

Assuring PNT-  
*A PTA program*  
and  
Recommendations  
of the US PNT Advisory Board

Brad Parkinson

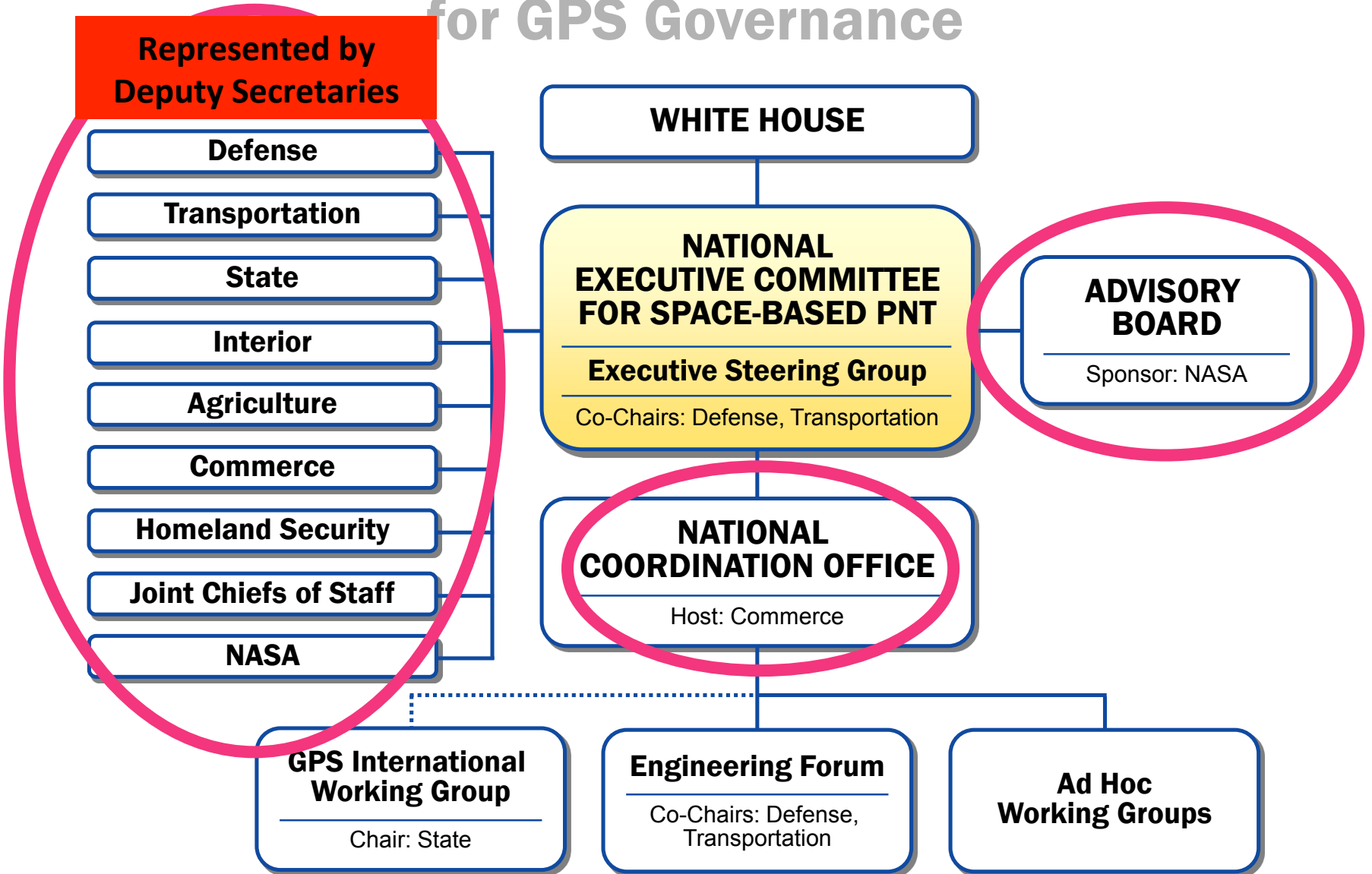
1<sup>st</sup> Vice-Chair of US PNT Advisory Board

Supported by FAA, NASA, AND Aerospace Corp.

(All opinions are my own)

- Dr. Bradford Parkinson was the **Chief Architect for GPS**, and led the original advocacy for the system in 1973 as an Air Force Colonel. Gaining approval, he became the **first Director of the GPS Joint Program Office** and led the original development of spacecraft, Master Control Station and 8 types of User Equipment. He continued leadership of the Program through the extensive test validation Program, including being the Launch Commander for the first GPS satellite launches. This original deployment of GPS demonstrated comfortable margins against all PNT (Positioning, Navigation, and Timing) requirements.
- Earlier in his career, he was a key developer of a modernized AC-130 Gunship, introduction of which included 160 hours of combat missions. He was also an **instructor at the USAF Test Pilot School**. In addition he **led the Department of Astronautics and Computer Science at the US Air Force Academy**.
- He **retired from the US Air Force as a Colonel in 1978**.
- He was appointed a **Professor at Stanford University in 1984**, after six years of experience in industry. At Stanford University, he **led the development of many innovative applications of GPS**, including:
  - Commercial aircraft (Boeing 737) **blind landing using GPS alone**,
  - Fully **automatic GPS control of Farm Tractors** on a rough field to an accuracy of 2 inches,
  - **Pioneering the augmentation to GPS (WAAS)** that allows any user to achieve accuracies of 2 feet and very high levels of integrity assurance.
- He has been the **CEO of two companies**, and serves on many boards. He is the author of the AIAA Award winning book “GPS Theory and Applications” and is author or coauthor of over 50 technical papers.
- **Among his many awards is the Draper Prize** of the National Academy of Engineering, considered by some to be the “Engineering Nobel”.

# U.S. Organizational Structure for GPS Governance



# 2015-2017 PNT Board Membership: Focus is Assured PNT through “PTA” (Protect, Toughen, Augment)

## Unites States Members:

- **John Stenbit (Chair)**, former DoD Chief Information Officer
- **Bradford Parkinson (Vice Chair)**, Stanford University, Founding GPS Program Director
- **James E. Geringer (2nd Vice Chair)**, ESRI, Former Governor of Wyoming
- **Thad Allen**, Booz Allen Hamilton, retired Commandant of the U.S. 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
- **Scott Burgett**, Garmin International
- **Joseph D. Burns**, Sensurion, Former Chief Technical Pilot of United Airlines
- **Ann Ciganer**, Vice President, Trimble Navigation, Director of GPS Innovation Alliance
- **Per K. Enge**, Stanford University, Head of Stanford Center for PNT
- **Martin C. Faga**, MITRE, Retired CEO, Former NRO Director
- **Dana A. Goward**, Former DHS SES, Founder of Resilient Navigation & Timing
- **Ronald R. Hatch**, consultant to John Deere, inventor of the GPS “Hatch” filter
- **Larry James**, Deputy Director, Jet Propulsion Laboratory
- **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**, Boeing Technical Fellow, Commercial Airplane Group
- **Ruth Neilan**, Jet Propulsion Laboratory, Vice Chair, Global Geodetic Observing System (GGOS)
- **T. Russell Shields**, Ygomi, Founder of NavTeq

## International Members:

- **Gerhard Beutler**, Professor of Astronomy and Director of the Astronomical Institute, U. of Bern (Switzerland)
- **Sergio Camacho-Lara**, Secretary General, United Nations Regional Education Center of Science & Space Technology for Latin America & the Caribbean (Mexico)
- **Arve Dimmen**, Division Director, Maritime Safety Norwegian Coastal Administration (Norway)
- **Matt Higgins**, President, International GNSS Society (Australia)
- **Rafaat M. Rashad**, Chair, Arab Institute of Navigation (Egypt)

# PNTAB Charter

The National, Space-Based, Positioning, Navigation, and Timing (PNT) Advisory Board (**PNTAB**) provides:

- **Independent** advice to the U.S. government on GPS-related
  - *policy,*
  - *planning,*
  - *program management, and*
  - *funding profiles*

In relation to the current state of national **and international satellite navigation services.**

- **Fundamental Purpose:**  
**Assured PNT** (At required availability, accuracy and integrity)

◆ PNTAB Generally meets 1 to 2 times per year.

# PNTAB Actions to Assure PNT for all users

- **First** – Increase National Awareness of Value of GPS (and GNSS) and System Vulnerabilities

## PNTAB is sponsoring “Economic Study of Value”

- Initial result: GPS provides over \$60B/yr of Benefits
- Refinement underway

## “Develop a Formal National Threat Model for PNT Applications in Critical Infrastructure:

The 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 sectors, do not have a validated threat model.”

- **Second** – Implement specific PTA steps to:
  - Protect Clear and Truthful Reception -7 steps
  - Toughen User’s Receivers
  - Augment or substitute PNT sources

Highlights in **Red**  
are PNTAB  
recommendations  
or Actions

# Progress in Quantifying GNSS Benefits: Economic Study under US PNTAB Now being Refined

	Annual GPS Equipment Spending (\$ billion)	Estimated Annual Benefits (\$ billion)
Precision agriculture (crop farming)	\$0.5	\$19.9 - \$33.2
Engineering Construction (heavy & civil and surveying/mapping)	\$1.1	\$9.2 - \$23.0
Transportation (commercial surface transportation)	\$3.2	\$10.3 - \$15.1
Sub-total (3 industries examined)	\$4.8	\$39.4 - \$71.3
Other commercial GPS users	\$3.5	\$28.2 - \$51.1
<b>Total commercial GPS users in the U.S.</b>	<b>\$8.3</b>	<b>\$67.6 - \$122.4</b>

• Over \$65B In Annual Benefits in identified Commercial Areas

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# Selected PNTAB Recommendations

(More on Web Site [gps.gov](http://gps.gov))

**“Prevent the Proliferation of Licensed Emitters in GPS Frequency Bands: European Proposals by 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.”**

- **“We support the FAA’s efforts to provide Alternate PNT options that can provide a robust backup to GPS and deter malicious interference.”**

- **“We strongly recommend that the previously announced decision (to deploy eLoran as the primary Alternate PNT) should be **reconfirmed** and quickly implemented.”**



# Sixteenth Meeting October 30-31, 2015



University Corporation for Atmospheric Research (UCAR) Center Green Conference Center (CG1)  
3080 Center Green Drive, Boulder, Colorado 80301  
<http://www2.ucar.edu/campus/center-green-campus>

## Agenda

### FRIDAY, OCTOBER 30, 2015

9:00 - 9:05	<b>BOARD CONVENES</b> <i>Call to Order &amp; Announcements</i>	Mr. James J. Miller, <i>Executive Director, PNT Advisory Board, NASA Headquarters</i>
9:05 - 9:20	<b>Welcome Members to the 16th Meeting!</b> <i>New Chair, 2nd Vice-Chair, &amp; Members for 2015-2017 Charter Period</i>	Mr. Badri Younes, <i>Deputy Associate Administrator, Space Communications &amp; Navigation, NASA Headquarters</i>
9:20 - 9:50	<b>Opening Remarks &amp; Introduction of Issue Areas</b> <i>Outcome from Sep. 3 PNT Executive Committee (EXCOM) &amp; Current Objectives</i>	Mr. John Stenbit, <i>Chair</i> ; Dr. Bradford Parkinson, <i>1st Vice-Chair</i> ; Gov Jim Geringer, <i>2nd Vice-Chair</i>
9:50 - 10:10	<b>PNT National Coordination Office (NCO) Policy Update</b> <i>PNT EXCOM Focus Areas</i>	Mr. Harold "Stormy" Martin, <i>Director, National Coordination Office for Space-Based PNT</i>
10:10 - 10:40	<b>Global Positioning System (GPS) Status &amp; Modernization Progress</b> <i>Service, Satellites, Control Segment, and Military User Equipment</i> • <b>GPS 2F-11 - Launch: 10:17 a.m. MDT (1617 GMT)</b>	Col. Shawn Brennan, <i>GPS Transition Director, GPS Directorate, U.S. Air Force</i>

10:40 - 11:10	<b>U.S. Department of Transportation (DOT) Civil GPS/PNT Update</b> <i>GPS Adjacent Band Compatibility, NDGPS, &amp; Complementary PNT (CPNT)</i>	<b>Ms. Karen Van Dyke, Director for PNT, DOT Office of the Secretary, Research and Technology</b>
11:10 - 11:30	<b>Update on GPS Modernization for Space Operations &amp; Science Missions</b> <i>Ensuring a Robust Space Service Volume (SSV) to Maximize Societal Benefits</i>	<b>Mr. Frank Bauer, FBauer Aerospace Consulting</b>
11:30 - 12:00	<b>The Economic Impact of GPS</b> <i>Furthering the Analysis</i>	<b>Dr. Irving Leveson, Founder, Leveson Consulting</b>
12:00 - 1:00	<b>LUNCH</b>	
1:00 - 1:30	<b>GPS Interference Detection &amp; Geolocation Technology</b> <i>Identify &amp; Detect as First Steps towards Mitigation</i>	<b>Mr. Joe Rolli, Business Development Manager for Space and Intelligence Systems, Harris Corp.</b>
1:30 - 2:00	<b>Resilient PNT - An Outsider's View</b> <i>Some Key Developments from Across the Pond</i>	<b>Prof. David Last, Strategic Adviser, Lighthouse Authorities of the United Kingdom and Ireland</b>
2:00 - 2:30	<b>TimeLoc: A New Ultra-Precise Synchronization Technology</b> <i>Results from World-First Urban Trials in Washington DC</i>	<b>Mr. Nunzio Gambale, Chief Executive Officer, Locata &amp; Dr. Jimmy LaMance, Locata Engineer</b>
2:30 - 3:00	<b>Multi-constellation Air and Sea Navigation</b> <i>Advanced Receiver Autonomous Integrity Monitoring (ARAIM)</i>	<b>Dr. Per Enge, Stanford University, PNT Board</b>
3:00 - 3:15	<b>BREAK</b>	
3:15 - 3:30	<b>Introduction of Youth for GNSS (YGNSS)</b> <i>Results from the Space Generation Congress (SGC)</i>	<b>Mr. Juan Duran, Co-Lead of Youth for GNSS, Space Generation Advisory Council (SGAC)</b>
3:30 - 4:00	<b>Reflections on the Ten Year Anniversary - Lessons Learned</b> <i>Perspective from an Previous PNT National Coordination Office (NCO) Director</i>	<b>Mr. Tony Russo, Chief Engineer, Space Communications &amp; Navigation, NASA HQ</b>

9:00 - 9:05	<b>BOARD CONVENES</b> <i>Call to Order</i>	Mr. James J. Miller, <i>PNT Advisory Board Executive Director, NASA Headquarters</i>
9:05 - 9:30	<b>Announcements &amp; Agenda</b> <i>Quick Thoughts &amp; Member Feedback from October 30 Deliberations</i>	Mr. John Stenbit, <i>Chair</i> ; Dr. Bradford Parkinson, <i>1st Vice-Chair</i> ; Gov Jim Geringer, <i>2nd Vice-Chair</i>
9:30 - 11:00	<b>Representative PNT Board Member Updates &amp; Perspectives</b> <i>(at member's discretion)</i> <ul style="list-style-type: none"> <li>▪ Mr. Matt Higgins, <i>International GNSS Society, Australia</i></li> <li>▪ Dr. Refaat Rashad, <i>Arab Institute of Navigation, Egypt</i></li> <li>▪ Dr. Sergio Camacho-Lara, <i>UN Center of Science and Space Technology, Mexico</i></li> <li>▪ Mr. Arve Dimmen, <i>Norwegian Coastal Administration, Norway</i></li> <li>▪ Dr. Gerhard Beutler, <i>International Association of Geodesy, Switzerland</i></li> <li>▪ Ms. Ann Ciganer, <i>GPS Innovation Alliance, United States</i></li> <li>▪ Mr. Dana Goward, <i>Resilient Navigation and Timing Foundation, United States</i></li> </ul>	
11:00 - 11:15	<b>BREAK</b>	
1:00 - 1:30	<b>Overcoming Obstacles in Creating a Harmonious Multi-GNSS World</b> <i>Making the Most out of Bilaterals &amp; International Committee on GNSS (ICG)</i>	Mr. Dave Turner, <i>Deputy Director, Office of Space &amp; Advanced Technology, U.S. Department of State</i>
1:30 - 1:55	<b>International Committee on Global Navigation Satellite Systems (ICG)</b> <i>The Way Forward to Provide Positioning, Navigation and Timing Globally</i>	Ms. Sharafat Gadimova, <i>Executive Secretariat, ICG, UN Office for Outer Space Affairs</i>
1:55 - 2:20	International Update from Canada <i>Technology Implementation &amp; Governance</i>	Ms. Jina MacEachern, <i>Head, GNSS Coordination Office, Industry Canada / Government of Canada</i>
2:20 - 2:45	International Update from Australia <i>Australian Government PNT Activities</i>	Dr. Grant Hausler, <i>Coordinator, National Positioning Infrastructure, Geoscience Australia</i>
2:45 - 3:15	Benefits of Using Multi-GNSS for Mobile/Cellular Platforms <i>Pros &amp; Cons of Performance to the User and Market Access</i>	Mr. Greg Turetzky, <i>Director of Strategic Business Development, Intel</i>
3:15 - 3:30	<b>BREAK</b>	
3:30 - 4:00	European Union Activities on GNSS Spectrum Protection <i>Protect, Toughen, Augment (PTA) Initiatives</i>	Mr. Pieter De Smet, <i>Senior Policy Officer, European Commission</i>
4:00 - 4:30	<b>On the Challenge to PNT from the Perspective of Global Common Security</b> <i>Addressing Mutual Interests</i>	Professor WU Haitao, <i>Academy of Opto-Electronics, Chinese Academy of Sciences</i>

## Multi-constellation for Toughening Air Navigation example is based on RNP 0.3

Constellation	GPS only Mask=5°	GPS only Mask=15°	GPS+Galileo Mask=5°	GPS+Galileo Mask=15°
Depleted with 23 satellites	99.1%	0%	100%	69.3%
Baseline with 24 satellites	100.0%	2.3%	100%	100%
“Optimistic” with 27 satellites	100.0%	19.0%	100%	100%

Small part of aviation portfolio for intentional interference and spoofing  
Please see Ken Alexander briefing to RTCA in October, 2015.

# Conclusion...

## GNSS is the backbone of “Assured PNT”

[e.g. Availability, Accuracy, & Integrity]

- but -

**To continue the PNT Revolution for all users,**

- **Let’s Accelerate and Expand *PTA*:**
  - **Protect** – Legal and Law enforcement
  - **Toughen** – Maximize affordable Jam resistance
  - **Augment** – Use all available sources of PNT

# Thank You