

746th Test Squadron

Best in Test



U.S. AIR FORCE

**Validation of the New GPS Master
Control Station Using GPS User
Equipment**

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746 Test Squadron
Holloman AFB NM**



Integrity ~ Service ~ Excellence ~ Agility

UNCLASSIFIED



“We just changed the world... and nobody knows”

**-- Colonel Ken Hasegawa
GPSW/GPG**



Outline



- **Program Purpose**
- **Test Overview**
- **Test Process**
- **Test Results**
- **Conclusions**



AEP Purpose



The purpose of the DOD's Architecture Evolution Plan (AEP) was to create a New GPS Master Control Station (NMCS) that improves operations, increases efficiency, improves performance accuracy and provides a foundation for new GPS capabilities.

FUTURE GPS UPGRADES DEPEND ON THE SUCCESSFUL DEVELOPMENT, VALIDATION AND TRANSITION OF THE GPS NMCS



Test Purpose



The purpose of the Global Positioning System Architecture Evolution Plan (AEP) Operational end-to-end User Equipment (UE) verification is to obtain GPS UE confirmation of nominal on-orbit performance of AEP-generated navigation uploads.

**INCREASE CONFIDENCE THAT AEP TRANSITION
WILL BE TRANSPARENT TO USERS**



Test Overview



PHASE I – Upload SVs set unhealthy with AEP

- Confirm nominal UE performance of AEP-generated navigation upload transmitted from a Block IIA satellite(s)
- Confirm nominal UE performance of AEP-generated navigation upload transmitted from a Block IIR/IIR-M satellite(s)

PHASE II – Upload SVs set healthy with AEP

- Confirm nominal UE performance of AEP-generated navigation upload transmitted from a Block IIA satellite(s)
- Confirm nominal UE performance of AEP-generated navigation upload transmitted from a Block IIR/IIR-M satellite(s)

PHASE III – Transition GPS Operations to NMCS

- Confirm nominal UE performance of AEP-generated navigation uploads transmitted from all satellites as they transition to NMCS operations

METHODICAL APPROACH REDUCES RISK TO USERS



Phase I Process



Executed 9 March and 14 April

Methodology

- GPS Operations performed NMCS generated navigation uploads on PRN 5 (SVN 35) and PRN 14 (SVN 41) while in L-Band visibility of Holloman AFB (set unhealthy)
- 746 Test Squadron (746 TS) monitored and assessed real-time performance using military GPS UE testing suite of equipment (forced tracked); providing rapid notification to operations
- 746 TS forced tracked using two Defense Advanced GPS Receivers (DAGR) and three R3A receivers



Phase I Results

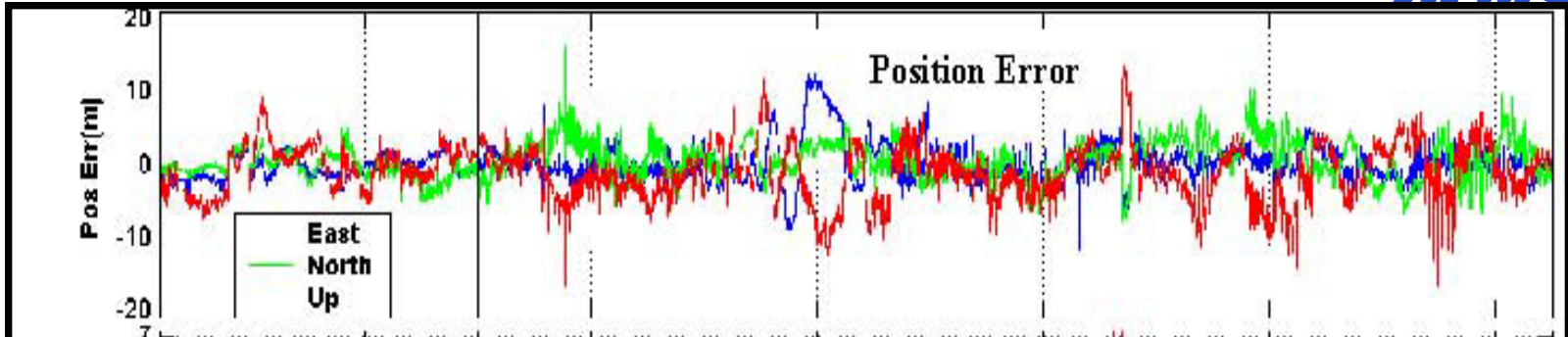
Receiver	LEP (m)	CEP (m)	SEP (m)	2DRMS (m)	Hours tracked	# of points used
9 March 2007						
R3A #1	2.4	4.6	5.6	9.1	6	22,326
R3A #2	2.3	4.6	5.4	8.9	6	21,696
DAGR #1*	2.7	1.2	3.0	2.4	6	2,811
DAGR #2*	1.1	0.9	1.7	2.2	6	5,799
14 April 2007						
R3A #1	2.1	4.6	5.7	7.6	8	26,215
R3A #2	2.5	4.8	5.9	8.1	8	26,229
R3A-SRS	2.5	4.9	6.0	8.1	8	26,239
<p>* The DAGRs would not force track, therefore results from the DAGRs represent a free-roaming receiver navigating using the entire constellation</p> <p>** Results differ from between the R3A receiver and the DAGR due in large part to sub-optimal DOP incurred because of the 'force track'</p>						



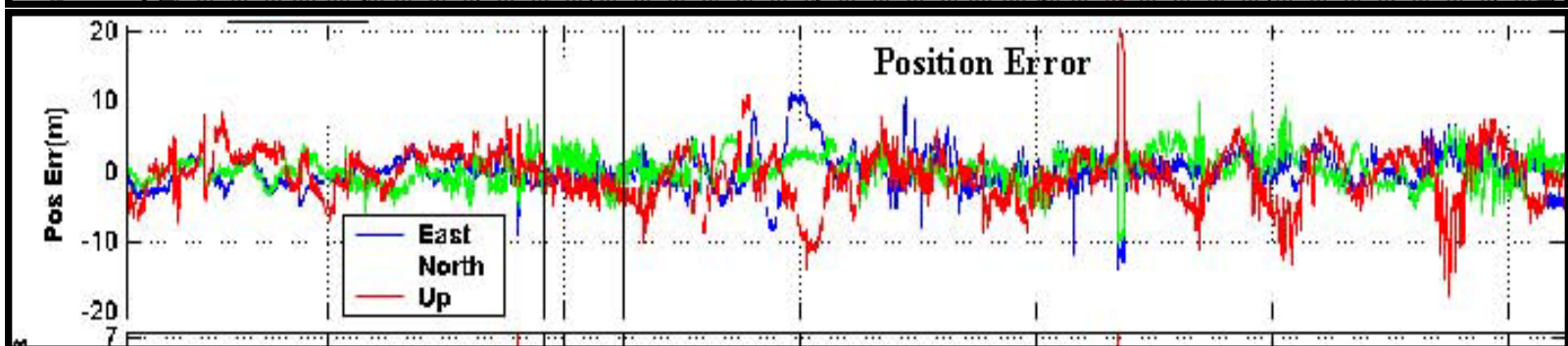
Phase I Results (Cont)



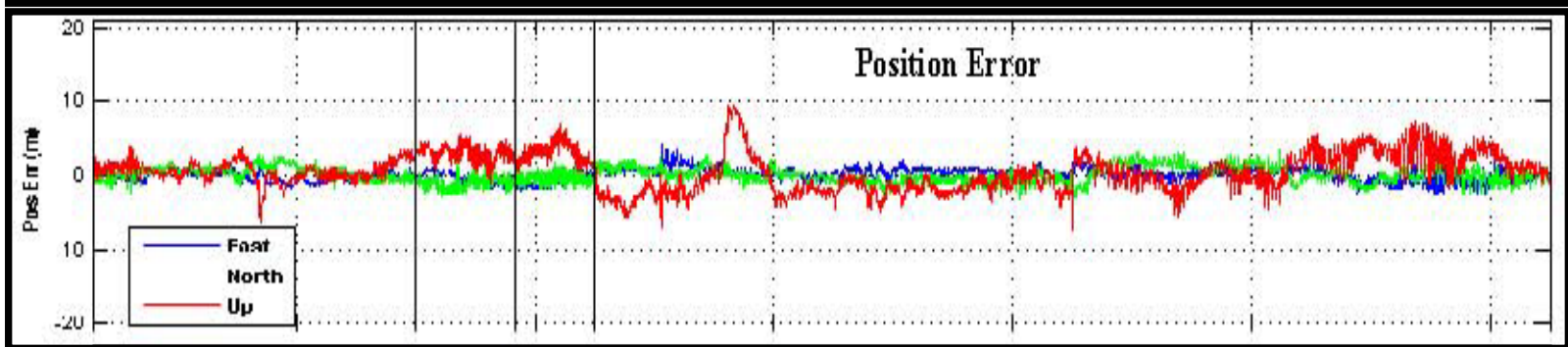
R3A #1



R3A #2
(Cesium
aided)



DAGR



** Results represent test using PRN 5 (9 Mar) – PRN 14 showed similar results



Phase II Process



Executed 26 – 27 June 2007 and 30 August – Upon successful completion of Phase I

Methodology

- GPS Operations performed NMCS generated navigation uploads on PRNs 25, 22, 17 and 26 (SVNs 25, 47, 53, 26) while in L-Band visibility of Holloman AFB (set healthy)
- 746 TS monitored and assessed real-time performance using military and civilian GPS UE testing suite of equipment – providing rapid notification to operations
- Equipment included DAGRs, PLGRs, MAGRs, R3As, Trimble Force 5s, Starlink Invicta, Ashtech Z-12
- During 4-satellite tests, forced tracked receivers to navigate using those satellites



Phase II Results

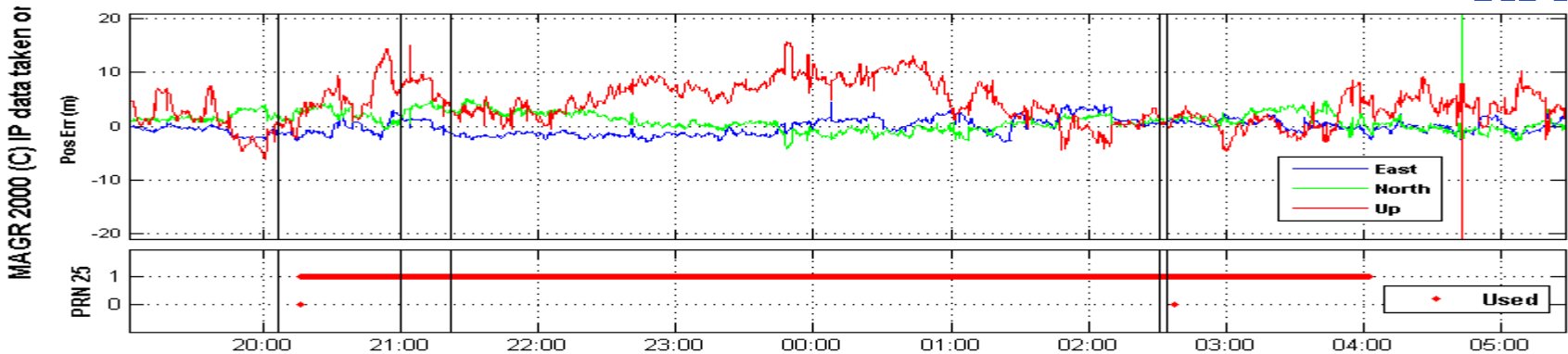


Test Day/ Satellite	LEP (m)	CEP (m)	SEP (m)	2DRMS (m)	Hours Tracked	# of Points Used
Pre Test/ BIIR	3.1	2.9	5.0	9.0	7.5	26767
Mission/ BIIR	3.4	3.1	5.5	9.2	7.5	26709
Post Test/ BIIR	3.7	3.7	6.2	10.2	7.5	26805
Pre Test/ BIIA	3.6	3.3	5.7	7.9	6.7	23936
Mission/ BIIA	3.0	3.0	5.0	7.1	6.7	23871
Post Test/ BIIA	3.6	3.2	5.5	7.6	6.7	23869

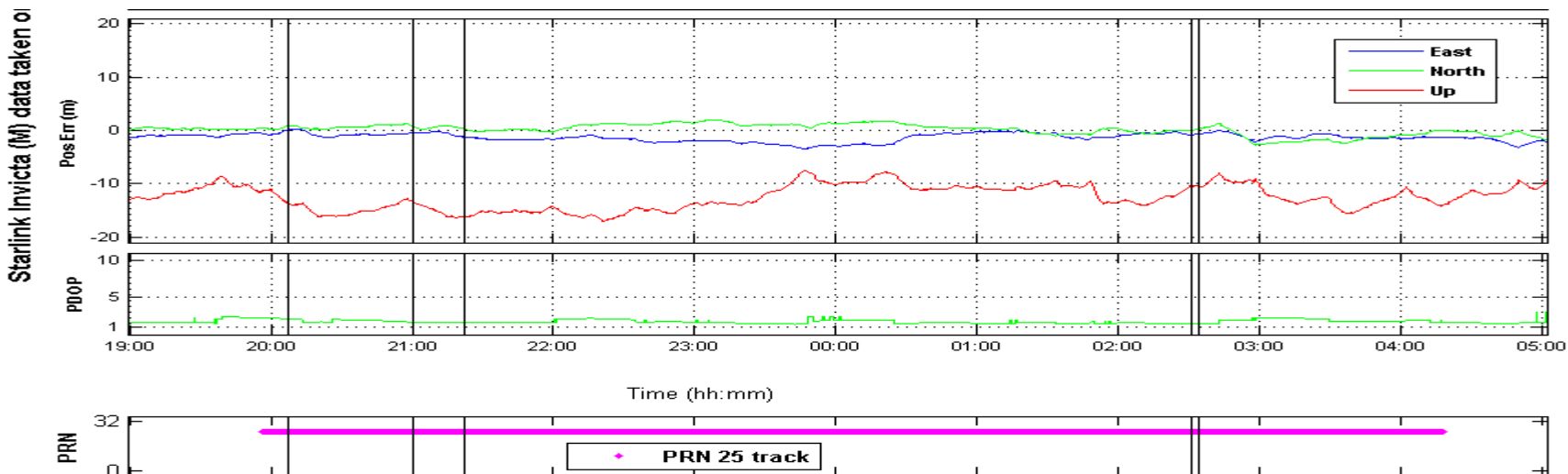
Results tabulated from June missions, similar results observed with August missions



Phase II Results (Cont)



Results for PRN 25 test using MAGR 2000



Results for PRN 25 test using Starlink Invicta



Overview Phase I & II Results



Phase I and II

- **Results consistent with nominal receiver performance levels**
 - Navigation accuracy
 - Carrier-to-Noise
 - Satellite power levels
- **Navigation accuracy using forced 4-satellite solution equated to 16.1 m (2D RMS)**
 - Poor solution resulted from sub-optimal DOP (DOP >10)



Phase III Process



Executed 13 – 14 September – Upon successful completion of Phase I & II

Methodology – Consisted of 2 sub-phases: Enhanced Phased Operations Transition (EPOT) and ops transition

EPOT:

- GPS Operations performed NMCS-generated navigation uploads on PRNs 08, 09, 28 and 17 (SVNs 38, 39, 44 and 53)
- 746 TS forced tracked receivers to navigate using four AEP uploaded satellites; monitored and assessed real-time performance

TRANSITION:

- GPS Operations performed NMCS-generated navigation uploads on all satellites
- 746 TS monitored & assessed real-time constellation performance



Phase III Results (Cont)



EPOT

Receiver	LEP (m)	CEP (m)	SEP (m)	2DRMS (m)	Hours Tracked HH:MM	# of Points Used
R3A #1 12 Sep	2.9	2.4	4.3	5.5	23:40	83810
R3A #1 13 Sep	2.5	2.3	3.9	5.5	23: 34	85231
R3A #1 14 Sep	2.7	2.4	4.1	5.7	23: 34	84863
<p>LEP: Linear Error Probable CEP: Circular Error Probable SEP: Spherical Error Probable 2DRMS: 2-Dimensional Root Mean Square</p>						



Phase III Results (Cont)



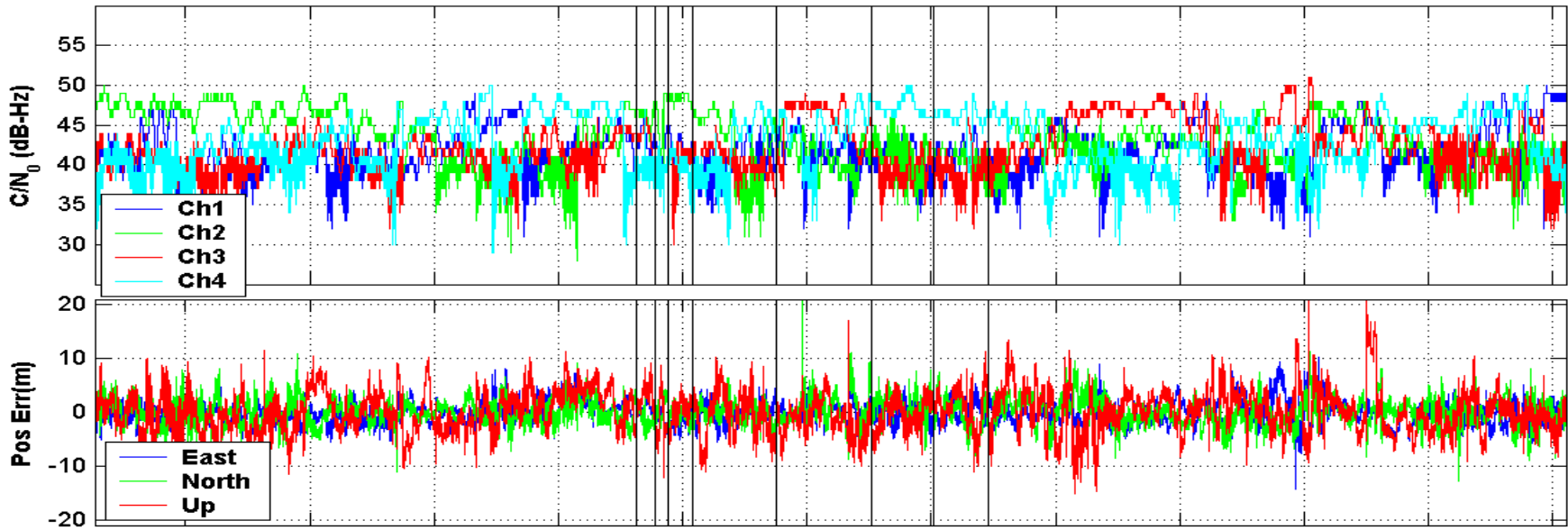
EPOT & TRANSITION

Receiver & Date	Satellite Type	Satellite ID	User Range Error (rms-m)	Notes
R3A 306 #1 13 Sep 2007	BIIA	PRN 08 (SVN 38)	2.1	Critical Mission Day URE values are excellent
	BIIR	PRN 09 (SVN 39)	2.4	
	BIIR	PRN 17 (SVN 53)	2.6	
	BIID	PRN 28 (SVN 44)	1.9	

URE VALUES INDICATED NOMINAL SATELLITE PERFORMANCE



Transition Results



**** Results calculated using R3A receiver during 13 Sep transition**

**POSITION AND CARRIER-TO-NOISE RATIOS INDICATE
NOMINAL SATELLITE PERFORMANCE**



Phase III Results



EPOT:

- **Results consistent with previous tests**
- **Navigation accuracy indicated nominal satellite performance**

Transition:

- No anomalous conditions monitored
- Entire constellation transitioned and entered normal operations at 1123



Conclusions

- **The Department of Defense reduced risk to all users through systematic End-to-End test**
- **Always maintained direct communications between operations and testers**
- **No adverse or anomalous conditions experienced**
- **Constellation now being controlled using NMCS**



Acknowledgements



Lt Col Janet Grondin (GPSW)

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Questions?

