Global Positioning Systems Wing

GPSW Panel Session
CGSIC 2010

21 September 2010

GPS Wing

Overview

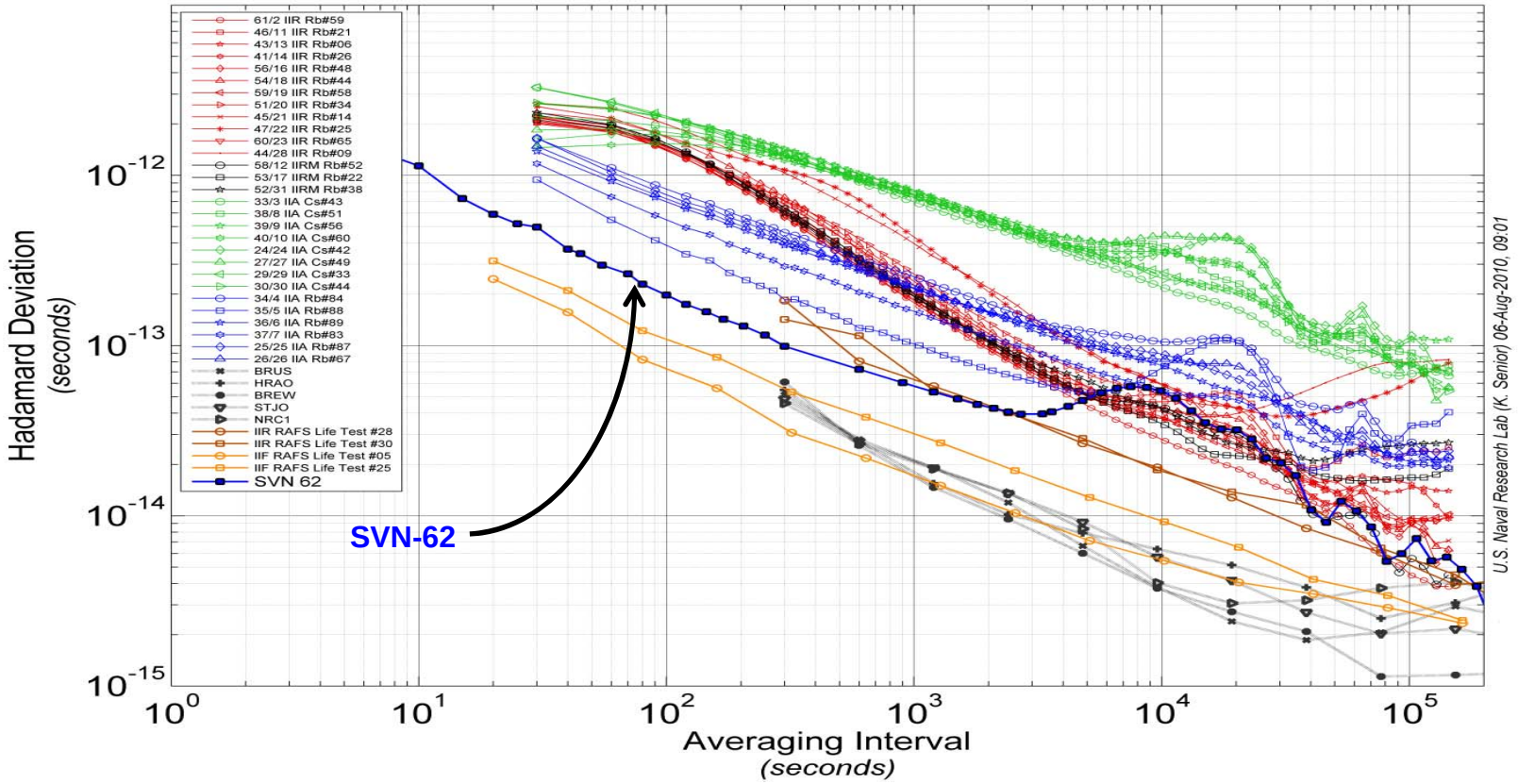
- **SVN-62**
- **SVN-49**
- **Recent Lessons Learned**
- **Performance Standards**

SVN-62

- **IIF-1 is SVN 62 and PRN-25**
  - Launched May 2010, set healthy August 2010
- **Three SVN-62 signals characteristics have generated interest recently**
  - Clock performance
  - L5 phase variation
  - L5 digital distortion
- **L1 C/A, L1 P(Y), L2 P(Y) signals meet specs**
  - Comply with the ISs/ICDs and the Performance Standards (PSs)
- **L2C, L5, M-Code will meet specs with OCX**
  - OCX required for CNAV or MNAV data messages
  - Modernized signal PSs will be published as signal IOCs approach
  - No SVN-62/PRN-25 technical problems to prevent meeting specs

IIF-1 SVN-62/PRN-25 Clock

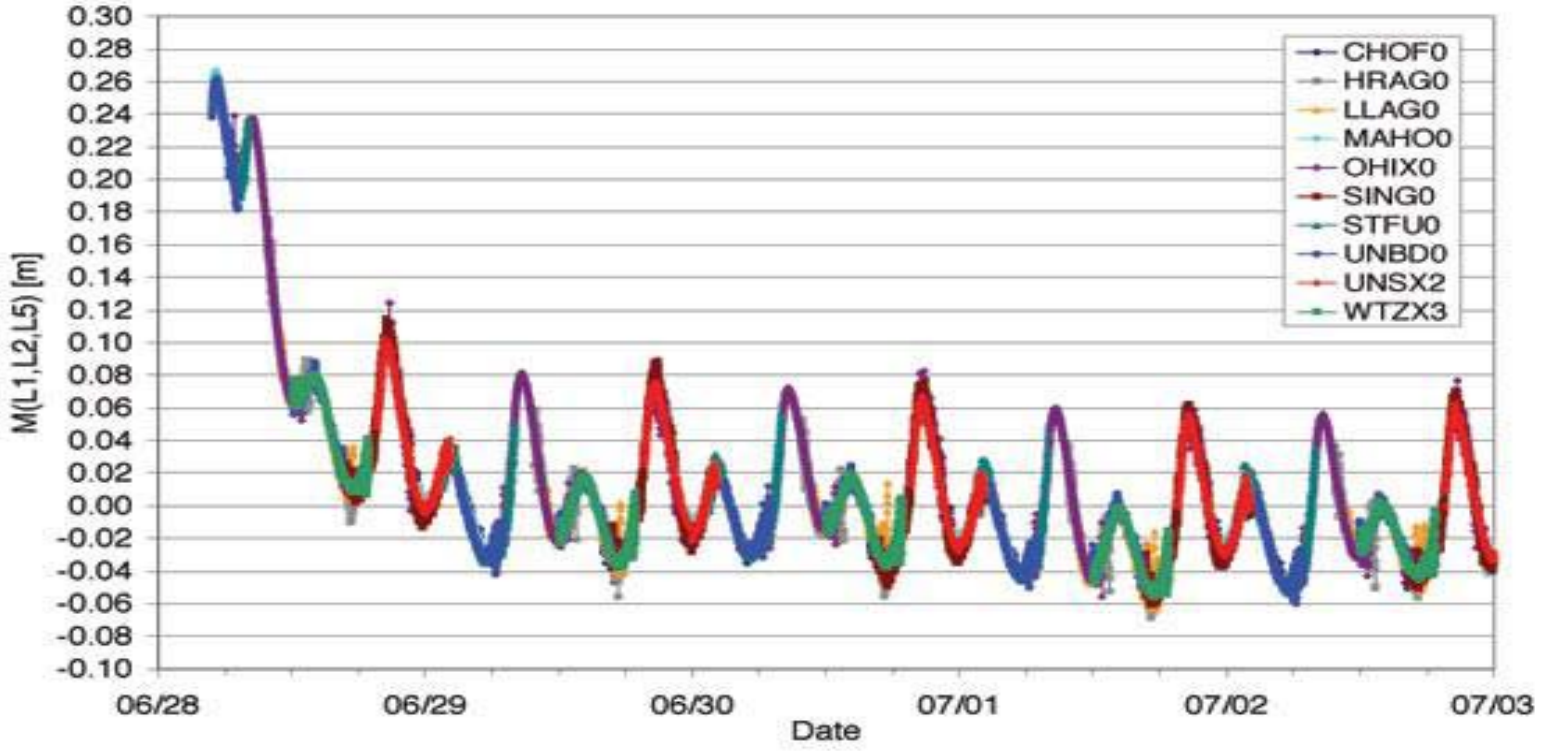
- **Rubidium clock is among best ever seen**
  - Stability of "apparent clock" affected by orbit-period harmonic errors
    - Similar effect seen with other high-stability satellite clocks
  - Expect clock stability to gradually improve
    - Further clock settling and updates to solar pressure model



Plot from Ken Senior at Naval Research Laboratory

SVN-62/PRN-25 L5 Carrier

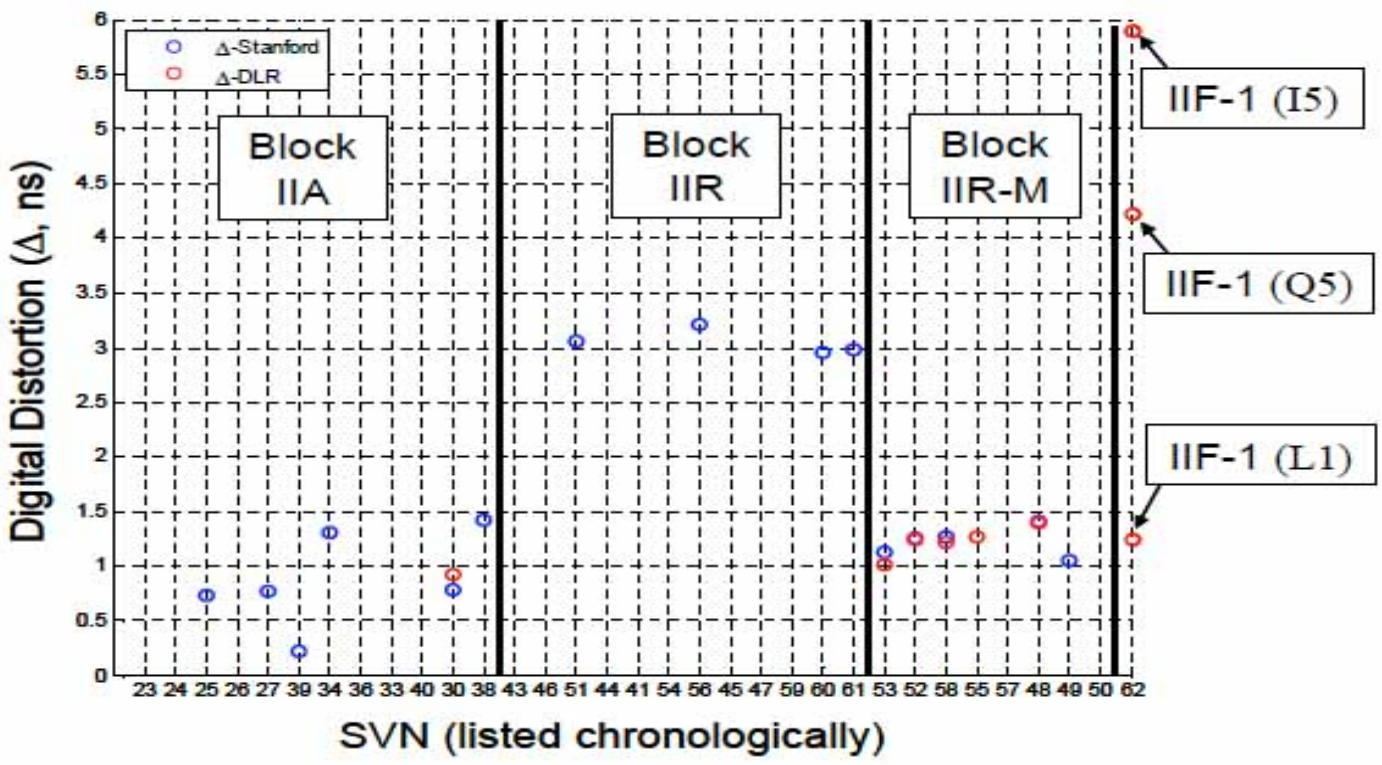
- **L5 carrier not as coherent as L1 and L2**
  - L1/L2 carriers & all PRN codes are coherent with each other
  - L5 carrier is coherent with other signals within ±0.06 m worst case
- **Well within related GPS III specification value of ±6.1 m worst case (FAA)**



Plot from Montenbruck, Hauschild, Steigenberger, and Langley; "Three's the Challenge"; published by *GPS World*, 20 July 2010

SVN-62/PRN-25 L5 Codes

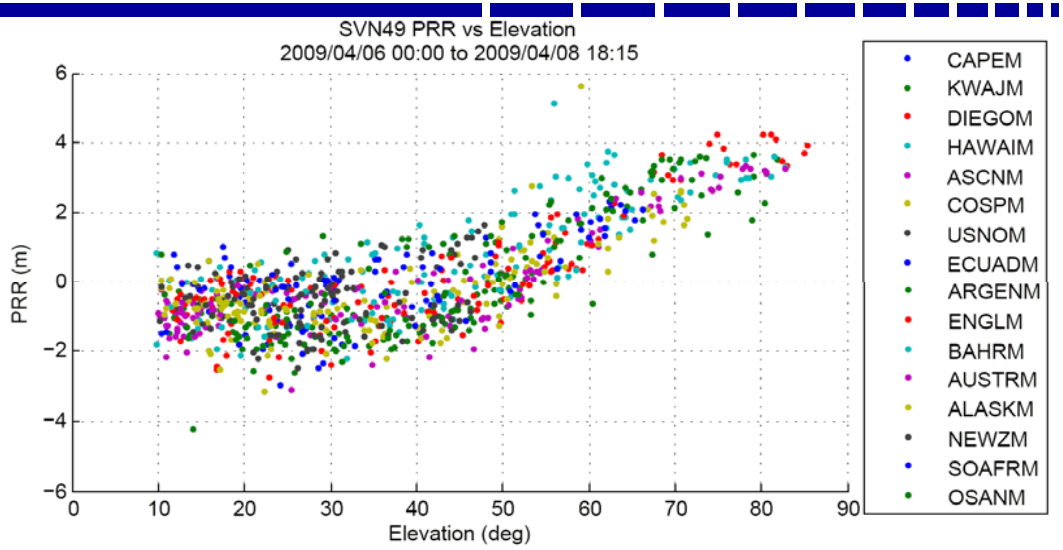
- **L5 codes are slightly more distorted than usual**
  - The benchmark for "usual" is L1 C/A-code
  - L5 codes have a slight Δ values (+1 vs -1 chip duration mismatch)
- **Well within related GPS III specification value of 10 nsec worst case (FAA)**



Plot from Phelts, Gao, Wong, Heng, Walter, Enge, Erker, Thoelert, and Meurer; "Aviation Grade"; published by *Inside GNSS*, July/August 2010

SVN 49

- **GPS IIR-20(M) (SVN 49) was launched 24 Mar 09**
  - Navigation payload was modified to include an L5 demonstration payload
- **Signal distortion observed during On-orbit check-out**
  - At higher elevations, the user sees a 4m+ error from the navigation signal

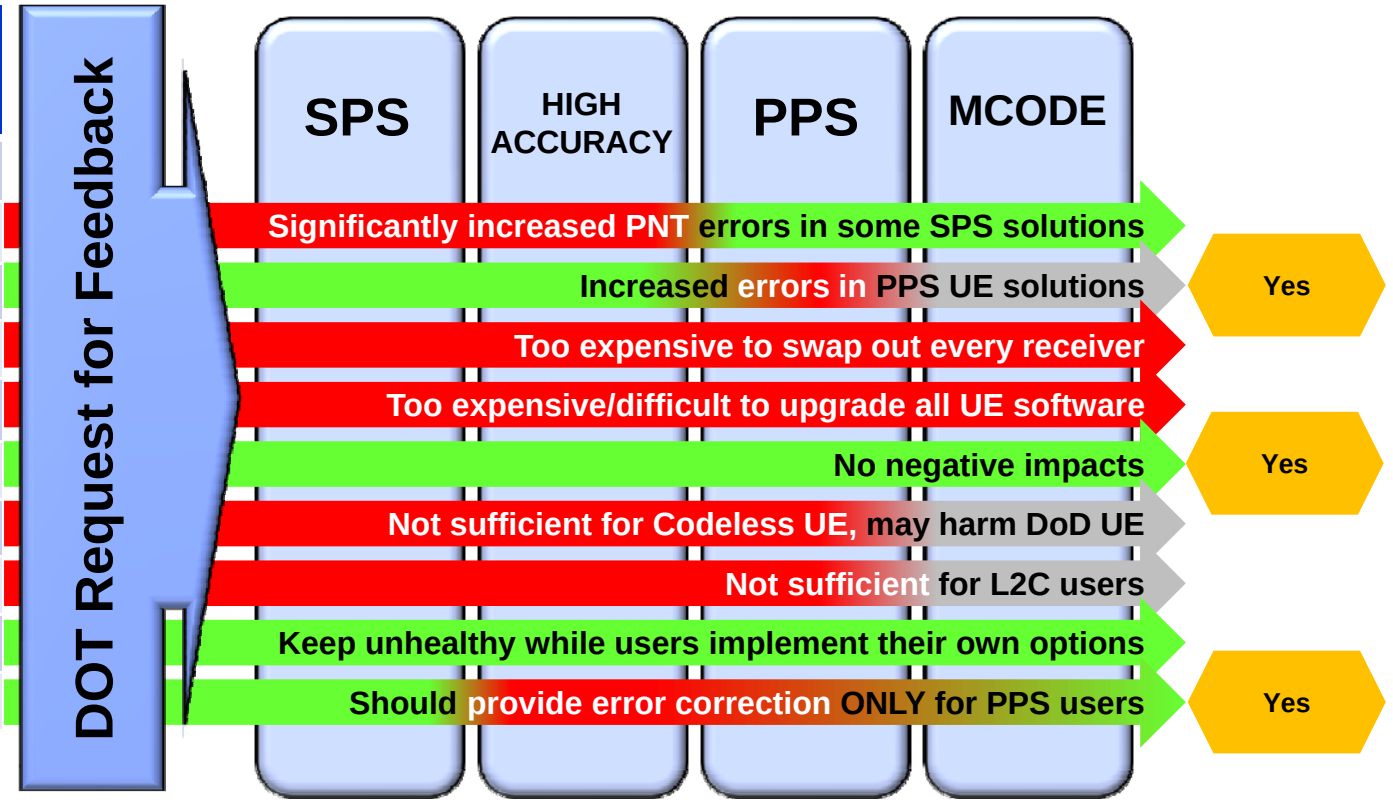


- **Improper installation of L5 payload determined as root cause of the anomaly**
  - A small amount of L1/L2 energy is reflected from the L5 filter back into the antenna, creating a multi-path effect as the delayed signal gets rebroadcast
  - SVN-49 does not meet spec with distortion (IS-GPS-200 3.3.1.4, “Spurious Transmissions”)
- **Vehicle currently “UNHEALTHY” to all users**
  - GPSW and 50 SW are working to develop a way ahead that may allow setting SVN 49 “HEALTHY”

SVN 49 Investigation

- **Mitigation techniques and response of stakeholders**

Mitigation Technique
1) 152m APC & Clock Offset
2) Factory APC + AEP 5.5.4
3) Multipath Resistant Rcvr
4) SW Updates for UE
5) Increase URA to 3+
6) No Data on L2P(Y)
7) Change L2C PRN
8) Unhealthy but Usable*
9) Other PPS Mitigation



*Requires unique ID

GPSW is pursuing mitigations 2, 5, and 9
Receiver vendors are encouraged to pursue 3 and 4

SVN 49 Summary

- **SVN 49 accomplished L5 demo successfully but caused signal distortion**
- **Distortion can be mitigated sufficiently to make SVN 49 useful**
  - Some mitigations feasible from Space and Ground Segments
  - Others needed from User Segment
- **Cannot make SVN 49 compliant with ICD-200**
  - Should not be included in availability predictions
- **Provide 3-4 years to prepare for setting SVN 49 healthy**
  - Kalman Filter upgrade in AEP 5.5.4 & eventually for OCX
  - URA increase to 3+
  - PPS user mitigation
  - Other user mitigations
  - Updates to performance standards for SVN 49 (IS-GPS-200, 700, 705)
- **Set SVN 49 healthy after mitigations have been implemented and affected users have had time to prepare for it**
  - Set it healthy sooner if total # of SVs drops to <24 or if constellation needs demand it

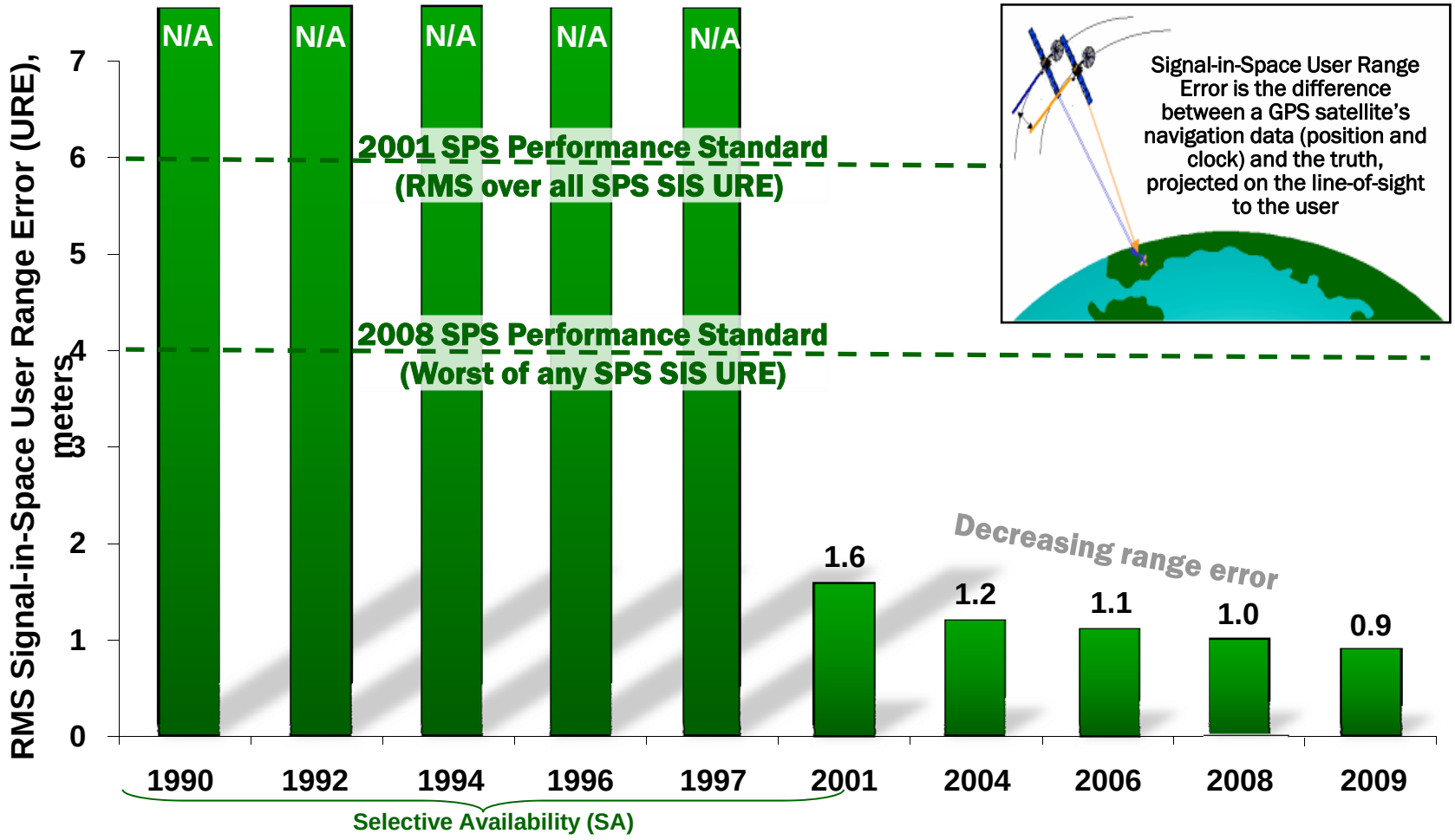
Striving to Maximize Usefulness of SVN 49

Recent Lessons Learned

- **GPS receiver anomalies were reported several times this year coinciding with testing activities**
  - Almanac problem in Nov 2009, SAASM issue in Jan 2010, etc.
- **Problems were traced to non-compliant UE**
  - Unauthorized use of reserved bits, incorrect assumption on almanac time, incorrect implementation/interpretation of SAAM function
- **Problems mitigated by working extensively with UE vendors to fix non-compliance issues**
- **Resulted in delays to fielding of SAASM capabilities**
- **Improvements in compliance verification are being put in place**

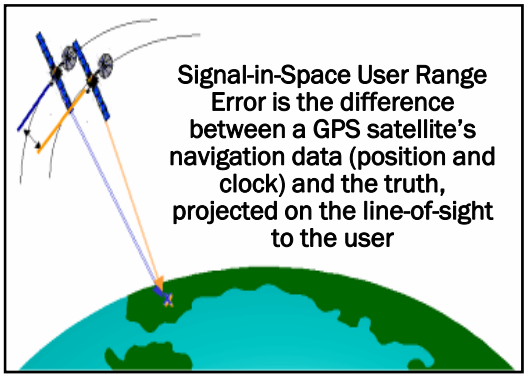
ICD Compliance is Critical for GNSS Success

SPS Signal in Space Performance



System accuracy exceeds published standard

PPS Signal in Space Performance



System accuracy exceeds published standard

Coming Up: SPS PS Update

- **Planning a draft update of the SPS PS by Q1FY11**
  - Name change to "Open Service Performance Standard" (OS PS)
  - Addition of L2C signal to current L1 C/A signal
  - Same performance values
  - Draft update will be circulated for review & comment within U.S. Government
  - SPS PS update approval before Initial Operational Capability (IOC) declaration for L2C
- **Planning subsequent draft updates for L5 signal and for L1C signal**
  - Prior to each subsequent IOC declaration
- **Exploring new performance metrics**
  - Different users and applications
  - Different environments