



SVN-49 / PRN-01 Lessons Learned

International Committee on GNSS (ICG-4)

Working Group A

Saint Petersburg, Russia

15 September 2009

Colonel David B. Goldstein, United States

“Set no satellite healthy before it’s time”



Purpose



- Provide lessons learned on GNSS anomaly resolution with SVN-49 as a case study



Background



- GPS IIR-20, SVN-49 (PRN 01), carries an L5 Demonstration Payload
- The demonstration payload made use of an Auxiliary Payload port on the spacecraft
- No impact on the L1 and L2 signals was intended or expected
- However, 2SOPS and Aerospace reported “out of family” elevation angle dependent Pseudo Range Residuals (PRR) from the monitor stations
- “Out of family” measurements also seen by other GNSS users world-wide



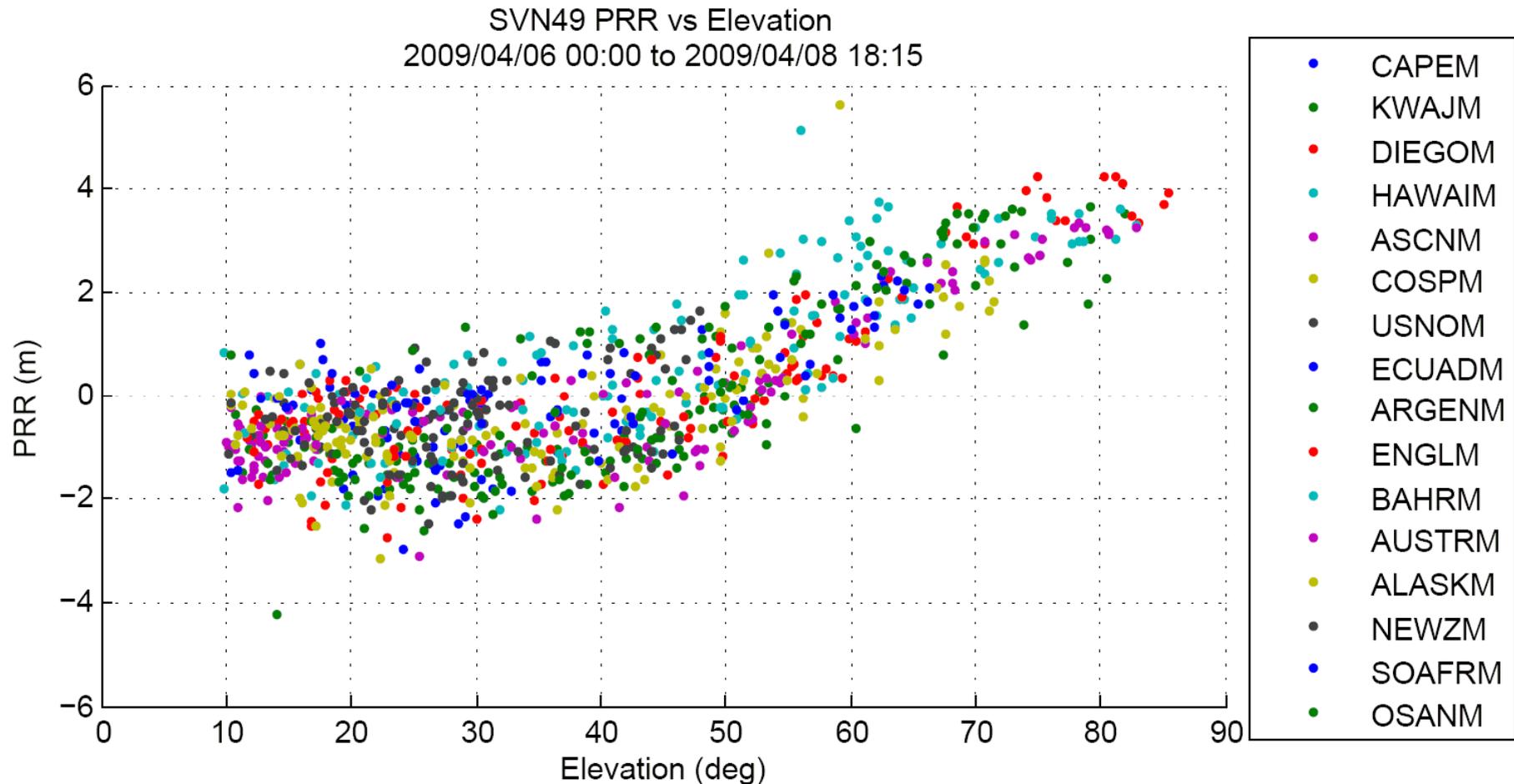
Background (cont.)



- Root cause established
- Caused by signals reflecting off L5 filter and transmitted through satellite antenna
- Overall effect characterized as a permanent, static multipath signal being generated within the satellite
- Effects most prominent on portion of antenna, whose influence is greatest at high elevation angles
- Signal distortion is user elevation angle dependent, with little or no distortion at low elevation angles



Pseudorange Residuals



Ionospheric refraction corrected pseudoranges

Relative to a “best fit” orbit determined early in the test program

Roughly a 4+ meter spread from 10 to 80 degrees



Anomaly Resolution Process



- Typical Satellite Anomaly Resolution Process
 - Assemble anomaly resolution team
 - Determine root cause
 - Return satellite to nominal operations
- Challenge presented when unable to return to “nominal” operations
- Challenge presented by users who are non-compliant with interface specifications
- Challenge presented working anomaly resolution with world-wide, diverse user base
 - No process in place to discuss problems or solutions with broad user base
- Difficult to test potential fixes across user base with satellite set unhealthy



Anomaly Resolution Process (cont.)



- Despite challenges, SVN-49 anomaly resolution proceeding
- Personal interviews with user base have been extremely useful
- Path forward to include additional testing opportunities
- Openness is key to building effective solutions and gaining trust
- Additional input by world-wide user base highly desired
- SVN-49 will not be set healthy until “it’s time”



Lessons Learned



- Prior to anomaly occurrence, document agreed to process for vetting potential fixes in “pseudo-nominal” return to operations
 - Virtual collaboration may be best means to communicate problems and solutions
- Open and inclusive dialogue facilitates best solutions
- Gaining consensus with broad and diverse use base is difficult
- Prioritizing users with safety of life impacts is key
- Documentation of solutions in public interfaces a must
- Interviews with user base sample necessary but not sufficient
- Significant resources required to fully discuss problems and solutions



Conclusion



- SVN-49 anomaly presents an unique opportunity to improve anomaly resolution process
- Anomaly resolution process more challenging when return to “nominal operations” unattainable
- Strong anomaly resolution process key to determining SVN-49 root cause and determining way-forward for potential solutions
- Many lessons learned by GPS team
- Openness and inclusive dialogue a must
- Set no satellite healthy before it’s time!



Questions?