# Architecture and Sustainability

Sustainment, Availability, Affordability (the cost/quantity tradeoff) and being the Gold Standard

# Topics Addressed

- Is the U.S. meeting its declared commitments?
- Reasons for more than 24 Satellites other than U.S. Military Needs
  - Aviation
  - Agriculture
- Meeting the Gold Standard at lower cost
- What does ‘Being the Gold Standard Mean?
- International Cooperation

# The U.S. is Keeping its Space Policy Commitments

In creating and sustaining the GPS system the U.S. has provided an important global infrastructure for its own military purposes; with augmentation, its domestic air traffic management purposes; and many other civil and commercial uses. It has pledged to provide access to this system to all users, foreign and domestic, without charge. It has been a world-changing achievement. In 2010 the President established a new Space Policy for Space Based PNT which continues these commitments. Current plans, programs and activities position the U.S. to satisfy these commitments.

# The U.S. is Keeping its Space Policy Commitments

- However, we are concerned about the limitations of DoD's planned 24 MEO satellite constellation.
  - Will not provide adequate support to military operations in some important situations
  - Past years of 30 satellites has established expectations
  - Eventual risk of not maintaining 'Gold Standard' of superior or equivalent capability
- None the less, the proper DoD authorities have made their considerations of cost, benefit and risk to come to the judgment that 24 is an adequate number for their mission. For the moment, therefore, we take that position as a baseline assumption in any further analysis we make.

# Reasons for more than 24 Satellites other than U.S. Military Needs

- The services that can be derived from GPS are manifold. They now comprise an important infrastructure upon which many civil and commercial activities depend as well as for military use. As we assess things, most of these critical services can be adequately supported with the service levels associated with a 24 MEO constellation and the 2010 commitments of the U.S. A potential, important exception is a GPS-based, global air traffic management system. A second might be agriculture.

# Aviation

- For integrity purposes, any reasonable number of satellites at MEO will not permit the elimination of augmentation systems
  - GPS alone will not provide adequate elevation information
  - With WAS systems, 30 satellites do not provide material advantages
  - Augmentation systems also provide a mechanism for local sovereign control and system contribution
  - ILS/DME will also likely be retained for back up

# Mitre Study Conclusions

- A 30 satellite GPS constellation provides only minimal benefits for civil aviation users over a 24 satellite constellation with WAAS
  - Only significant benefit is for those who choose not to equip with WAAS
- A 24 satellite GPS constellation with WAAS satisfies NextGen civil aviation availability needs

# Aviation

- We judge that an assured level of 24 MEOs with GEO augmentation is a practical architecture for aviation purposes.
- To assure a constellation of 24 is in place, a nominal level of 27 will be needed

# Agriculture

- Substantial usage, U.S. and World Wide
- Size of Equipment market:  $2+ billion/yr
- Size of U.S. Agriculture Segment Savings through GPS:  $15-20 billion
- Global Agricultural Impact is X times greater  (Australia and Europe).
- Potential U.S. efficiency leverage:  5-15%

# Agriculture

- Agriculture applications appear to be supportable with 24 slot configuration operated over the past few years
- However, 24 is on the edge of adequate performance.  Most Agriculture applications want access to 6 satellites.

# Meeting the Gold Standard at lower cost

- We assess that sustaining excellence with the current GPS III program with current non-PNT add-ons is going to be challenging in the current financial environment
- In our judgment, there are architectures and configurations that would permit equivalent  or better performance at a lesser cost.

# Meeting the Gold Standard at lower cost

- Examples-----

  -Replace some GPS III with a GPS-only simpler, lighter and cheaper

  -Put GPS capabilities on other satellites as a hosted payload

  -Etc.

# Senate Language

- The mini-GPS satellites would be small satellites using one of many existing small commercial satellite buses with L1, L2, and L5 signals only, and no additional capabilities. The committee directs the Air Force to review the possibility of using mini-GPS satellites and to submit a report to the congressional defense committees setting forth the results of the review no later than December 1, 2010. The report should include an estimate of the cost of each mini-GPS satellite.

# What does ‘Being the Gold Standard Mean? The 2010 Space Policy says:

- **Maintain and Enhance Space-based Positioning, Navigation, and Timing Systems.** The United States must maintain its leadership in the service, provision, and use of global navigation satellite systems (GNSS).To this end, the United States shall:
- Provide continuous worldwide access, for peaceful civil uses, to the Global Positioning System (GPS) and its government-provided augmentations, free of direct user charges;
- Engage with foreign GNSS providers to encourage compatibility and interoperability, promote transparency in civil service provision, and enable market access for U.S.industry;
- Operate and maintain the GPS constellation to satisfy civil and national security needs, consistent with published performance standards and interface specifications.Foreign positioning, navigation, and timing (PNT) services may be used to augment and strengthen the resiliency of GPS; and
- Invest in domestic capabilities and support international activities to detect, mitigate, and increase resiliency to harmful interference to GPS, and identify and implement, as necessary and appropriate, redundant and back-up systems or approaches for critical infrastructure, key resources, and mission-essential functions.

# International Cooperation

- The U.S., Europe, China and Russia plan to put in 90+ MEO GNSS satellites in orbit
- Each system will have different constellation attributes
- When all are activated, users will have a rich set of choices to achieve their PNT objectives
- This is likely to evolve without significant system to system coordination
- Ultimately, this evolution may influence the investment levels for each system
- Exploitation of the precision promised by this combination of systems is greatly enhanced by cooperative monitoring and dissemination of perfomance information (IGS)