Space-Based PNT Advisory Board Fact Finding Panels

¹ Unless otherwise indicated, all material distributed at the meeting is on file at NASA Headquarters, Office of External Relations, Advisory Committee Management Division, 300 E Street SW, Washington, DC 20546.