Current PNT Advisory Board

- **Bradford Parkinson** (Acting Chair), Stanford University original GPS Program Director
- **Thad Allen**, Booz Allen Hamilton retired Commandant of the Coast Guard
- **Penina Axelrad**, University of Colorado, Chair of Department of Aerospace Engineering
- **John Betz**, MITRE, Former Chair Air Force Scientific Advisory Board
- **Dean Brenner**, Vice President, Government Affairs Qualcomm
- **Joseph D. Burns**, United Airlines, Former Chief Technical Pilot, United Airlines
- **Per K. Enge**, Stanford University, Head of Stanford Center for PNT
- **Martin C. Faga**, MITRE Retired CEO of Mitre
- **James E. Geringer**, ESRI Former Governor of Wyoming
- **Ronald R. Hatch**, consultant to John Deere, inventor of the GPS “Hatch” filter
- **Rajiv Khosla**, Colorado State University, Past President, International Soc. of Precision Agriculture
- **Peter Marquez**, Planetary Resources, Former White House National Security Space Policy
- **Terence J. McGurn**, private consultant, retired CIA analyst of Position, Navigation and Control
- **Timothy A. Murphy**, The Boeing Company, Technical Fellow with Boeing Commercial Airplane
- **Ruth Neilan**, Jet Propulsion Laboratory, vice chair, Global Geodetic Observing System
- **T. Russell Shields**, Ygomi, a founder of NavTeq
- **Ann Ciganer**, VP Trimble Navigation, Director of GPS Innovation Alliance

International Members:

- **Gerhard Beutler**, Professor of Astronomy and Director of the Astronomical Institute, U. of Bern.
- **Elizabeth Cannon**, Canadian Aeronautics and Space Institute (Canada), President U of Calgary
- **Arve Dimmen**, Division Director Maritime Safety Norwegian Coastal Administration (Norway)
- **Matt Higgins**, President International GNSS Society (Australia)
- **Hiroshi Nishiguchi**, Chairman Japan GPS Council (Japan)
- **Rafaat M. Rashad**, Chairman Arab Institute of Navigation (Egypt)

Previous PNTAB Recommendations & Outcomes

- Eliminate S/A capabilities from GPS III
  - Officially announced by DoD DepSec England on Sep. 18, 2007
- Implement Laser Retro-reflector Arrays on GPS III
  - MOU signed by Gen Shelton (AFSPC), Gen Kehler (USSTRARCOM), and C. Bolden (NASA) on Aug. 22, 2013
- Ensure balanced participation by agencies, manufacturers, and users in NTIA/DoD/DOT spectrum studies
  - Full understanding of impacts and alternatives
  - On-going Adjacent Band Compatibility Assessment
- Incorporate NASA worldwide civil-signal monitoring into OCX verification of GPS signal
  - Cost effective, early satisfaction of up to 96% of requirements
  - On-going discussions with DOT




Background PNTAB

- Primary PNTAB Objective:
  - Assured *PNT* for all users
- Current Assessment
  - No current or foreseeable alternative to GNSS (primarily GPS) can deliver equivalent accuracy (to millimeters, 3D) and world wide 24/7 availability
  - But “Space-to-Earth” L-Band signals are very weak
- Therefore our Focus is ***PTA***
  - ***P***rotect the radio spectrum + identify + prosecute interferers
  - ***T***oughen GPS receivers against natural and human interference
  - ***A***ugment with additional PNT sources and techniques

PNTAB Recommendations

(29 Aug. 2014 letter to DepSecs Work and Mendez)

1. Formally Designate GPS as a Critical Infrastructure Sector for the United States
   - 14 of 16 current CIs deeply dependent
2. Develop a Formal National Threat Model for PNT Applications in Critical Infrastructure
   - Build on earlier Ms. K. Van Dyke effort at DOT
3. Prevent the Proliferation of Commercial Emitters/Pseudolites in GPS Frequency Bands
   - Threat continues
4. Establish a Nationwide CONUS Back-Up to GPS with Existing Infrastructure (eLoran)
   - Previously supported by PNT EXCOM (2009)

GPS Economic Assessment - Phase II

- **Phase I** GPS Economic Assessment study identified over $65B in annual benefits derived from select commercial areas
- Effort now underway to further quantify productivity gains and document economic data from newer, more specialized sectors
  - **Phase IIa**
- PNTAB will facilitate industry/market inputs to support coordinated NCO, DoC & NASA study effort
  - Interagency team of gov economists to assist in preparing a comprehensive, authoritative GPS economic benefits assessment
  - Targeting majority completion of Phase IIa in time for PNTAB May meeting
- Second Stage to Follow – **Phase IIb**
  - Plan to build on efforts of government economists to include derived benefits to intl partners/markets & potential costs of service disruptions from spectrum denial

Way Forward

- Continue current and related study efforts
  - GPS Economic Assessment
  - Ready to assist in developing National Threat Model if PNT EXCOM directs
  - Measures to insure PNT for all users – The ***PTA*** Program –examples:
    - Anti-spoofing authentication codes
    - Tracking progress for eLoran deployment and other complementary systems
    - Status of FCC licensing use of non-U.S. GNSS receivers
    - Explore state-of-the-art in commercially available receiver toughening
- Participation in International Fora related to GPS and GNSS
  - ICG-9 sponsored by UN in Prague November 2014
  - Recommendation that other PNT service providers establish similar citizen-based user advisory boards to enable U.S. reciprocal participation
  - Will revisit Recommendation at ICG-10 when U.S. hosts November 2015

Backup Slides

PNTAB Recommendations

(29 Aug. 2014 letter to DepSecs Work and Mendez) 1/2

1) Formally Designate GPS as a Critical Infrastructure Sector for the United States

Virtually every Department of Homeland Security (DHS)-designated critical infrastructure sector is dependent on access to GPS for positioning, timing, or both. Specifically, these PNT services are pervasive elements in 14 of 16 critical U.S. sectors. Preliminary economic studies show a *direct* value of GPS equipment manufacturing of over $30B a year, which may triple to over $90B when also including the *indirect* benefits facilitated by the use of GPS. These impacts, however, are not yet fully understood nor appreciated by the critical infrastructure sectors, thus relegating GPS to a "stealth utility" status, lacking appropriate protections. Serious potential threats to GPS users range from changes in spectrum regulations, to intentional interference, cyber-attacks, spoofing, and even natural atmospheric disturbances. Such threats are credible and rapidly growing. It is therefore essential that resources and attention be focused on addressing such vulnerabilities. In order to achieve this goal, the PNTAB recommends that the DHS advocate and the President designate GPS as a *separate sector of critical infrastructure* and provide national leadership to counter these threats to our economy and security.

2) Develop a Formal National Threat Model for PNT Applications in Critical Infrastructure

The Department of Defense (DoD) routinely develops and updates threat models to GPS defense capabilities, and also prioritizes countermeasures to these threats. However, public safety GPS stakeholders, and other critical infrastructure sectors, do not have a validated threat model. We have studied this in some detail and strongly believe that there is a potential for serious national economic and public safety disruption. The PNTAB therefore proposes that the PNT National Coordination Office (NCO) be tasked and funded to lead the development of a detailed, PNT National Threat Model (PNT NTM) for GPS. This study should include all classes of threats, the probabilities and economic impacts, and outline potential countermeasures. The PNT NTM study should be developed in cooperation with *all* appropriately cleared civil GPS stakeholders, in particular GPS equipment manufacturers and PNT service providers. We believe the PNT NTM will enable federal departments and agencies, state and local governments, and commercial service providers to better understand and prioritize resource allocation for mitigation strategies.

PNTAB Recommendations

(29 Aug. 2014 letter to DepSecs Work and Mendez) 2/2

3) Prevent the Proliferation of Licensed Emitters in GPS Frequency Bands

Recent regulatory proposals by the European Conference of Postal and Telecommunications Administrations (CEPT) would license certain terrestrial transmitters, or "pseudolites," to operate in the primary GPS band (also known as GPS L1). This frequency band is designated as a Radionavigation Satellite Service (RNSS) and should be very carefully regulated. These transmitters pose a significant interference threat to GPS and other Global Navigation Satellite Systems (GNSS), including Europe's emerging Galileo system. Therefore, the PNT AB recommends that the PNT EXCOM strongly oppose such licenses and that the U.S. Department of State urgently engage the European Signatories under a demarche pursuant to the terms of the 2004 U.S.-E.U. GPS-Galileo Agreement. The U.S. and the European Union should work cooperatively with the European Commission and CEPT, to prevent the authorization and proliferation of harmful devices in GNSS frequency bands.

4) Establish a Nationwide CONUS Back-Up to GPS with Existing Infrastructure (eLoran)

In 2006, an Independent Assessment Team (IAT), commissioned by DOT, unanimously recommended: "*Retain eLoran (enhanced Loran) as a primary backup for critical GPS applications.*" After studying the situation, thePNT AB unanimously concurred and made the same recommendation to the PNT EXCOM in 2007. The PNTEXCOM, with participation from all represented Federal departments, also unanimously concurred. Unfortunately, due to competing fiscal priorities, eLoran was cut from the budget in 2009 and its existing infrastructure is being dismantled. The PNT AB believes that existing Loran sites and antennae could provide an affordable path to a National GPS back-up system, and restated its recommendation at the last PNT EXCOM meeting held on March 14, 2014. We believe that the deployment of a national PNT back-up is now even more urgent due to the rapidly evolving threats to GPS-based PNT services. The PNT AB therefore reaffirms its previous recommendation and requests urgent action to preclude further dismantling of existing infrastructure that could be used as a GPS back-up to prevent disruptions to the U.S. economy, public safety, and security.

eLoran Previously Recommended by PNT EXCOM

Conclusions – (DOT IRB Dec. 2006):

- Reasonable assurance of national PNT availability is prudent & responsible policy
  - For critical safety-of-life & economic security applications
  - For all other ”quality-of-life” applications
- eLoran is a cost-effective backup –to protect and extend GPS- for identified national critical GPS-based applications
  - Interoperable & independent
  - Different physical limitations & failure modes
  - Seamless operations & GPS threat deterrent
- Given US Government support, it is anticipated users will equip with eLoran as backup of choice
  - International community is looking for US leadership

Recommendation:

Summary of Results from Independent Review Board

Re: Loran – Convened by US/DOS (2006)

- Unanimous Recommendation – deploy eLoran
- DOT, DHS, and PNT EXCOM supported this recommendation
- But eLoran was a victim of budget tightening, and dismantling or existing Loran stations began