



**SPACE-BASED POSITIONING  
NAVIGATION & TIMING**  
NATIONAL ADVISORY BOARD

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

**Fifth Meeting  
May 14-15, 2009**

**Chevy Chase Ballroom – Third Floor  
Embassy Suites, Chevy Chase Pavilion  
4300 Military Road NW  
Washington, DC 20015-2020**

**Meeting Minutes**

  
**James R. Schlesinger**  
**Chair**

  
**P. Diane Rauseb**  
**Executive Director**

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

**Fifth Meeting  
May 14-15, 2009**

**Agenda**

**Thursday, May 14, 2009:**

9:00 – 9:05	<b>BOARD CONVENES</b> <i>Call to Order &amp; Welcome</i>	Ms. Diane Rausch, <i>NASA</i> <i>Advisory Board Executive Director</i>
9:05 – 09:15	Introductions, Announcements, & Agenda <i>What we want to accomplish – Preparing for</i> <i>Advisory Board Report to PNT EXCOM</i>	Dr. James Schlesinger, <i>Chair</i> Dr. Bradford Parkinson, <i>Vice-Chair</i>
9:15 – 09:45	U.S. Update on GPS, PNT Policy, & PNT EXCOM <i>PNT EXCOM Expectations, Transition Planning</i>	Mr. Michael Shaw, <i>Director, National</i> <i>Coordination Office for Space-Based PNT</i>
9:45 – 10:00	Issues Requiring Further Discussion	Dr. James Schlesinger, <i>Chair</i>
10:00 – 10:30	International Member Regional Updates <ul style="list-style-type: none"> <li>• Mr. Gerhard Beutler (Switzerland)</li> <li>• Mr. Arve Dimmen (Norway)</li> <li>• Mr. Hiroshi Nishiguchi (Japan)</li> <li>• Capt. Richard Smith (United Kingdom)</li> <li>• Dr. Suresh Kibe (India)</li> </ul>	(at member's discretion)
10:30 – 10:45	<b>BREAK</b>	
10:45 – 11:15	International Initiatives and Opportunities	Mr. Dave Turner, <i>Deputy Director</i> <i>Space and Advanced Technology, State</i> <i>Department</i>
11:15 – 12:00	Galileo Program Update	Mr. Paul Verhoef, <i>Program Manager,</i> <i>EU Satellite Navigation Programs</i>
12:00 – 13:00	<b>LUNCH</b>	
13:00 – 13:30	GPS Issues & Challenges (IIF, L5 & L2)	Brig Gen John Hyten, <i>Director,</i> <i>Space Requirements Air Force Space</i> <i>Command</i>
13:30 – 14:00	FAA SatNav Program Progress -- WAAS, ADS-B	Mr. J.C. Johns <i>Director of Navigation Services, FAA</i>

14:00 – 14:30	Satellite Laser Ranging and Rules of the Road for the International Laser Ranging Service	Dr. Mike Pearlman <i>Harvard-Smithsonian Center for Astrophysics</i>
14:30 – 14:45	<b>BREAK</b>	
14:45 – 15:15	LORAN-History & Need	Mr. James Doherty <i>Institute for Defense Analyses (IDA)</i>
15:15 – 15:45	E-LORAN (International)	Dr. Sally Basker, <i>Director,</i> <i>Research and Radionavigation,</i> <i>General Lighthouse Authorities, UK</i>  Sir Jeremy de Halpert, <i>Executive Chairman,</i> <i>Trinity House UK</i>
15:45 – 16:15	Department of Homeland Security PNT Interference Detection & Mitigation Initiatives	Mr. John Merrill, <i>GIS Manager,</i> <i>Department of Homeland Security (DHS)</i>
16:15 – 16:50	Preliminary Review and Approval of 2007-2008 PNT Advisory Board Report	All Advisory Board Members
16:50 – 17:00	Afternoon “Wrap-Up”	All Advisory Board Members
17:00	<b>ADJOURNMENT</b>	

**Friday, May 15, 2009:**

9:00 – 9:05	<b>BOARD CONVENES</b> <i>Call to Order</i>	Ms. Diane Rausch, <i>NASA</i> <i>Advisory Board Executive Director</i>
9:05 – 9:15	What is to be accomplished?	Dr. James Schlesinger, <i>Chair</i> Dr. Bradford Parkinson, <i>Vice-Chair</i>
9:15 – 9:45	Current PNT Policy Fundamentals & Future Expectations	All Advisory Board Members
09:45 – 10:15	Discussion of Future GPS Presidential Directives: GAO Report Findings on GPS	Dr. James Schlesinger, <i>Chair</i> Dr. Bradford Parkinson, <i>Vice-Chair</i>
10:30 – 11:00	Messages for the PNT Executive Committee : June 18 at Department of Commerce	Dr. James Schlesinger, <i>Chair</i> Dr. Bradford Parkinson, <i>Vice-Chair</i>
11:00 – 12:00	Final Approval of PNT Advisory Board Report 2007-2008	All Advisory Board Members
12:00 – 13:00	<b>WORKING LUNCH</b> PNT Advisory Board “Wrap-Up” Discussions	
13:00	<b>ADJOURNMENT</b>	

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*Session of Thursday, May 14, 2009:*

Board Convenes:

Ms. Diane Rausch, *Executive Director*

Ms. Rausch, Executive Director, National Space-Based Positioning, Navigation and Timing (PNT) Advisory Board, , welcomed all to the fifth meeting of the Advisory Board. She noted that the Advisory Board members present had recently been re-appointed by Acting NASA Administrator Christopher Scolese, and that the Advisory Board's three panels – Leadership, Strategic Engagement and Communications, and Future Challenges had met the previous afternoon in preparatory sessions.

Ms. Rausch reminded the meeting that this was a Federal Advisory Committee Act (FACA) meeting and as such, the session is public. Members of the audience are asked not to interrupt speakers or Board members. All comments are on the record and formal minutes were being kept. Individual Board members are either Special Government Employees (SGEs) or Representatives. The former represent their individual expertise; the latter represent a given industry, sector, or international interests. SGEs are required to file financial disclosure statements, subject to Federal ethics requirements, and must recuse themselves on matters that represent a conflict of interest .

Introductions and Announcements:

Dr. James Schlesinger, *Chair*

Dr. Schlesinger, Board Chair, welcomed all persons to the Advisory Board's fifth meeting and noted that on this day, May 14, Meriwether Lewis and William Clark launched their expedition into the newly-acquired Louisiana Territory at the behest of President Thomas Jefferson. Even had Lewis and Clark had GPS , he noted, they would have still have lacked the necessary maps to make it useful. An analogy may be drawn with the Advisory Board being a launching point for the new Administration to chart its course. Budgetary pressure facing the new Administration might be helpful to certain GPS initiatives. A report is to be provided to PNT EXCOM (Executive Committee) on June 18, 2009 to help shape the new Administration's expectations in space activities generally and GPS in particular.

Dr. Schlesinger thanked NASA for its continued support of the Advisory Board, adding that he believed the Department of Commerce (DOC) would likely be the next sponsor. Mr. Miller, from NASA, noted that interest had been expressed both by the DOC and Federal Aviation Administration (FAA), but no formal commitment had been made.

Dr. Schlesinger reported that he had briefed EXCOM since the Board's last meeting in October 2008, and identified the following taskings from the EXCOM:

- Recommend areas where GPS and its augmentations can be made more competitive.
- Recommend ways to promote and demonstrate current and future capabilities of GPS and its augmentations to the U.S. and international communities.
- Assess technology and market trends as the number of worldwide GNSS providers increase.

The recommendations made to date by the Advisory Board co-chairs to the EXCOM include:

- “Remove the capability for Selective Availability from GPS III.”
  - This has been achieved.
- “Begin to transmit navigation message on L2C.”
  - This is underway.
- “Designate E-LORAN as a backup to GPS.”
  - Dr. Schlesinger expressed the wish that this matter be resolved.
- “Place GPS III quickly under contract with early delivery.”
  - Dr. Schlesinger considers this item to be critical and that Dr. Parkinson would provide a briefing on how this has become urgent.
- “Take actions to maintain current levels of GPS service.”

- This issue is critical especially as we transition to GPS III.

Dr. Schlesinger identified the themes for the new Presidential Administration which, responding to a query from Dr. Hermann, would include past recommendations that have not yet been implemented. These are:

- “Maintain the policy for an open signal free of direct user charges.”
  - Dr. Schlesinger believes this is well established.
- “Seek to ensure that GPS remains the signal of first use.”
  - Dr. Schlesinger believed this needs to continue being the case for the foreseeable future.
- “For users -- ensure transparency and stability in the evolution of GPS”
  - Dr. Schlesinger noted this outcome remains uncertain.
- “Implement laser retro-reflectors on future GPS”
  - Dr. Schlesinger believed this had yet to be achieved.
- “For National Security Infrastructure: develop means to detect, measure, locate and mitigate radio interference/jamming”
  - Dr. Schlesinger believed this had yet to be achieved.

Dr. Schlesinger expressed his thanks to all, specifically the excellent support received from the former Deputy Secretary of Defense, Mr. Gordon England. He also expressed thanks to Mr. Michael Shaw, Director, National Coordination Office for Space-Based PNT, for his efforts.

The major task for this meeting is to approve the Advisory Board Report for 2007-2008; any member comments, edits, and updates to the draft report will be incorporated into the draft. In addition, the Board needs to discuss plans for PNT interference detection and mitigation, as well as the Bush Administration’s NSPD [National Security Presidential Directive] for space which could be modified by the Obama Administration.

Dr. Schlesinger queried members – particularly the international members – for suggestions or corrections to the draft report. Dr. Parkinson noted some comments had already been provided by e-mail; these, Mr. Miller said, had been incorporated into the draft. Mr. Miller thanked Dr. Oria, NASA contractor, for his work in capturing comments in time for the meeting. Capt. Smith said his panel (Strategic Engagement and Communications), believed the draft report to be factually correct and would propose additional edits to clarify issues that non-technical readers may have. Mr. Trimble noted that Mr. Nishiguchi would provide a few additional edits; otherwise, he said, his panel (Future Challenges) thought the document very good. Dr. Enge said his suggestions had already been taken into consideration.

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Presentation: U.S. Update on GPS, PNT Policy, & PNT EXCOM

Mr. Michael Shaw, *Director*

National Coordination Office for Space-Based PNT

Mr. Shaw said he would present a top-level review of accomplishments since the October 2008 meeting; the results of the 2008 EXCOM work plan and the content of the 2009 EXCOM work plan; and address the relationship between space-based PNT and the new Administration. A key accomplishment is the publication of the first GPS WAAS [Wide-Area Augmentation System] performance standard. Dr. Parkinson asked if this standard would be adopted by EGNOS [European Geostationary Navigation Overlay Service]; Mr. Shaw suggested raising that question during Mr. Johns’ FAA presentation that afternoon. Mr. Shaw noted creation of an SBAS (Satellite-Based Augmentation System) interoperability working group as a result of the third International Committee on GNSS (ICG) conference in Pasadena, California, in December 2008; a fourth ICG meeting is scheduled for St. Petersburg, Russia, in September 2009; NASA has renewed the charter for the Advisory Board through 2010; the FY09 Omnibus Budget Bill includes \$20.7 million in funding for the implementation of L1C while the pending FY10 budget includes \$43.3 million. Mr. Shaw noted that the effort to secure civil funding for the fourth civil GPS signal, or L1C, had begun in 2007 with \$7.2 million. While civil funding was not large compared to the overall budget, he said, it was becoming appreciable. Responding to a question from Ms. Ciganer, Mr. Shaw said these funds were used for civil monitoring and Operating Control Segment (OCX) in support of L1C. Further, he said, GPS IIR-20(M) had been launched, and begun broadcasting an L5 demo signal. Mr. Shaw reported that the 2008 work plan included 59 action items; 54 were completed. Thus far, he said, the draft 2009 work plan had 29 action items, including five from the previous year. Mr. Shaw identified key events for

2009, including launch of the first GPS IIF satellite; award of the OCX contract; transfer of FY09 civil funding for L1C to the Air Force, and other steps, including the completion of the Advisory Board report.

Mr. Shaw presented the pending EXCOM membership list, noting that some appointees were waiting for confirmation, including Mr. William Lynn for Deputy Secretary of Defense and Mr. John Porcari for Deputy Secretary of Transportation-Designate. The latter's confirmation hearing is scheduled for the week of May 26, 2009. Dr. Parkinson asked if either was versed in space-based PNT, or GPS; Mr. Shaw said he believed that was not case. Dr. Hermann noted that Mr. Lynn had considerable background in defense; therefore, would likely have some familiarity with GPS. Dr. Schlesinger noted that the Obama Administration still lacked a clear standard on appointment of former lobbyists, and Mr. Lynn had been a lobbyist for Raytheon. Mr. Shaw noted that during confirmation, Sen. McCain had questioned Mr. Lynn on this and they had established a list of matters from which he would recuse himself. Mr. Shaw did not believe this list included anything related to GPS. Mr. Shaw noted that no nomination had been advanced yet for NASA Administrator or Deputy Administrator. The June 18 EXCOM session would focus on orientation and, he believes, should not be pushed to make decisions yet. Dr. Parkinson asked if Mr. Shaw planned to assemble information packets for new EXCOM members and to meet with them face-to-face prior to the June 18 meeting. Mr. Shaw said that was intention but had been unable to schedule such meetings.

Summarizing, Mr. Shaw noted that 92 percent of the 2008 work plan had been achieved – in consequence, the 'good news' was that space-based PNT was in relatively good shape; the 'bad news' was that this was a difficult time to get attention paid to one's concerns. He believed progress was being made and expressed that hope that it continue with the June 18 EXCOM meeting.

#### Comments: International Members

Dr. Gerhard Beutler, *President*  
International Association of Geodesy

Dr. Beutler represents the International Association of Geodesy (IAG); and since 1991 served on the IGS governing board – the IAG entity that dealt with GNSS issues. He's also served on the Galileo Science Advisory Board (GSAC), which has recommended improvements to Galileo and also maintains the science opportunity document. This group's second meeting had been two weeks earlier. Science issues currently under GSAC consideration include navigation fundamentals, Earth sciences, metrology and astronomy; for more information refer to the program for the Second International Colloquium on Scientific Aspects of the Galileo Program, October 14-15 2009. Dr. John Dow, chair, International GNSS System (IGS) governing board, would brief on Galileo, GPS and GLONASS (Russian GNSS) and interoperability issues would also be on the agenda. A detailed report will be provided to the Advisory Board at its next session.

Mr. Arve Dimmen, *Director*  
Maritime Safety Division  
Norwegian Coastal Administration

Norway has participated in Galileo development through ESA; Norway, however, is not a member of EU which now runs Galileo. Responding to this, the Norwegian Government has introduced legislation authorizing the country's full participation in Galileo's implementation phase.

In 2003, the International Maritime Organization (IMO) adopted international standards for defining suitable radio navigation systems and currently there is pressure to re-evaluate these requirements – particularly on continuity and reliability – to allow for more systems to be included. This will be important as awareness on radio navigation increases and the concept of eNavigation materializes. Dr. Schlesinger asked Mr. Dimmen if progress had occurred between Norway and Russia on the line of demarcation over the Arctic Ocean; Mr. Dimmen said he could not comment.

Mr. Hiroshi Nishiguchi, *Secretary General*  
Japan GPS Council

Mr. Nishiguchi discussed the draft of Japan's Implementation Plan for the Basic Space Law, enacted last year. This plan is now in the public comments phase and will be published by the end of the month. The plan's significance is that it establishes basic policy for promoting space exploration and utilization; identifies measures to be undertaken by the Japanese Government in space exploration and utilization, and addresses matters relevant to promoting these objectives. He called attention to the Japanese Government's decision to place greater priority on utilization while

enhancing research and development, and presented the six basic objectives for space exploration and the nine major needs that Japan’s space exploration and utilization plan will address. The organization structure to promote these activities should be defined this year. Ms. Neilan asked if Japan had plans to track Compass, the Chinese global and regional navigation system, Geostationary Earth Orbit satellites whose footprint, she believes, would extend over Japan. Mr. Nishiguchi said he had heard nothing about such plans.

Capt. Richard Smith, *President*  
International Association of Institutes of Navigation

Since the last Advisory Board meeting there has been increasing concern among International Association of Institutes of Navigation (IAIN) members about the future of Loran in the U.S. There is an on-going rumor that India is now considering undertaking its own global system. The next IAIN Congress is to be held in Stockholm in October 2009.

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Announcement: Youth Promoting GNSS

Ms. Stephanie Wan, *Project Co-Leader*  
Youth Promoting GNSS Cooperation and Education  
Space Generation Advisory Council

Mr. Miller introduced Ms. Stephanie Wan, a former NASA intern and graduate student in the Space Policy Institute at George Washington University, who is co-leader of Youth Promoting Global Navigation Satellite System (GNSS) Cooperation and Education project. Ms. Wan stated that her exposure to GNSS while at NASA had prompted her to help “spread the word” about GNSS. The YGNSS program began in April 2008 with the aim to increase awareness of GNSS importance, and since then membership has grown to over 3,000 members worldwide. The YGNSS Project Team currently has 17 delegates worldwide and aims to bring the maximum benefits of GNSS to the future society. Responding to a question from Ms. Neilan, Ms. Wan explained this activity was sponsored by the Space Generation Advisory Council (SGAC), a non-governmental organization in support of the United Nations Program on Space Applications located in Vienna, Austria.

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International Initiatives and Opportunities

Mr. Dave Turner, *Deputy Director*  
Space and Advanced Technology, Department of State

Mr. Turner presented slides of familiar material; then, he then focused on U.S. international diplomatic initiatives. He identified the world’s planned GNSS and augmentation systems.. Dr. Schlesinger noted that the ‘24 satellites’ for the U.S. was a guaranteed number while figures for other systems were planned targets, and asked whether GLONASS’ “checkered” history influenced the Department of State (DOS) estimate of its plans. Mr. Turner responded that DOS had no basis for questioning the plans of others.

Dr. Hermann stated didn’t believe all the systems identified in the briefing would become operable and that if all these systems were realized over 100 satellites would be in operation: he believed collaboration could produce a better result. Alternately, if that number of satellites was not realistically expected then there could be less urgency for collaboration. Knowing the likely number of satellites, he said, may dictate the urgency of global cooperation.

Dr. Parkinson noted that if all planned satellites came on line, then Federal Aviation Authority (FAA) operations would not require additional satellites to meet the goal for Receiver Autonomous Integrity Monitoring (RAIM). However, considerable time would pass before other satellites could be useful to U.S. safety-of-life service. Dr. Hermann agreed: GPS had not yet reached a level of service assurance that would permit disinvestment in augmentation systems. Dr. Parkinson said current probability for not meeting satellite availability is on the order of 10<sup>-3</sup>; whereas the FAA requires 10<sup>-10</sup> and even then the satellites themselves do not meet integrity requirements. Thus, while 100 satellites may seem a lot from an aviation perspective these satellites only “count” once they meet minimum performance standards. Mr. Turner clarified that the DOS does not determine technical requirements; these come from other Government agencies and international partners. The current goal is to ensure the principles of compatibility – to prevent interference among signals – and interoperability. The additional goal of interchangeability will be addressed in the future.

Mr. Turner presented information on current international signal plans, which are broadly aligned on the L1 and L5 frequency bands. The DOS is pursuing these plans through bilateral and multilateral settings, including the December



2008 International Committee on GNSS (ICG) meeting in Pasadena, California. In addition, the 2004 GPS-Galileo agreement resulted in the establishment of working groups for trade, technical, and service issues. Also, bilateral agreements were established with Japan in 1998; Russia in 2004 and India in 2007.

The ICG meeting in Pasadena included discussions among provider and user communities. The Providers Group engaged in long discussions on basic definitions, which led to changes to definitions agreed upon at the previous meeting in Bangalore, India. It would be desirable for definitions to be definitively “nailed down”, but it is unlikely to happen. Mr. Turner thanked Advisory Board member Ms. R. Neilan for her contribution to the success of this conference. The ICG has working groups other than the one addressing compatibility and interoperability: these include technical improvements; information dissemination and outreach; and interaction with monitoring and reference station network organizations. The latter has created task forces on geodetic references and time references. The next ICG meeting will be in St. Petersburg, Russia, September 14-18, 2009. In summary, international cooperation in space policy and space-based PNT is a top priority of the U.S. Government.

Dr. Schlesinger commented that while 40, 50 or 60 satellites may be available, the U.S. would only rely on them if a set of agreements were reached: what process did this involve? Mr. Trimble suggested an alternate possibility: if, in addition to GPS, there were two other independent global systems serving their own national interests and they were regarded as reliable, then the U.S. could, by monitoring their signals, rely on them. However, we cannot depend on partial systems or systems yet to achieve overall reliability.

Dr. Hermann noted that if every nation decided it had sovereignty requirements, then the total number of satellites placed into service would be more than any single nation would launch for its own needs. Historically, he noted, nations have, by treaty arrangements, relied upon other nations to do certain things and there could be an opportunity to do with GNSS. He made reference to Capt. Burns’ comments that a certain level of international cooperation is required to avoid having to put multiple “boxes” on each aircraft. However, while it is doubtful we are ready for this level of collaboration existed this prospect should be kept in mind so that current decisions do not inadvertently rule out future opportunities. The U.S. has a lead role to play in this.

Mr. Turner said DOS and other bodies are concerned with these issues. Discussions on global monitoring frequently occur within the GNSS community, including the interference and mitigation effort under the ICG work plan as well as the discussions on interoperability and integrity at its most its December meeting. Bilateral work with Europe includes discussions on how GPS and Galileo could evolve to provide better service to safety-of-life users. Additional comments to the GNSS interoperability on-going survey for may be submitted through the DOS.

Ms. Ciganer noted that Mr. Turner’s questionnaire on interoperability used the receiver complexity as one of the metrics while, on the other hand, there was only one reference to sustaining open market access; perhaps sustaining open market access could also provide useful leverage in minimizing receiver complexity. Mr. Turner agreed: open markets were important to the policy. Mr. Trimble said that from the commercial market point of view open access does not simply benefit commercial users, but all users – to add Galileo to a chip might cost 20 cents, while purchasing a separate Galileo receiver might cost \$100. Thus, open access allows for larger savings. Mr. Turner re-posted his chart on current international signal plans, calling attention to the frequencies available for open access and how this is important to overall private sector competitiveness worldwide. This, Mr. Parkinson noted, could allow for relatively simple interoperability. Mr. Trimble said that, to the commercial world, open access includes a requirement that there be no licensing. Capt. Burns commented that for civil aviation, L1 is at present the only consequential frequency for aviation and is likely to remain so for a decade until L5 is fully implemented.

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Galileo Program Update

Mr. Paul Verhoef, *Program Manager*  
EU Satellite Navigation Programs

This presentation covered European GNSS programs such as EGNOS and Galileo, and the relationship between the European Union (EU) and the U.S.

EGNOS is an augmentation to GPS developed by the European Space Agency (ESA) and funded by ESA and the EU. The system has been turned over to the EU for operation beginning April 1, 2009, with transition operations conducted by a short-term contractor. A long-term operations contract is being negotiated with a new company created by seven European service providers. Currently EGNOS includes seven remote stations and a number of stationary transponders. There have been some diplomatic difficulties in placing some stations in northern Africa. Service performance is excellent and the system has maintained 100 percent availability for eighteen months.

The new Galileo Open Service (OS) Interface Control Document (ICD) release is planned for autumn 2009.

Mr. Lewis asked about the funding source for intended extensions. Mr. Verhoef responded that funds for reference stations in the Middle East would come from the host countries, while in Africa host country funding was not available so aid funds would need to be secured. Ms. Neilan asked if such funding fell within the Lighthouse project; Mr. Verhoef said it would not and instead would flow through normal aid channels to the African nations and then back to his agency. To date, he added, these discussions are only at a political level. European nations are interested in improved navigation over Africa. Dr. Parkinson suggested that operations in Africa would require considerable data bandwidth. Mr. Verhoef noted that south of the Sahara there are atmospheric issues that remain. Further, should operations in Africa be an extension of the European system, or a separate system, poses questions of ownership, liability and performance. The solution might be a long-term program with evolution in EGNOS service and added value. Dr. Enge asked if Airbus was interested in EGNOS. Mr. Verhoef replied that Airbus said they would place the system on their aircraft although large airlines remained reticent, he added, not out of any technical concern but because of concerns they may be charged for EGNOS. His view is that market pressures would make EGNOS a reasonably attractive proposition. Mr. Verhoef noted that in the U.S., he's heard "competition, competition, competition" being praised but then when discussing EGNOS he's being asked why it could not be available for free. Capt. Burns said that potential user fees is not his airlines' major concern, though at present there is not a business case for equipping aircraft with a Wide Area Augmentation System (WAAS)-type receiver that operated only in Europe and Africa.

Mr. Verhoef said his first concern is to get EGNOS operational. Second, on Galileo the schedule will be clearer by year's end once the contract is awarded. Dr. Schlesinger asked whether the experimental satellites would be upgraded, or would serve as the model for operational satellites. Mr. Verhoef said design reviews thus far suggested only minor changes would be needed. The first test satellite (Giove-A) is now well beyond its test period, and its operations are extended on a year-to-year basis. Procurement contracts entailing security concerns are restricted to European Union companies whereas other contracts are open to international competition and a number of U.S. companies have entered contract discussions. Responding to a question on Galileo governance, which is not the fifth such organization, Mr. Verhoef said that he was a staff member of the European Commission.

Mr. Hall asked if all funds needed for full capability were in hand. Mr. Verhoef identified two funding phases: first, 2.2 billion Euro from the ESA and the EU; and second, 3.4 billion Euro from the participating countries. Dr. Schlesinger asked if this funding was sufficient to complete the constellation. Mr. Verhoef said costs should end near the funding limit, "plus or minus." Dr. Parkinson asked what type of contract was used: fixed, cost, cost-plus, or incentive. Mr. Verhoef said that depended on whether the contract was for hardware, service or supply. Mr. Smith asked the status of the Public Regulated Service (PRS), and Mr. Verhoef responded that member states were not in agreement on whether PRS should be used for military purposes only and while the UK is opposed other EU nations are strongly in favor. He believes this political discussion would continue for some time; however, from his perspective the discussion was immaterial as he was required by law to put PRS on the system. If, he added, the decision was made to use PRS for military purposes, it would place "100 difficult questions" on the table. If that was so, Mr. Smith asked, why put PRS in? Mr. Verhoef said PRS would address purposes -- beyond military ones -- of interest to various governments. Mr. Smith said no UK entity wanted PRS used. Mr. Verhoef acknowledged that the position of the British government was clear; he did not, however, see that as a consensus opinion among other EU partners.

On EU-U.S. relationships, Mr. Verhoef reported that EGNOS has a strong working relationship with the U.S., including various working groups currently in place. There is a strong, shared interest in compatibility and interoperability that goes beyond GPS and includes systems planned by other countries; further, talks are underway on defining common safety-of-life standards. He believed that compatibility and interoperability are primarily national security issues.

Interoperability is a more fluid concept. Agreement is needed with industry partners on what should be done through the marketplace and what should instead be done through international agreements. Mr. Verhoef noted that the trade working group was attempting to create as “level a playing field” as possible. The possibility remains open that a concession holder might charge for services, but this possibility has not been well received. Mr. Verhoef’s closing thought was that new global and regional systems are coming, spectrum is getting crowded, and continuous attention needed to be made to frequency issues.

Mr. Hall asked if ‘fleeting opportunities’ existed; did the current status of Galileo development present any matters that would require a joint U.S.-EU decision in the next year significantly affecting interoperability or other aspects? Mr. Verhoef said he was not aware of any such issue, and both Galileo and the U.S. are well aware of what each other are planning. While both parties are engaged in evolution/modernizations he does not see any issue as large as Mr. Hall’s question suggested. Dr. Parkinson asked about the relationship between L1 signals and COMPASS on wide-band signals, and Mr. Verhoef responded that progress in this area is not as quick as he would wish. A technical meeting with the Chinese is scheduled in the near future to discuss these issues. It has been decided to raise the matter at a higher level; specifically, at a China summit to be held in Europe the week following the Advisory Board meeting.

Ms. Ciganer asked if the first four Galileo satellites would broadcast the commercial encrypted signal. Mr. Verhoef responded that in principle they should, but at present a complete description of that signal is not ready. If a concession holder had been established that holder would have addressed this issue. A decision is needed, but the main concern is to ensure that first the contents of that signal be clearly defined technically Ms. Ciganer asked if some licensing would be required. Mr. Verhoef said this is as of yet unresolved. Efforts continue on two tracks: first, to ensure that technical requirements were being provided; second, to determine what to do on the service side. One possibility is for a Request for Proposals (RFP) to be issued, a vendor selected for a period of some years and asked to attempt to develop a market, and then follow on with a review.

Dr. Enge praised ongoing work on safety-of-life interoperability. He noted the interoperability/compatibility chart presented by Mr. Verhoef depicting the signal spectrum would, with luck, in the future include information on fault detection, fault rates, and the size of fault magnitudes. He hoped that GPS and Galileo could move forward in concert on this. Mr. Verhoef agreed and noted that various exploratory discussions are underway about what could be done jointly. He believes it is wise to focus on concrete accomplishments, particularly in the area of safety-of-life.

Mr. Miller asked, in relation to prospective charges for commercial users, whether offering the E6 signal at no cost for science applications was under consideration. Mr. Verhoef said the political authority which employed him had chosen a two-step approach: first, focus on the technical issues; second, make decisions regarding commercial matters. He could not, thus, project whether there would be a commercial portion to the system or how that system would operate. Search and Rescue services will be offered for free but he is not aware on what may happen with other services. Some Government ministries have asked why they should have to pay given that the effort had been financed by other ministries. His response has been they should address this question to the other ministries in their nation. He believes that operating a fully commercial system financed solely by the revenue that system produced would not be viable: GPS is free; other systems are free – so the context exists. Formal discussion of this matter, including a review of the economic underpinnings, had not yet occurred and a considerable range of opinions exist among the nations involved. Capt. Smith sought Mr. Verhoef’s comments on the European Radio Navigation Plan, and Mr. Verhoef said a working group has begun to address that topic and a serious effort would be made to move that work along.

Dr. Schlesinger asked how much of the 6 billion Euro budget was for acquisition of satellites. Mr. Verhoef said the budget for the first four satellites, which include most of the non-recurrent engineering expenses, is approximately 2 billion Euro. Budget targets have been established for the subsequent satellites but, since the contracts haven’t yet been awarded, he was not authorized to disclose them at this time.

Mr. Verhoef then added comments on the total number of satellites in operation, where he believes the discussion has two sides, linked but independent. On the civil side the world will see a large number of satellites, perhaps up to 150 satellites in orbit, but military applications of the U.S., China and Russia would see only their own 24 satellites. Therefore, two completely interests exist. Dr. Hermann commented that while he was not expert on military issues, if he were in the military he would find a way to make use of those other satellites in operation. Dr. Parkinson termed this statement as ‘visionary,’ adding that it remains to be seen whether military officials could be persuaded to share it.

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Presentation: Mitigation of Possible GPS BrownoutsDr. Bradford Parkinson, *Co-Chair*

This briefing is a follow-up to a Congressional staffer seeking an opinion on risks to GPS in light of the recent Government Accountability Office (GAO) report. GPS is vital to national infrastructure and to virtually every existing weapons system. The current service requirement is 24 satellites, but on any given day there may be 29 to 31 in service. While an independent review has urged the service requirement be raised to 30, it is probable that for the next five or six years the current number could “roll through”. This is of concern due to the potential for service ‘brownouts’, which could be aggravated by delays in the implementation of GPS IIF. It is hoped the first IIF launch will occur this year, and the GPS IIIA program is underway. However, while independent reviewers are enthusiastic IIIA is at this time still at the Preliminary Design Review (PDR) stage and no flight hardware yet built. There is a belief that progress is, in general, impeded by a complex multi-layered approval process. In comparison, the first GPS satellite, built when review processes were simpler, went from contract award to launch in 44 months. There are concerns, shared by Dr. Parkinson, that the constellation may fall below 24 satellites by 2018 and this should be cause for concern. Further, any effort to mitigate brownouts must employ signals compatible with GPS receivers already in use.

The practical problem is to supplement the constellation with six satellites by 2018, and there are for possible options:

- Option 1: Reactivate existing satellites.
  - This is something the Air Force is already addressing. Five satellites suitable for re-activation exist; while three or four of these lack complete functionality they could be turned on to supplement the constellation. The procedures for doing this are known and cost is minimal. On the ‘down’ side, these satellites are old and their additional service life uncertain.
- Option 2: Speed up work on GPS IIIA.
  - This may be difficult due to budget and funding processes.
- Option 3: Develop a simplified GPS ‘IIIS’ in parallel with GPS IIIA.
  - GPS IIIS satellites would not carry non-PNT payloads. The ‘boxes’ that would house such a satellite are already at PDR and could soon reach the Critical Design Review (CDR) stage. Removal of non-PNT payloads would enable launching these satellites in pairs and save, approximately, \$75 million per satellite. The ‘down’ side is that the capabilities of these non-PNT payloads would be lost and the fact that such satellites are not currently budgeted would strain contractor and program offices.
- Option ‘X’: Restart/Extend the GPS IIF Line:
  - Dr. Parkinson believes this has a ‘down’ side in that many IIF components may be obsolete, require redesigning, and the current design lacks the more powerful military signal and the new L1C signal for civilian user and compatible with Galileo Open Service (OS). This option presents significant near-term budget implications and, further, a re-design may require that bids be re-competed since it might differ sufficiently from the original design that contractors could insist it be re-bid.

Several of these options could be pursued simultaneously. Option 1 is already being pursued by the Air Force; Option 3 enables expansion of the constellation with satellites that do not carry additional functionality that would be required by users needing a 30-satellite constellation. Dr. Parkinson believes that the fourth option, or Option ‘X’, is a ‘non-starter.’ In any case, senior decision makers need to address this circumstance with some urgency.

Dr. Enge described Options 1, 2 and X as short-term; Option 3, however, offers a long-term approach. It is doubtful that the non-PNT functions on GPS have the same constellation requirements as GPS and, thus, unless Option 3 is pursued a mismatch will always exist.

Dr. Parkinson agrees with this observation and, thus, Option 3 enables one to “mix and match” the satellites in orbit to the needs of differing functions, which should result in savings. Any recommended action is, of course, for the entire Advisory Board to consider and agree upon.

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GPS Issues & Challenges (IIF, L5 & L2)

Brig Gen John Hyten, *Director*,  
Space Requirements Air Force Space Command

Commenting on Dr. Parkinson's remarks, Gen. Hyten does not believe GPS has a problem with constellation size. While there may be a risk, there is a two year margin in the schedule to launch additional satellites. Satellite IIR-21(M) will be turned on this summer: and three residual Block II satellites remained. Thus, 4 additional satellites, over the current 30 satellites in service, are available although 34 satellites in service is more than the current ground control system can accommodate. There are 12 Block IIA satellites at risk, but Gen. Hyten does not believe those satellites have issues that preclude power management techniques from working. Power management includes turning off secondary payloads off to ensure operation of the primary GPS navigation mission. The larger problem is those satellites are operating on their final clock, which would render the satellite useless should it fail. It is very difficult to predict how long a clock will last. The current constellation is the strongest in GPS history, and the Air Force has confidence in the GPS IIF and IIIA programs. From the latter, many lessons have been learned on how to manage weight issues on future satellites.

Dr. Schlesinger expressed reservations about the GPS IIF program, recalling that he had planned to be present for its originally scheduled launch in 2001. Dr. Hyten noted that the first IIF satellite has been already shipped to Cape Canaveral for testing. Mr. Trimble asked about the status of the latest IIR(M), which incorporates an L5 demo signal, and Gen. Hyten responded the satellite had been turned off after a review identified an anomaly in its signal; while the Air Force believes it has determined how to remove the error the satellite will remain 'unhealthy' until the cause of the error is established.

Recent GPS successes include the replacement in 2007 of the 22-year old GPS Master Control Station with a seamless transition, scheduling of launches of the final IIR-M and first IIF; and validation of the GPS III Capabilities Development Document (CDD). The GPS III requirements document is 440 pages long and contains 'every requirement ever thought up by humankind', which is regarded as a significant issue both within the GPS Program and across the Department of Defense (DoD). The 'high level' view at the DoD is that such documents tie the hands of program managers and acquisition managers. A recent DoD report highlights how it believes the requirements processes should be simplified.

GPS satellites will eventually broadcast a total of eight signals – four military, four civil. Broadcasting eight signals takes power off the satellites – this raises the question: if power becomes low, which signal should be turned off? Any decision made will affect some users. While transitioning off given signals might not occur for 10 or 20 years, policy decisions made now have implications future users.

Gen. Hyten acknowledged receipt of a letter from the U.S. GPS Industry Council expressing concern that Pseudo-Random Noise (PRN) codes did not adhere to a sound interagency review process, and noted that the National Space-based PNT Engineering Forum (NPEF) would review those processes and make recommendations.

The Military GPS User Equipment (MGUE) will bring M-Code capability to the warfighter. The desire is to take advantage of all the capabilities available from this signal, and chip-code technology in future receivers will enable military users to use M-Code. An on going issue is whether to create a single large system that could survive in all the environments – at sea; in the desert; etc. – or a set of number of smaller systems tailored for each one.

Gen. Hyten referred to the Government Accountability Office (GAO) report on GPS satellite availability and reemphasized ongoing mitigation efforts for bringing residual satellites back online as well as power management. He noted the addition to GPS III of mission assurance practices that had not existed when contracts on GPS IIF were issued. When contracts are put together in certain ways it becomes difficult to identify where problems may be occurring. He agreed with Dr. Schlesinger's comment that until IIF is launched and put into service questions will remain. However, he is confident the program is considerably closer to success. In summary, Gen. Hyten believes GPS is healthy; that efforts to develop and deploy civil signals are moving forward; that the GPS program is teaming with NPEF to review the PRN code assignment process; that MGUE will improve GPS capabilities for warfighters; and that a new acquisition approach is necessary.

Dr. Schlesinger asked Gen. Hyten to define 'healthy', since there is a perception that the GPS constellation is, metaphorically speaking, in an oxygen tent." Gen. Hyten responded that the 34 usable satellites in orbit is the highest ever, which provides a lot of flexibility. Mr. Trimble asked if Gen. Hyten believed the constellation was in better shape than two to four years ago, to which he responded that this was the case since the risks to GPS have been identified. There is, of course, some concern with 12 GPS satellites being on a "watch list". Dr. Parkinson commented that while the constellation might be at its largest, it is also at its oldest. Gen. Hyten acknowledged this. Dr. Hermann asked if Gen. Hyten had a running estimate of the number of effective satellites available over the next five to 10 years, to

which Gen. Hyten replied that long-term analyses have been run and shown that there is margin within the current system even without factoring in the residual satellites. A lifespan analysis of the residual satellites is in progress. If IIIA proceeds as planned there is a two year margin when including the residual satellites.

Dr. Hermann asked whether the ground control system established a constraint on number of satellites that could be used. Gen. Hyten said this was the case, as is also the case with some user capability issues. Dr. Hermann asked if the system might fall below 24 healthy satellites over the next decade, Gen Hyten said that as he interpreted the data the required number of satellites would remain available. Gen. Hyten said the desire is to remain at around 30 satellites, which is a good number considering all the needs, but no additional satellites beyond those currently planned would be required to meet the fundamental requirement.

Dr. Parkinson provided data on a satellite availability analysis, though it did not include the residual satellites. This analysis includes 'gap charts' for 30, 27 and 24, and they show that some threat exists to 24 even assuming GPS IIF to begin deployment in 2009 and assuming no problems once in orbit, as well as IIIA remaining on schedule. Dr. Parkinson acknowledged that the residual satellites would make a difference; so long there isn't a substantial slip in IIF, IIIA, or a launch failure.

Mr. Hall asked if Gen. Hyten had any suggestion on where discussion of signal transition should begin. Gen. Hyten urged the Advisory Board to elevate this matter to the PNT Executive Committee (EXCOM) as signal transition is not solely an Air Force issue and requires broad engagement. Asked by Mr. Hall what policy he would advocate, Gen. Hyten said he would urge that a study be made to decide in what sequence signals would be discontinued. Dr. Hermann said such a study would not be trivial. Dr. Parkinson said any approach should involve all stakeholders and everyone be allowed a chance to speak. Mr. Trimble said that from a commercial perspective the easiest way to move forward is to ensure that any new signals provide at least the same capability as the signals they'd be replacing. This has been a particularly 'sticking point' as it relates to maintaining phase stability on the new L2C signal. If this issue is resolved satisfactorily then manufacturers will be motivated to move earlier onto the new signals while providing customers with a seamless transition. Ms. Ciganer added that it is the single-frequency manufacturers on the GPS Industry Council who are most concerned with the performance on modernized signals to at least equal legacy performance.

Ms. Neilan asked if Gen. Hyten has worked with the requirements process on programs other than GPS, to which he responded he has done so for every Air Force space program. Ms. Neilan highlighted the previous comments about the complexity of this process and asked how this could change? Gen. Hyten called attention to Dr. Parkinson's comment that a structure had been created that allowed everyone to weigh in on the process and to delay things until their own particular concern was addressed; in consequence, he said, the documents to be reviewed have expanded fourfold. This process needs to change, and would do so once it gets support from senior decision makers. Dr. Parkinson said that one problem in the current process is that there was virtually no way to determine who had placed any particular requirement into the document. Gen. Hyten said this is being addressed and single focal points are being created for Army and Air Force requirements whereas before these had come from various offices.

Dr. Parkinson advocated for a streamlined process that goes all the way down to manufacturers and users. Gen. Hyten said that, taking the long view, the acquisitions process is much better now than two years ago and hopes to replace the current 440-page document with a 30-page document that describes capabilities, but not specify every subsystem.

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FAA SatNav Program ProgressJ. C. Johns, *Director*

Navigation Services, FAA

This briefing addressed WAAS and Local Area Augmentation System (LAAS), and provided an overview of the Automated Dependent Surveillance Broadcast (ADS-B) status.

WAAS provides a regional augmentation to GPS down to Instrument Landing System (ILS) Category I while LAAS provides local coverage in the vicinity of an airport. As of March 2009 Garmin had sold 43,000 WAAS receivers, 1516 Localizer Performance with Vertical guidance (LPV) have been published at 832 airports including 356 for airports that previously lacked precision-approach capabilities. The goal is for 6,000 approaches to be available by 2018.

Dr. Hermann asked if the equipment needed is particular to the U.S., to which Mr. Johns responded that U.S. standards are being adopted by other Space-Based Augmentation System (SBAS) providers worldwide and his office is working to ensure the system's interoperability with Galileo and EGNOS.

Capt. Murphy commented that different regional systems would require global carriers to employ multiple systems – e.g. EGNOS does not provide a ranging source while WAAS does, or the Japanese system does not support precision approach. While a receiver purchased in the U.S. may work in other environments what the receiver provides depends on what services are available locally. Thus, while an LPV approach may be possible in all locations there are also other requirements, including runway lighting systems and visibility. Mr. Johns acknowledged that while it would be possible to seamlessly fly a receiver acquired in the U.S. into non-U.S. airspace, operationally the services level would not be the same.

A LAAS Category 1 (CAT-1) system has approved for Memphis by the end of 2009; CAT-III prototype validation is expected by 2010; and Cat-III system design should be approved by 2012 with the first delivered system that year. Cat III capability will permit a single LAAS installation at O'Hare Airport to service all runways now separately serviced by ILS, with considerable savings. Capt. Burns asked when LAAS may be deployed in the first 35 airports, since having "something on paper" would support his airlines' discussion with manufacturers. Mr. Johns said no current plan exists. Capt. Burns asked if deployment would follow system design approval by four or five years, and Mr. Johns responded he could not say. Dr. Parkinson said airlines want to know what lead times were applicable, and Capt. Burns responded that airlines do their capital planning years in advance. Mr. Johns acknowledged that more information is needed for long term planning.

ADS-B will eventually replace radar, and although some people may call it a space-based surveillance system no system component is located in space. Mr. Lewis asked if ADS-B requires one to have a transponder; Mr. Johns said it did. Mr. Johns described the dual track strategy for ground infrastructure and avionics equipment, which is intended to accelerate the program and all efforts are currently on schedule. Mr. Johns also presented an overview on the Aviation Rulemaking Committee and the recommendations provided to the FAA in September 2008. Mr. Johns cautioned that the ADS program may be entering a difficult period in transitioning from an advisory role to developing safety certification procedures. The WAAS program had also become "somewhat bogged down" during a similar transition. There is a recommendation for the FAA to partner with industry to define an ADS-B strategy by 2012 which, if implemented, should allow for an earlier introduction of information and traffic services.

In summary, the WAAS program is maturing and should be up and running in five years and the ADS-B program is on track. The FAA has faced "a difficult phase" where those conducting the agency's five-year budget reviews failed to understand why WAAS funding remained at a given level, and did not appreciate the transitional costs when moving to a new navigation system. Mr. Johns is confident the CAT-III 2012 target will be met and that the ADS-B program is on track.

Dr. Enge asked whether there is an advantage in deploying Ground-Based Augmentation System (GBAS) CAT-I once WAAS CAT-1 is implemented. Capt. Burns replied that currently there is no business case for GBAS CAT-I, although the case is better for CAT-II and CAT-III. Capt. Murphy added that while GBAS CAT-1 may not offer added value in the U.S., there is a market for it outside the U.S., and added that the absence of an FAA program to purchase and field CAT-I GBAS may be the cause for the delay. Mr. Johns clarified that a number of CAT-I GBAS systems are already in place around the world. Capt. Murphy acknowledged that if GBAS may be somewhat held back due to a perception it is a replacement for ILS even though in reality it outperforms ILS.

Mr. Johns added that the earlier thinking had been to "build WAAS and they will come", but now it is acknowledged that users first need to see the operational benefits. Capt. Murphy said he believes the ADS-B program could be going down "the same bad path" as WAAS had gone, that is, focusing on how to retire existing technology instead of

emphasizing the benefits that flow from redesigning the airspace. Capt. Burns expressed agreement, and noted that the ADS-B's 'best case' calls for decreasing aircraft spacing requirements only from 5.0 to 4.6 miles. Mr. Johns said the FAA is moving towards the view that aircraft spacing requirements will not be decreased without GPS augmentation systems.

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Satellite Laser Ranging and Rules of the Road for the International Laser Ranging Service

Dr. Mike Pearlman

Harvard-Smithsonian Center for Astrophysics

Satellite Laser Ranging (SLR) is the precise range measurement between a ground station and a retro-reflector equipped satellite by means of ultra-short laser pulses corrected for refraction, satellite center of mass, and the internal delay of the laser ranging equipment. He noted that "our wavelengths do not interfere with your wavelengths." Laser ranging activities are conducted under the umbrella of the International Laser Ranging Service (ILRS). SLR provides a direct range measurement and data is available in near-real time. This technique enables to detect small changes in range by means of brief ranging campaigns conducted over long periods.

Currently the ILRS network of stations tracks approximately 30 of the 60 retroreflector-equipped operational satellites in orbit. There used to be a gap in the southern hemisphere but as of late there has been cooperation with China (which has a station in Argentina); Germany (which has a station in Chile), and NASA has added a station in Peru. There is a broad range of technologies in use, with some stations being new and others 20-30 years old. The next generation of SLR systems developed by NASA, called SLR 2000, will replace many older stations and equip new ones. There are procedures in place for nations to determine go / no-go windows for laser ranging onto their satellites.

Dr. Parkinson noted that in the 1970s, some satellites – rather than employing a laser reflector – pasted "scotch-lite" on their surface. Would it be possible to use this approach? Dr. Pearlman replied that this would not be practical for the types of measurements currently sought. Dr. Parkinson noted that GPS IIIA satellites would not carry retro-reflectors and asked whether one could "glue something" to obtain a return laser return. Dr. Pearlman responded that a large reflecting surface would cause the signal to spread out on its return, and thus degrade accuracy. Dr. Parkinson asked if such an approach would be better than nothing. Dr. Pearlman replied: "Off the top of my head, no."

Dr. Pearlman presented information on Lageos and Jason-2. to which Ms. Neilan added those also carried high quality GPS receivers which greatly increased the quality in laser range measurements. Some of the satellites currently being tracked are 45 years old, and there are procedures on how to list new satellites for laser ranging. Only satellites providing direct benefits to the community may be included, which excludes purely commercial ones. Laser ranging to GPS have shown that GPS radiometric measurements and laser tracking readings are off by a few cm. Five years ago this difference was 6-8 cm. While this is an improvement it shows that there is still 'something' not fully understood. Laser ranging to the different GNSS systems supports their interoperability. It should be noted, however, that SLR would not track 120 satellites at one time. Currently only 8 GNSS satellites are tracked at any one time.

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LORAN-History & Need

Mr. James Doherty

Institute for Defense Analyses

Mr. Doherty reported that an independent review of LORAN began in August 2006, sponsored by the Undersecretary for Policy at the Department of Transportation (DOT) and the Deputy Undersecretary for Preparedness at the Department of Homeland Security (DHS), and in December 2006 reported that the nation is highly dependent on PNT in the civil world and beyond and that a universal backup such as LORAN was needed. PNT users include safety (aviation, maritime, alerting and dispatching first responders and others) and critical economic activities (e.g. tracking of “just-in-time” inventory while in motion), and backup provisions tend to be legacy systems that exist on a mode-by-mode basis (e.g. lighthouses were a maritime backup; not an aviation backup). Thus, in the event of an attack on GPS service, an “un-jammable” backup like LORAN would be greatly advantageous. Given the large user base in this country, if the U.S. Government designated LORAN as its backup of choice, then users in other countries would likely follow suit.

There are some advantages to E-LORAN. First, the ‘big money’ expense associated with transmitters have already largely been met. Second, E-LORAN technology is ‘tested and in view.’ Third, E-LORAN is ‘free’. The worst case estimate for system completion is \$143 million and the estimated cost of eliminating current infrastructure is \$146 million. Thus, the program could be implemented by sustaining the current annual expenditure of \$30 million. The importance of a backup system was highlighted by the difficulties in locating a source of interference. During the ‘San Diego incident’ it took 36 hours to locate the interference source to within one mile. Had E-LORAN been operating, no disruption of service would have occurred. This conclusion had been reported to the PNT EXCOM in March 2007.

Dr. Schlesinger asked why this presentation was necessary, since the Advisory Board long ago already endorsed E-LORAN as had the EXCOM. The pertinent question might instead be why this recommendation had not been followed-through. Mr. Doherty explained that in February 2008 DHS issued a statement strongly supporting E-LORAN as the backup and leaving its operation within the Coast Guard, but then in February 2009, OMB announced the decision to turn off LORAN-C. To determine why things “fell apart” one needs to look inside this decision. Mr. Doherty in his discussions with the Coast Guard prior to February 2009 characterized his message as: “you have it; you own it; Congress wants you to complete and operate it.” Thus, he recommended that the Coast Guard determine how to automate the augmented stations, allowing it to remove 200 people from current operations, and direct those savings to E-LORAN costs. When the E-LORAN decision was reversed, Mr. Doherty was “shocked and flabbergasted.” Dr. Schlesinger noted that the EXCOM and DHS had recommended go moving forward, so perhaps the Coast Guard should be contacted by those in Congress responsible for their appropriations.

Mr. Shaw clarified that the recommendation came to the EXCOM from DoD and DHS and the EXCOM endorsed this decision. However, from a DoD perspective, LORAN is not considered a credible backup since it only covers North America. From an FAA perspective, LORAN is a tertiary backup – if LORAN were fielded, it is doubtful air carriers would equip for it. From a maritime standpoint the Commandant of the Coast Guard believed an adequate backup already existed without E-LORAN. Furthermore, the Maritime Transportation Advisory Committee also said that a backup adequate for commercial shipping already exists. In general, the transportation functions have stated that adequate backup exists without LORAN. As for DHS, after its endorsement of LORAN, it contacted the various stakeholders of the National Infrastructure Protection Plan and received a mixed response. Based on all of this, OMB ordered termination of LORAN-C in the FY10 budget.

Dr. Parkinson said that in its early days GPS encountered similar “headwind”, and the Air Force tried to cancel the program on several occasions. The purpose of the LORAN independent assessment was to figure out what was in the *national* interest, not the parochial interests of various agencies. This problem will continue until someone exercises ‘leadership’ on the matter. E-LORAN is virtually without cost and this is the point that needs to be emphasized.

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E-LORAN INTERNATIONAL

Dr. Sally Basker, *Director*,  
Research and Radionavigation,  
General Lighthouse Authorities, UK

Sir Jeremy De Halpert, *Executive Chairman*,  
Trinity House, UK

Admiral De Halpert explained that Trinity House is not a UK Government department but, rather, is funded by shippers and serves as the national pilotage authority. The UK has been developing E-LORAN for the past six years and has great faith in it as a backup to GPS. The UK has 20,000 miles of coastline and the Dover Straits are the busiest shipping lane in the world, with more ship traffic than aircraft landings at Heathrow Airport. The sea east of England is the fastest changing sea lane in the world and, thus, requires resurveying every three months. Only two approved systems exist to aid navigation as sea: GPS and direct visual referenced navigation with radar backup. The British experience is that except for military ships, well-run container ships, and few others, there is no real capacity to revert to direct navigation. It is dangerous to tell ships' captains that if GPS fails they should revert to something with which they've had little experience. Trinity House has been seeking for alternative solutions and E-LORAN is essential to this effort.

British investments in E-LORAN began in 2004 and the signal was declared operational in January 2008. Dr. Schlesinger asked if this investment would have been made had it been known the U.S. would withdraw support from E-LORAN, to which Admiral de Halpert responded that the investment was made in concert with similar French efforts and because they believe E-LORAN is the future of navigation and work well on Europe's coastline. The issue, thus, is to then convince users worldwide that this is 'a going system', which is something that would require U.S. support.

Dr. Schlesinger raised hypothetical question regarding another shipping lane, the Bosphorus channel between the Aegean Sea and Black Sea. This channel is considerably narrower than the English Channel and, for some years, Turkey has talked about the possibility of restricting tanker traffic because of the risk of collision. If interference with GPS would occur then it would be very likely Turkey would opt to restrict ship traffic with a potential for impact on oil markets. Did Admiral de Halpert share this view? Admiral de Halpert said he did and noted that while both the English Channel and the Bosphorus are international waters, Turkey now controls ship movements through the Bosphorus. Similarly, one could consider the possibility that at some future date "more positive control" could be exerted over shipping through the Dover Straits. Ship owners would not like how this could affect their scheduling, but maritime safety and environmental safety are the priority concern. Dr. Schlesinger observed that the economic impact in taking such steps is disproportionately greater than the cost to complete E-LORAN.

Dr. Basker presented a slide on current LORAN locations and noted that 72% of the world's 50 largest seaports are served by LORAN, and all could be upgraded to E-LORAN. India has delayed decommissioning its system pending a U.S. decision, and Norway is anxious to keep LORAN she added that Norway – concerned with increased Russian ship traffic through shrinking ice sheets – was anxious to keep LORAN operating. Dr. Basker presented the relevant policy perspective, which noted the importance of radio navigation; the dominant role of the U.S.; and the February 26 statement from OMB announcing the intention to decommission LORAN-C. She presented a commercial perspective, which asserted that extension of E-LORAN would create a significant market opportunity that would best be taken advantage of by the U.S. She estimated the international market for E-LORAN at \$5 billion.

Dr. Basker said British law enforcement authorities are increasingly concerned with the frequency with which GPS jammers are being used to steal high-end automobiles equipped with GPS-based tracking devices. GPS underpins much of Britain's critical infrastructure, so when GPS is lost the economic impacts are severe. A 24-hour blackout across Europe could result in losses as much as 3.5 billion Euro, which is comparable to the cost of the 2003 blackout in North America. Another example is that of a small container vessel that in January 2007 suffered a catastrophic navigation failure and beached on England's south coast, and to-date the cleanup has cost over 120 million pounds (~\$180 million). Building a business case for LORAN based on risk is not a straightforward exercise, but decommissioning LORAN represents a lost opportunity whose cost impact was likely to increase "exponentially" in future years.

Dr. Basker described the effects of a 1.5 Watt jamming device, which are potentially hazardous to ships at sea including, among other things, the bridge crew finding the sounding alarms to be hugely distracting. There are also problems in reverting to traditional navigation techniques, since 80% of accidents at sea are already caused by human error and this had the potential to further increase this rate. In summary, a U.S. decision to back E-LORAN would be welcomed worldwide many nations are looking for U.S. leadership on the matter.

Dr. Schlesinger commented that many in the U.S. thought the recent Presidential election had replaced an Administration allegedly insensitive to the views of its allies with a more sensitive one. However, it turns out the U.S. has, unilaterally and without consultation, terminated a program it had previously pledged.

Mr. Dimmen commented that Norway is cooperating with France and on an operational level in the North Sea, and in 2008 Norway decided to continue operating LORAN. In addition, Russia has initiated a shared venture with Norway to improve LORAN coverage over the Bering Sea, which comes at a time when Russia is also using Glonass, the Russian GNSS.

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DHS GPS Interference Detection and Mitigation (IDM)

John Merrill, *DHS GIS Program Manager*  
DHS Office of Applied Technology/  
Geospatial Management Office

Mr. Tim White, a contractor with General Dynamics working with the National Coordinating Center for the National Communications System (NCS), briefed for Mr. Merrill on the current Interference Detection and Mitigation (IDM) mandate, GPS dependencies, and current preparedness activities.

Dr. Parkinson asked whether he operated a jamming device at that moment from his sea, how soon would it be identified? Mr. White said no existing plan could handle such an incident within a 'golden hour' although that capacity would be developed. Dr. Parkinson expressed concern that since mitigation has been discussed since 9/11, a systematic response should be in existence by now. Mr. White agreed, but also explained that there have been several transient interference events below noise levels that had indeed been detected through Federally-operated systems. DHS is working with the communications industry, where a wireless provider may detect interference not picked up other detection equipment.

Dr. Parkinson asked whether there is a specific point of contact at DHS that could protect PNT users by pinpointing jamming sources. Since this is not the case, a "plan" cannot be termed to be in existence until the persons responsible for its execution are identified and milestones established. Mr. White responded that John Merrill's office is currently working on the problem from the repository perspective. Mr. White presented the Threat Assessment and Operations Plan.

Dr. Schlesinger noted that this plan, by removing any backup system, increases dependency on GPS. Mr. White said that was not the intent, even though it was clear that dependence on GPS would increase in all sectors.

Mr. Miller commented that while those involved with GPS understand the system requirements, most users do not and often a user's reaction to a problem may take days.

Ms. Neilan asked if this activity was, perhaps, too diffused within DHS instead of a single office holding responsibility? Mr. White responded that certain offices have picked up particular mandates, and they're hoping their missions would become clearer by year's end. Ms. Neilan asked if Mr. Merrill was the coordinator, to which Mr. White said that was indeed the case.

Mr. White presented information on the requirements for a Central Data Repository. Capt. Smith noted that the discussion seemed to focus on detection, but not mitigation. Mr. White explained that he believed identification allows for mitigation, and presented described a proposal for a system called Patriot Watch, which is designed to provide real-time monitoring, location, and notification of GPS interference. Sensor placement is crucial to ensure they are able to identify and characterize signals quickly. A backup system would be needed in case strong jamming overwhelm the system. Dr. Schlesinger said the Board had been urging E-LORAN as just such a system. Mr. White explained that initially hundreds of Federal sensors would be used – from the National Oceanic and Atmospheric Administration (NOAA), the Federal Aviation Administration (FAA), and the U.S. Coast Guard. Dr. Parkinson asked whether cell phone towers could provide rapid reporting, to which Mr. White responded that cell phone towers issued no reports during the first 60 seconds of interference. Therefore, if someone repeatedly re-locates a jammer even by several blocks there is no current capability to detect it within a 40-block by 40-block area. This inability to resolve interference occurs in places like, for example, 'sensor-rich' Manhattan.

In summary, the Central Data Repository will be funded by December 2009, and the vulnerability assessment should be completed by early 2009/2010, and a national-level sensor capability established in three to six years.

Mr. Dimmen noted that, for example, if no backup exists one might need to build a mitigation plan that shut off an interference source in one hour; if, however, E-LORAN is available as a back up then a less rapid plan might suffice. In another example, all sensors could perhaps be used as radiators with backup capability coming from cell phone towers. Was this second option possible? Mr. White said he had heard no engineering discussion of this, but it could be possible.

*The Thursday, May 14, 2009 session adjourned at 5:42 p.m.*

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*Session of Friday, May 15, 2009*

Board Convenes:

Ms. Rausch, Executive Director, called the session to order and turned the meeting over to Dr. Schlesinger, Chair.

Advisory Board Discussion

Dr. James Schlesinger, *Chair*

Dr. Schlesinger asked for suggestions on how to bring the E-LORAN proposal back on the table. Mr. Lewis said a paper could be prepared on the subject and believes that Congress remains interested in this issue. Dr. Schlesinger sought names of members of Congress serving on the Appropriations Committee that support LORAN. Mr. Lewis commented that the Coast Guard had long sought E-LORAN's cancellation to reduce their overhead expenses. Dr. Parkinson said former Senator Stevens (Alaska) has been a strong supporter of E-LORAN. Dr. Enge identified Senator Collins (Maine) and Representative LoBiondo (New Jersey) as also being supporters. Dr. Schlesinger suggested that the report on LORAN from the Independent Assessment Team (IAT) could be presented to them. Dr. Parkinson seconded this proposed approach. Mr. Lewis added that since the decision had come from OMB a high-level discussion would be needed. Dr. Schlesinger noted that PNT EXCOM contained an Office of Management and Budget (OMB) representative. Ms. Neilan pointed out that the draft version of the Board's recommendations for 2007-2008 did not contain a statement on E-LORAN. Dr. Parkinson termed this a major omission and Mr. Miller said such a recommendation would be added. Miller noted that the forthcoming June 18, 2009, PNT EXCOM meeting would provide an opportunity to put PNT priority issues on the table, including that of GPS backup.

Dr. Schlesinger sought Capt. Smith's view of the final Thursday presentations on DHS Interference Detection and Mitigation. Capt. Smith characterized the presentation as requiring further definition before it could be considered a plan. Dr. Schlesinger characterized the presentation as that made by a contractor, not an official of the agency in question, which made it difficult for the presenter to address policy issues. Dr. Schlesinger asked Capt. Smith whether he anticipated an international reaction would be negative to the U.S. cancellation of E-LORAN, to which Capt. Smith said he believed that would be the case and, as a result, international LORAN was likely to be discontinued in the long term. Mr. Lewis asked if this would occur even in the event of significant collisions at sea due to navigation failures preventable had E-LORAN been in place, to which Capt. Smith responded he believed that would be the case and, in any case, technologies other than E-LORAN would still exist. Dr. Parkinson foresees additional difficulties in congested shipping lanes such as the St. Lawrence Seaway, but acknowledges the Coast Guard had not identified this as a significant concern. Capt. Smith added that E-LORAN was most effective in deep water offshore: it would be useful in places such as the Straits of Hormuz, but not essential as the waters there were very deep. Queried by Dr. Schlesinger, Capt. Smith said he doubted the British Government had a formal paper on the subject, but would inquire.

Dr. Schlesinger commented that if foreign governments remain silent on the cancellation of E-LORAN then the U.S. Government would not be aware of their equities. Capt. Smith believes European governments will support E-LORAN. Dr. Schlesinger asked who was responsible for developing the next National Security Presidential Directive (NSPD) on space policy, to which Mr. Miller explained it would be the White House Office of Science and Technology Policy (OSTP) and the National Security Council (NSC) that would initiate such a policy review, although these two bodies have not yet identified this as a priority task.

Dr. Schlesinger asked what shortcomings need to be addressed in the current NSPD for space. Mr. Lewis noted, relative to PNT EXCOM, the fact that the Co-Chairs were both Deputy Secretaries had already raised the level of interest; further, it is the first time the process includes OMB. Mr. Lewis added that the EXCOM has clearly stated that proceeding on E-LORAN is in the nation's best interest, although it does not have the authority to direct a particular example to execute this task.

Dr. Parkinson raised the issue of how civilian commercial requirements may enter the process. Currently most civil representation comes from the aircraft industry even though most GPS users are not in aviation. Ms. Ciganer noted the Presidential statement that the U.S. would sustain a *preeminent* military and a *competitive* civilian system; this indicates a split in equities. Dr. Parkinson said he had been pleased to hear during the Thursday sessions that senior DoD leadership had concluded that the requirements process was “the pits.” This may have been triggered by reaction to the 440-page GPS requirements document. Gen. Lord said ambiguity in the new process would revert to the Air Force as a stewardship issue, and he would speak to Gen. Kehler to support his effort to “lead the charge” to reinvigorate the policy process.

Mr. Hall served in 2008 on a Congressional committee that reviewed management of national space policy, including PNT, and added that while the review had not been highly detailed the conclusion was that current national space policy was “pretty darned good” even though there were some problems in its implementation. This committee recommended reestablishing the National Space Council, under the National Security Advisor, to engage all stakeholders in carrying out a national space policy. Dr. Schlesinger asked about the response to this recommendation, and Mr. Hall said it was too early to tell, but he believed members of the Obama Administration were taking cognizance of the issue. Mr. Hall added that the committee had also recommended all space components of national security within a single entity, under a newly-created DoD Undersecretary for Space, but this recommendation had not been well received by the agencies that would be combined.

Gen. Lord noted that the DoD is articulating a policy that calls for greater international support for matters affecting U.S. security and, perhaps, this interest could translate into support for E-LORAN. Dr. Parkinson termed this an excellent suggestion.

Mr. Lewis commented that the Department of State undertakes what it is told to do, but issues persist as to who ‘does the telling’, and he doubts existing EXCOM structure allows it to provide direction. Higher level direction may be needed as some issues have implications beyond individual agencies. Also, Mr. Lewis believes that the DoD, in portraying E-LORAN as not being global, is not appreciating the fact that that most Navy ships use it for backup. There appears to be a void when dealing with the international issues of GPS. Dr. Schlesinger added that because the advocates of Galileo have argued that GPS is dominated by the military, Dr. Schlesinger agreed: one reason the PNT Advisory Board had been established was to bring international perspectives to U.S. decision-making. He noted that advocates of Galileo had argued that GPS was U.S. national interest, dominated by the military; the Board had been internationalized as an antidote to that. The Advisory Board’s report will state that both it and EXCOM had embraced E-LORAN, only to see it disappear, and as a result it is concerned about the issue of GPS backup and the U.S. unilaterally cutting it off after years of urging other nations to fund LORAN. The E-LORAN issue not only affects Western European allies but also Russia, with whom relations are being “re-set” and the cancellation of E-LORAN is not helping.

Dr. Parkinson asked whether a ‘higher level’ body than the EXCOM may be needed. Mr. Miller noted that EXCOM representatives include nine Federal agencies, membership from the NSC, and a senior member of OMB. Also, the June 18 PNT EXCOM meeting will include new people in those positions and, thus, he urges the Advisory Board to formulate its position and convey it to EXCOM in advance of that meeting. Dr. Schlesinger noted the proposed revival of National Space Council and asked whether the NSPD was so weighted with ‘space concerns’ that it had forgotten the purpose of space activities is to serve people on Earth and, thus, space policy may need to be adjusted so issues like as user equipment on earth are not shortchanged. Dr. Schlesinger added that the Bush Administration had initiated a strong policy statement on cyber protection and the Obama Administration is taking an even more forceful view. Dr. Schlesinger also believes that protection of space-based assets needs to be a more explicit focus in the forthcoming NSPD.

Mr. Lewis, referencing earlier discussion on how GPS enabled energy efficiency, noted this is a goal of the current Administration and he believes the “point has been passed” in defining national responsibilities beyond defense and security. The expansion of GPS capabilities has largely been achieved by civilians (Dr. Parkinson noted the first GPS receiver had cost \$500,000 to develop and produce) and since 1997 the goal in issues of military vs. civilian needs is one where both sides should win but, unfortunately, problems remained with “stovepipes wishing to beat their own drums.”

Dr. Schlesinger urged the Advisory Board’s recommendations to emphasize that E-LORAN is a national priority that supersedes the narrow interests of any one agency and desires to avoid expenditures. Addressing national and international issues requires moving beyond expressions of interest of individual agencies.

Dr. Parkinson referred to reports that the Air Force will be forming a Cyber Command, with responsibilities for protecting information, and Gen. Lord confirmed this. Dr. Parkinson asked if one could argue that because GPS is

about disseminating information, perhaps, its defense needs to be placed under a Cyber context. Mr. Lewis drew a distinction between 'cyber' (protecting data) and 'information' (interpreted data), the latter which is more than data and unless information is communicated to someone there is no basis for asserting that knowledge has been delivered. GPS has two major components: one is enabling the delivery of information, and the other is the ability to distribute it in such a way that users have access when needed. These two components, when merged, provide a larger picture than thinking of GPS in terms of only satellite security. Is someone receiving data from GPS that enables them to add it to other data being collected and then relay this information to another user? The needs of navigation drive the requirement for global capability, but navigation is no longer the sole purpose of GPS since, for example, there are already far more timing users. People may be aware of the utility of GPS to their automobile, but are unlikely to know how it was important to their being able to get money from an Automated Teller Machine (ATM) or to talk worldwide on a cell phone. The basic backup source available to such users today is E-LORAN.

Dr. Enge believes the need for E-LORAN appears to be self apparent and it is distressing to see that this ground-based system is being deployed worldwide but not in the U.S. What strikes him the most are related events in education and innovation, such as certain programs on transportation tracking at Stanford University. This project, he noted, was being funded by Saudi Arabia for implementation in Bangalore. There appears to be great intellectual interest elsewhere in furthering GNSS technology and the U.S. needs to keep pace since any aspect of GPS could be replaced by Galileo. Dr. Schlesinger urges a paper be developed on this subject and asked Dr. Enge about American young people working in this area. Dr. Enge said such young people exist but their population is declining. Mr. Lewis reported that, increasingly, technical papers on GNSS are of non-U.S. in origin and this should be of concern to the EXCOM.

Dr. Parkinson made reference to a GPS "Industry Day" where in terms of user equipment military-derived equipment had lost the marketing war and was "hopelessly antiquated" in user interface. The "state of the art" is now being driven worldwide. Ms. Neilan said, in terms of the U.S. education system, that while some "pockets of excellence" exist a number of institutions -- including Ohio State, Colorado and Purdue -- have closed the departments they had working on GPS applications. Centers for excellence are now stronger in nations like Germany, Australia and China. However, for the time being GNSS operations are still seen as 'GPS-plus' rather than Galileo-based. GPS is deeply embedded with thousands of monitoring stations in Europe, 1,000 stations in Japan; and China expanding its network from 27 to 120 stations. Also, while the Chinese used COMPASS for earthquake research it is done in conjunction with GPS.

Dr. Beutler agrees with Ms. Neilan that currently the discussion does not center on Galileo or GLONASS but, rather, GPS-plus something else. GLONASS has made important progress in the past two years and may deploy a 24-satellite constellation by year's end and this will enable a global solution solely through GLONASS. At the same time, he noted, were it not for GPS then good receivers would not exist for GLONASS. Dr. Beutler believes it is important that industry provide receivers that can work with all system combinations, and called attention to the PNT Advisory Board's Vision Statement that the GNSS environment would consist of multiple systems.

Dr. Enge called attention to the U.S. Institute of Navigation (ION), which provides free transportation for selected students to the fall GNSS conference, and of 23 papers selected this year none are from the United States. Dr. Schlesinger said the Advisory Board report should highlight the issue of "intellectual ferment" in PNT applications. It has become an international phenomenon and evidence suggests the U.S. is becoming disadvantaged. This concern is not "jingoistic", and progress should be welcome from all quarters, but the EXCOM and other Government officials should be made aware.

Dr. Schlesinger invited Mr. Nishiguchi to state his views, and Mr. Nishiguchi said he believes GPS is a given and other systems -- GLONASS, Galileo and COMPASS -- will align their systems to existing GPS standards. He endorses the organization of the EXCOM and Advisory Board and added these structures are being used by Russia as a model for its GLONASS organization, and Japanese organizations are doing the same. Given the 30-year track-record of GPS, and bilateral agreements, it is likely future GNSS providers will seek multilateral relationships with GPS. The international community, he believes, hopes that its requests are given serious consideration and user comfort will rise if the U.S. moves to ensuring policy stability, specifically in reference to system sustainability. Regarding constellation size, Mr. Nishiguchi noted while it may be that 30+ GPS satellites would be better, he was not in a position to request such a number. Thus, the current 21+3 baseline constellation is fine even though, of course, 30+ would be much better. While the baseline may not provide an entirely satisfactory geometry, each country should be responsible for providing an augmentation and this has been the policy of Japan. Mr. Nishiguchi noted the remarks during Thursday's session that interference detection would be very difficult to accomplish without E-LORAN and, thus, he hopes to see a continuation of E-LORAN to provide protection of the sea lanes, which he regards as essential for international coordination and harmony.

Mr. Miller noted Mr. Nishiguchi's comment on policy stability being very important to Japan, and said that U.S. action in this area will depend on the new Administration. He noted, that the EXCOM, which had originally been expected to have two meetings a year, had in fact met bimonthly, a circumstance he attributes to the leadership of DoD Deputy Secretary Gordon England. If the Advisory Board favors an active EXCOM this is an important issue to call their attention. It is important that the EXCOM operates at the Deputy Secretary level; when, earlier, it had operated at the Assistant Secretary level which was not high enough for decisions to be made. Also, under DepSec England's tenure any EXCOM constituent agency was encouraged to bring matters forward for discussion, including technical matters. Thus, in order to maintain the engagement of the EXCOM as the relevant policy body it would be helpful to maintain policy stability. On the negative side, he noted, when transition from the 1996 Presidential Decision Directive (PDD) to the 2004 Policy Statement occurred he had co-chaired the group that drafted the charters for the EXCOM, National Coordination Office and the Advisory Board, there had not been drafts to work from and the delays resulted in, for example, loss of GPS stewardship funding that had been available under the IGEB. If the current Administration intends to update the 2004 policy, the Advisory Board may wish to recommend these documents be completed in such way that a vacuum does not occur. Dr. Schlesinger clarified that those funds in question had not disappeared but, rather, the Deputy Secretary of DOD and Director of OMB had made a private agreement to provide bridge funding but this arrangement disappeared when the administration changed.

Ms. Ciganer expressed support for Mr. Nishiguchi's emphasis on policy stability; such stability, she believes, is particularly important when transitioning from a legacy to a modern system, which tends to be period of increased risk. It is vital that any modernized system equal or surpass the legacy system. Dr. Parkinson said the Executive Summary of the 2007-2008 PNT Advisory Board Report would call attention to the importance of policy stability. Dr. Schlesinger said the Executive Summary should also stress that if one focused on GNSS as a set of physical assets this could 'blind' those involved to the fact that the main intellectual ferment has now moved outside the U.S.

Capt. Murphy added his endorsement to the importance of policy stability and sustainability; aviation, he added, would be dependent on GPS at least for the next decade and any brownout would be very damaging to the transition into new systems. Dr. Parkinson said he believes a program for 'GPS IIIS' should be undertaken and urged its consideration. Capt. Murphy said that while GPS IIIS is an interesting possibility, he is more concerned with the creation of a robust mitigation strategy. Mr. Lewis said that an infrastructure as important as GPS needs a risk mitigation plan that is continuously updated.

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#### Additional PNT Advisory Board Discussion

Dr. James Schlesinger, *Chair*

Dr. Basker commented, relative to Thursday's presentation on DHS interference and mitigation efforts, she had concerns about an organization like DHS would go through an effort of cataloging interference but not mitigating disruptions. Britain's experience, she added, is that interference – deliberate or not – is difficult to pinpoint. For example, there is the case of a British ship which had had an antenna cable problem that manifested itself as jamming and, while that problem had been resolved, it took considerable time to go through the ship's wiring to find the source of the problem. The experience of her organization is that it is indeed difficult to create a business case for a backup system. While the potential costs are quite large, the probability is quite small, and it is difficult to combine parameters from dissimilar cases into a reliable answer. Dr. Schlesinger asked if this measure had used a subjective probability measure, and Dr. Basker responded the study had been based on frequent low-level interferences. Dr. Schlesinger asked whether the U.S. had similar experience with low-powered jammers. Dr. Parkinson said he did not know. Dr. Schlesinger urged obtaining a copy of the British study.

Dr. Basker explained that the various telecommunications timing requirements in Britain could be met with E-LORAN. Ship owners, law enforcement, and service providers are concerned about OMB's decision to cancel LORAN. The issue now is, from a global perspective, how to proceed. Over time, she noted, U.S. and Europe have favored E-LORAN at differing times. It should be possible for agencies worldwide to agree on a course of action and undertake it and she believes U.S. industries were best positioned to take advantage of the market that E-LORAN would stimulate.

Dr. Schlesinger asked whether Britain's concern for E-LORAN continuation was sufficient to prompt it to communicate that view to the U.S. Government through official channels. Admiral de Halpert, Trinity House, said the British Government has "franchised" that issue to Trinity House. Current efforts, he said, are moving in parallel: (1) complete the remaining required trials; and (2) build political will. He believes the political is moving in the right direction and noted that when in March 2009, he and Dr. Basker had met with the Commandant of the U.S. Coast Guard, the British Government had provided a "positive push." Further, information had been provided to the U.S. State Department through the American Embassy in Great Britain. Dr. Schlesinger urged Admiral de Halpert that the issue was not one for "British understatement."

Mr. Murphy asked Admiral de Halpert if he believed E-LORAN would die absent U.S. support. Admiral de Halpert said his main concern was that while the British, French and Norwegians could continue to develop their system for Europe, he doubts mariners would purchase a navigation system that was only operable in Europe. Also, he noted last year's decision by the Indian government to delay decommissioning E-LORAN pending a decision from the U.S. If, the U.S. had supported E-LORAN he believes India and Saudi Arabia would have bought into a France and Italy wanted to develop for the Mediterranean. Ms. Neilan asked whether colleagues in other countries or organizations could deliver messages supporting E-LORAN to the U.S. Government. Dr. Basker replied that the EU Institutes of Navigation strongly supported E-LORAN; further, the matter had been raised with colleagues in France and Norway. She believes a global dialogue was needed. Capt. Smith agreed that the EU group had been strongly in favor and he would speak to the group's chair and urge him to submit a letter of support.

Next, Mr. Trimble presented comments reflecting his discussions with Dr. Hermann. He believes the U.S. Government and Air Force have an excellent reputation worldwide as stewards of GPS; this, however, had required several "diving catches" over time. He believes another is required now on the issue of phase stability in the GPS signals. Fixed phase relationships are important to precise applications such as surveying, construction and agriculture, which represent approximately 10% of the user base. Mr. Trimble explained that when the L2C signal was first proposed its definition called for a fixed phase, but three years ago during a test for flex power it was discovered that phase shifts were being picked up on L2C and this caused considerable "consternation" among users. The Air Force has studied the matter and identified four ways to eliminate the phase shift with flex power. In the meantime, the DoD / Networks and Information Integration (NII) announced that GPS modernization would be governed by signal specifications – with a reference to the pertinent website. When users internationally consulted that website, they encountered a document in which the original reference to "fixed phase relationship" going back to 1986 had been changed from "shall" to "can", which has prompted uncertainty as to the utility of the L2C signal for precision applications. Mr. Trimble urged that this concern be addressed either by returning the "shall" to the signal specification or by adding a covering statement that the U.S. Government intended the new system would provide at least equal capabilities as a legacy system. Ms. Ciganer seconded Mr. Trimble's suggestion, noting that user comfort was rooted in policy certainty.

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#### Final Approval of PNT Advisory Board Report

Dr. James Schlesinger, *Chair*

Dr. Schlesinger said Dr. Parkinson would present the Advisory Board's draft recommendations, so that these could be added to or amended as needed. Dr. Parkinson believes the E-LORAN issue needed to be more clearly addressed in the context of policy stability. Recommendations review:

- "Place GPS III quickly under contract with early delivery"
  - Dr. Parkinson commented that while this may not have happened "quickly," it was in progress.
- "Formally commit the U.S. to the current level of service"
  - Dr. Parkinson considers this the argument for 30+ satellites and said that the PNT Advisory Board had not seen the brownout probability charts for 30- and 27-satellite constellations which, he believes, show a bleak picture. While the GAO report gave a reasonably optimistic picture it was contingent on maintaining the existing schedules of II-F and III-A, and his experience shows that schedules tend to stretch. Dr. Schlesinger noted that the Board had repeatedly urged the U.S. to commit to the current level of service and suggested using the following wording: "the ultimate goal continues to be 30 satellites and, while there is some question as to the fragility of the system, this should not alter the ultimate goal." At Dr. Parkinson's suggestion, Mr. Miller said he would capture Dr. Schlesinger's remarks and Mr. Trimble's earlier concerns on policy stability.
  - Dr. Schlesinger said the EXCOM represents the stewards for U.S. GPS capabilities; however, the EXCOM needed to recognize that most GPS users were civilian; and, additionally, that the intellectual ferment with regard to PNT was increasingly outside the U.S. He believes this second statement should be reflected in the report.
- "Ensure affordability"
  - This, Dr. Parkinson said, supports the proposal that GPS satellites should be kept simple and lightweight, such as the III-S proposal to only navigation payloads as well as laser retro-reflectors used in the analysis of orbit errors and improvement of the GPS reference frame, so that they may be launched in pairs and produce substantial savings in launch costs. Dr. Schlesinger cautioned that the III-S, if introduced, could be perceived as a competitor to III-A and, as such, much harder to advocate successfully. Dr. Parkinson responded that modifying III-A by removing non-navigation payloads and launching the resulting satellites in pairs would achieve the same object.



Dr. Schlesinger commented that there is some resistance to launching satellites in pairs and, that being the case, the wording should be addressed to ends to achieve affordability rather than the method.

- “Place GPS signal specification under a true national organization”
  - Dr. Parkinson believes this policy statement, and the subsequent statement on “ensure transparency and evolution”, should be placed as sub-bullets of “policy stability.” Mr. Trimble expressed concerns on GPS ending up under the control of a single organization that would implement ‘stovepipe’ solutions with little accountability to users. Ms. Ciganer noted that, during the two decades in which GPS had served as a global utility the field had been characterized by grassroots vitality, and it remained to be seen if this same level of innovation would continue if one moved to more of a command and control model. Dr. Schlesinger added that it was unwise to make recommendations unless one knew what would happen if the recommendation is accepted.
- “Implement laser reflectors”
  - Dr. Parkinson said this was a matter about which the PNT Advisory Board continued to feel strongly supportive in terms of modeling GPS errors and further improving the GPS reference frame.
- “Develop means to detect and measure and geo-locate interference”
  - Dr. Parkinson believes the real issue is mitigation. The appropriate goal should be to mitigate interference with the creation of a plan for doing so that could serve as a blueprint for other nations. Dr. Schlesinger commented that, for six years, there had been talk about creating a detection plan while the “proof of the pudding,” is not detection but mitigation.
- “Maintain the policy of an open signal free of direct user charges”
  - Dr. Parkinson believes this should be placed under stable policy statement. Dr. Schlesinger noted that as this question was not currently at issue and, thus, should be a lower key statement.
- “Use a reference frame for GPS that is common to other GNSS systems”
  - Dr. Parkinson termed this a statement of scientific importance. Ms. Neilan stated that in Wednesday’s Strategic Engagement and Communications panel meeting, they had reworded various statements in the Recommendations, reflecting the view that the recipients of this summary, unlike those in the room, may not have a technical understanding of the matter. She noted that Dr. Beutler had reviewed these changes. At Dr. Parkinson’s suggestion, Ms. Neilan said these would be supplied to Mr. Miller to incorporate into the Advisory Board’s report.. Dr. Parkinson strongly urged the Advisory Board not back off from identifying three preeminent statements -- on brownouts, E-LORAN and policy stability. Ms. Neilan said her panel also believed several words needed to be added to the Vision Statement about stable policy and interoperability.
- “Assure adequate funding of GPS”
  - Dr. Schlesinger commented that the PNT Advisory Board’s recommendation of affordability is related to ensuring funding. He noted that higher funding was not being requested but, rather, a more economical operation required of existing. Ms. Neilan commented that this should include funding for ground infrastructure and her panel would add language on the importance of encouraging international investments in this area. Dr. Enge noted that E-LORAN was a point case.
- “Maximize use of PNT EXCOM”
  - Dr. Parkinson explained that this statement means the PNT EXCOM should be more assertive in pushing the overall national needs in PNT. Dr. Schlesinger suggested the following wording: “The EXCOM needs to be mindful of the full range of the national interests that it represents.” Dr. Parkinson suggested the statement belonged in a preamble. Dr. Schlesinger urged that the Advisory Board’s statement not be ‘overloaded’ and that he favored doing whatever could be done to reduce the numbers of points in the recommendations and with a clear distinction made between the necessary and the desirable. Capt. Smith said he was unsure whether the EXCOM would survive into the future and, therefore, perhaps not be referred to by name. Dr. Schlesinger agreed that the EXCOM’s energy had been a function of the then-serving Deputy Secretary of Defense and there was no assurance that successors would take the same interest.

- “Continue promoting international cooperation”
  - Dr. Parkinson believes that a strong statement on E-LORAN needs to be part of this, as well as brownouts and policy stability.

Dr. Parkinson asked for additional recommendations. Mr. Hall asked if a comment about the importance of orderly transition should be added to the statement about policy stability – e.g. signal structure. Dr. Parkinson welcomed this addition.

Dr. Schlesinger adjourned the fifth meeting of the PNT Advisory Board at 12:02 p.m.

*Meeting adjourned*

## Appendix A: ACRONYMS

ADS-B:	Automatic Dependent Surveillance-Broadcast
CAT	Category
CDR:	Critical Design Review
CH:	Switzerland
DHS:	Department of Homeland Security
DoD:	Department of Defense
DOS:	Department of State
EGNOS:	European Geostationary Navigation Overlay Service
EU:	European Union
EXCOM:	National Executive Committee for Space-Based PNT
FAA:	Federal Aviation Administration
FY:	Fiscal Year
GAO:	Government Accountability Office
GNSS:	Global Navigation Satellite System
GPS:	Global Positioning System
GSAC:	Galileo Science Advisory Board
IAG:	International Association of Geodesy
IAIN:	International Association of Institutes of Navigation
ICD:	Interface Control Document
ICG:	International Committee on GNSS
IDM:	Interference, Detection, and Mitigation
II:	GPS Block II
IIA:	GPS Block IIA
IIF:	GPS Block IIF
IIIA/III-A:	GPS Block IIIA
IIR(M):	Modernized GPS Block IIR
IIIS/III-S:	Proposal for a simplified Block IIIA satellite
ILRS:	International Laser Ranging Service
ILS:	Instrument Landing System
IMO:	International Maritime Organization
IN:	India
JP:	Japan
L1:	GPS frequency band
L1C:	GPS 4 <sup>th</sup> civilian signal
L2C:	GPS 2 <sup>nd</sup> civilian signal
L5:	GPS 3 <sup>rd</sup> civilian signal (safety-of-life)
LAAS:	Local Area Augmentation System
LORAN:	LOng Range Aid to Navigation
E-LORAN:	Enhanced LORAN
NASA:	National Aeronautics and Space Administration
NCO:	National Coordination Office for Space-Based PNT
NCS:	National Communications System
NO:	Norway
NSC:	National Security Council

NSPD:	National Security Presidential Directive
OCX:	Operating Control Segment
OMB:	Office of Management and Budget
OS:	Galileo Open Service
OSTP:	White House Office of Science and Technology Policy
PDD:	Presidential Decision Directive
PDR:	Preliminary Design Review
PNT:	Positioning, Navigation, & Timing
POC:	Point of Contact
PRS:	Galileo Publicly Regulated Service
RAIM:	Receiver Autonomous Integrity Monitoring
RFP:	Request for Proposals
SBAS:	Satellite-Based Augmentation Service
SLR:	Satellite Laser Ranging
UK:	United Kingdom
U.S.:	United States
WAAS:	Wide Area Augmentation System
YGNSS:	Youth promoting GNSS cooperation and education project

## Appendix B: ADVISORY BOARD MEMBERSHIP

### *U.S. Board Members:*

Dr. James R. Schlesinger (Chair)	MITRE Corporation; Barclays Capital
Dr. Bradford Parkinson (Vice-Chair)	Stanford University, Department of Aeronautics
Mr. Phil Boyer	Aircraft Owners and Pilots Association
Capt. Joe Burns	United Airlines
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
Gen. Lance Lord	Retired USAF, Former Commander, Air Force Space Command
Gen. James McCarthy	Retired USAF, U.S. Air Force Academy
Mr. Terence McGurn	Retired CIA (currently private consultant)
Mr. Tim Murphy	Boeing Corporation, Commercial Airplane Group
Ms. Ruth Neilan	Jet Propulsion Laboratory
Mr. Charles R. Trimble	Chairman, U.S. GPS Industry Council

### *International Board Members:*

Dr. Gerhard Beutler (Switzerland)	International Association of Geodesy
Mr. Arve Dimmen (Norway)	Norwegian Coastal Administration
Dr. Suresh Kibe (India)	Indian Space Research Organization
Mr. Hiroshi Nishiguchi (Japan)	Japan GPS Council
Capt. Richard Smith (United Kingdom)	President, International Association of Institutes of Navigation

**Appendix C: MEETING ATTENDEES:***U.S. Board Members:*

Dr. James R. Schlesinger	Chairman, Board of Trustees, MITRE Corporation
Capt. Joe Burns	United Airlines
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
Dr. Robert Hermann	Global Technology Partners, LLC
Mr. Chet Huber	OnStar Corporation, General Motors
Gen. Lance Lord	Former Commander, Air Force Space Command
Mr. Tim Murphy	Boeing Corporation, Commercial Airplane Group
Ms. Ruth Neilan	Jet Propulsion Laboratory and Astronautics
Dr. Bradford Parkinson (Vice-Chair)	Stanford University, Department of Aeronautics
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
Mr. Hiroshi Nishiguchi (Japan)	Secretary General, Japan GPS Council
Capt. Richard Smith (United Kingdom)	President, International Association of Institutes of Navigation

*NASA Attendees:*

Diane Rausch	PNT Advisory Board, Executive Director, NASA HQ
Barbara Adde	NASA HQ
Beryl Brodsky	NASA / Overlook Systems Technologies, Inc.
John LeBreque	NASA/HQ
James J. Miller	NASA HQ
Mike Moreau	NASA GSFC
A.J. Oria	NASA / Overlook Systems Technologies, Inc.
Brian Ramsay	NASA
Tom von Deak	NASA
Frank van Graas	NASA

*Other Attendees:*

Milton Abner	NSSO
Carl Andren	Institution of Navigation
Sally Basker	UK Lighthouses
Mark Bernstein	ASRCMS
Langhorne Bond	LIA
David Buckman	AFSR/ASP
Zack Conan	
Mike Conschalter	Aerospace Industries Association
Charlie Daniels	National Coordinating Office
Jeremy de Halpert	Trinity House, UK
Jim Doherty	Institute for Defense Analysis
Scott Grantham	Department of Defense, OSD/NII
Keith Hall	
Larry Hothem	United States Geological Survey
Keegan Hurley	AMA
Stephen Huybrechts	OSD/NII
Navin Jerath	Northrop Grumman
Jarrett Larrow	Federal Aviation Administration
David Logsdon	Self
Catherine Majauskas	Federal Aviation Administration
Bob Markle	RTCM
Jules McNeff	Department of Defense, OASD/OSTI
Dan O'Laughlin	MITRE Corporation
David Olsen	Federal Aviation Administration
Mike Pearlman	CFA
Charles Schue	Ursa Navigation
Christopher Shank	Applied Physics Laboratory
Michael Shaw	National Coordination Office for Space-Based PNT
Karen Van Dyke	DOT/RITA
Paul Verhoef	European Commission
Stephanie Wan	Space Generation Advisory Council

**Appendix D: LIST OF PRESENTATIONS MADE:**

1. National Space-Based PNT Advisory Board: Michael Shaw
2. Implementation Plan [Draft] for the Basic Space Law: Hiroshi Nishiguchi (Japan)
3. Youth Promoting GNSS Cooperation and Education: Stephanie Wan
4. U.S. Space-Based PNT; International Cooperation: David Turner
5. European GNSS Programs – EGNOS and Galileo: Paul Verhoef
6. Mitigation of Possible GPS Brownouts: Dr. Bradford Parkinson
7. PNT Advisory Board – GPS Issues and Challenges: Brigadier General John E. Hyten
8. GNSS Program Status WAAS, LAAS & ADS-B: J.C. Johns
9. Satellite Laser Ranging – and Rules of the Road for the International Laser Ranging Service: Dr. Michael Pearlman
10. LORAN – History & Need: James Doherty
11. E-LORAN – An International Perspective: Sir Jeremy de Halpert & Dr. Sally Basker
12. Department of Homeland Security GPS Interference Detection and Mitigation: John Merrill
13. National PNT Advisory Board: Observations and Recommendations: National PNT Advisory Board

*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.*