Improving the Accuracy of Precision Guided Munitions with a GPS Ephemeris & Ionospheric Correction Sharing Service (GEISS)

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What is the Problem?

- Small precision guided munitions need high accuracy GPS for guidance
- Munitions must be initialized prior to launch to allow rapid GPS acquisition
- GPS guided weapons only use satellites for navigation with pre-loaded NAV data
- Denial of GPS service at launch platform also limits PGM navigation performance

What is the Solution?

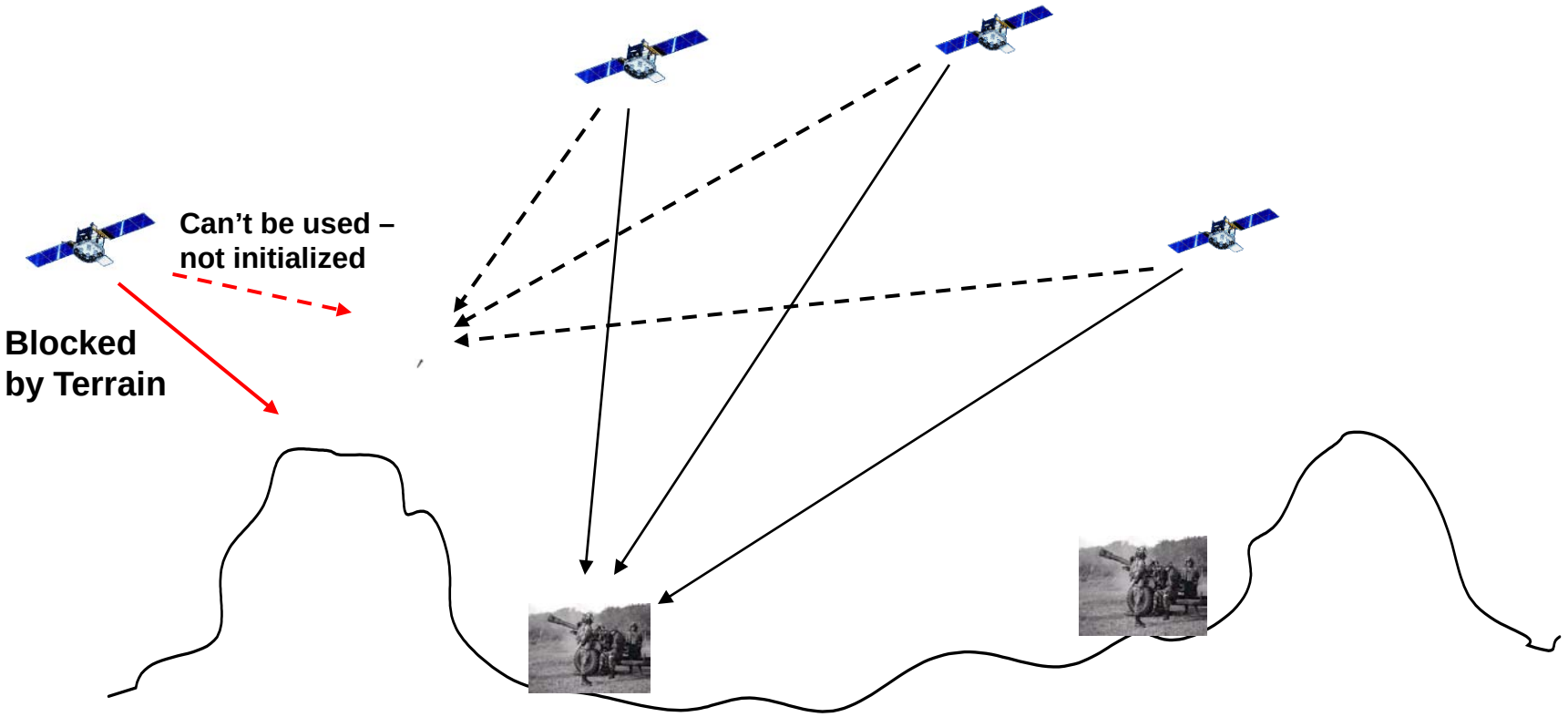
- GPS Ephemeris and Ionospheric Sharing Service (GEISS)
  - Shares ephemeris data and ionospheric corrections across AFATDS network
  - PGMs are initialized with data from all satellites in view across the network
  - Allows PGMs to operate with more GPS satellites once they have a better sky view following weapons launch

GPS-Guided Munitions that Could Benefit from GEISS

- Munitions
  - Excalibur
  - M107, M549/A1, M795 (w/ PGK)
- Platforms
  - Paladin, M777A2, Digitized M119

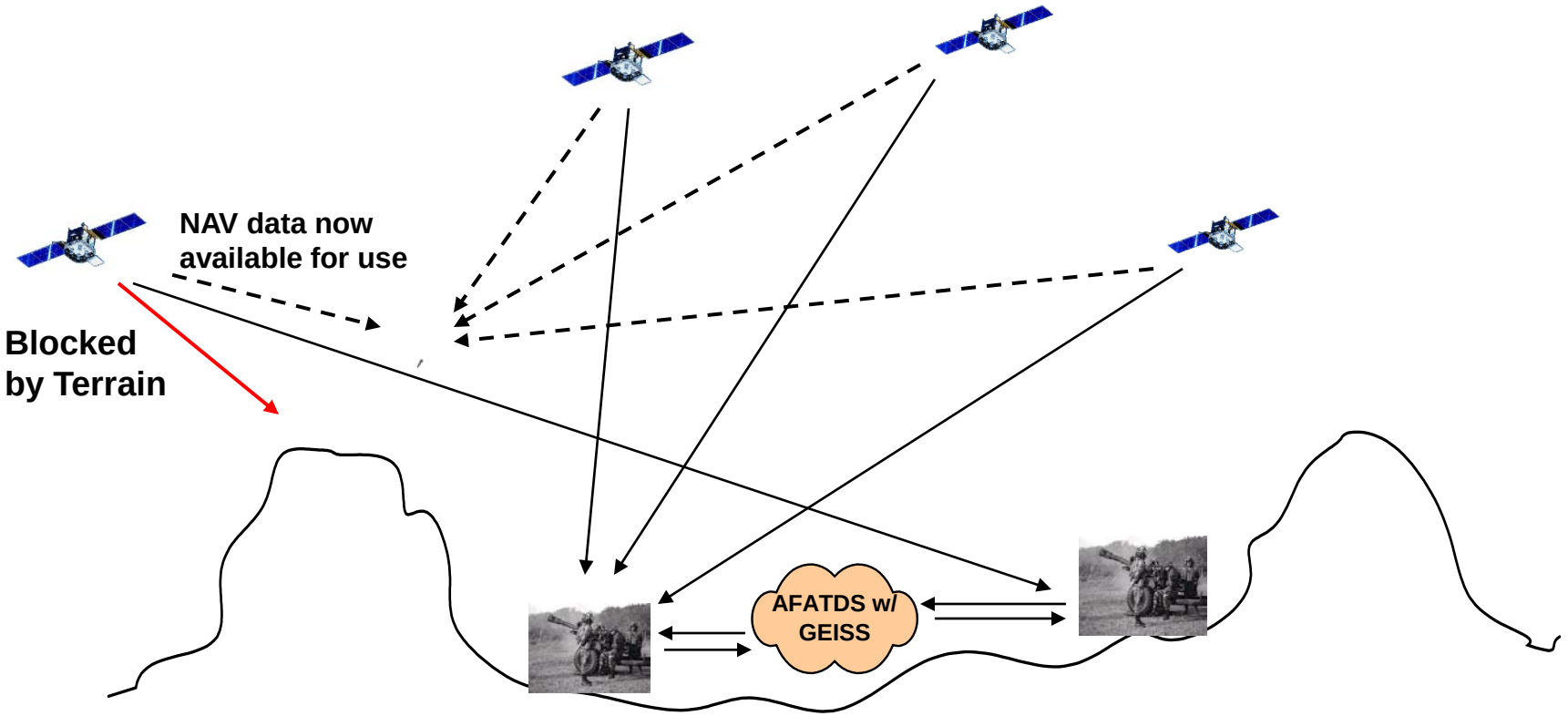
PGM Performance

- Currently, munitions are initialized with navigation, ephemeris, and Iono data from each weapon platform (WP) GPS receiver, using only satellites visible to that platform
- In flight, navigation data is only used from “initialized” satellites, reducing accuracy

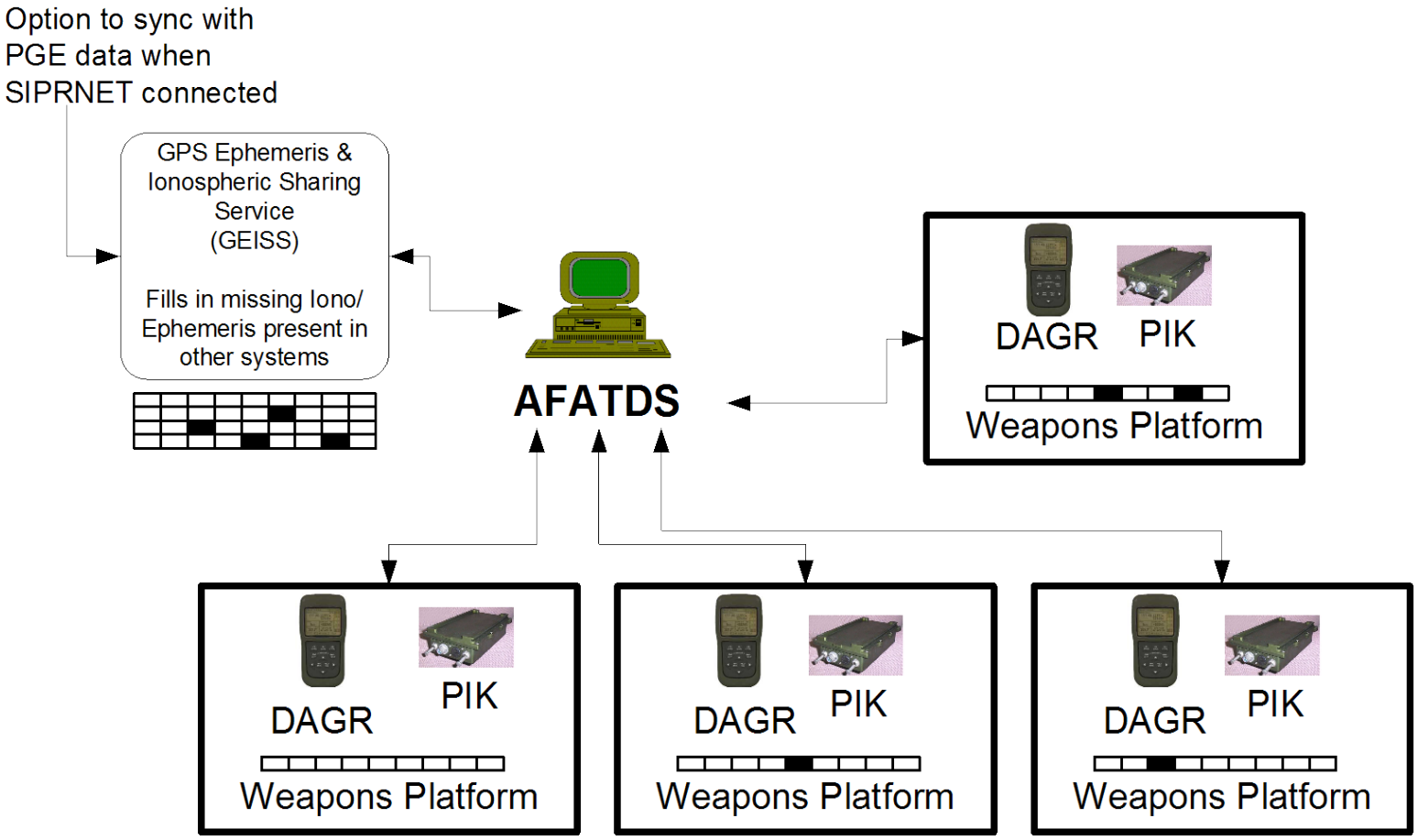


PGM Performance w/ GEISS

- GEISS “combines” satellite information from each WP GPS receiver and supplies the complete set to each WP through AFATDS for munitions initialization
- This allows even initially blocked satellites to be used in flight when available

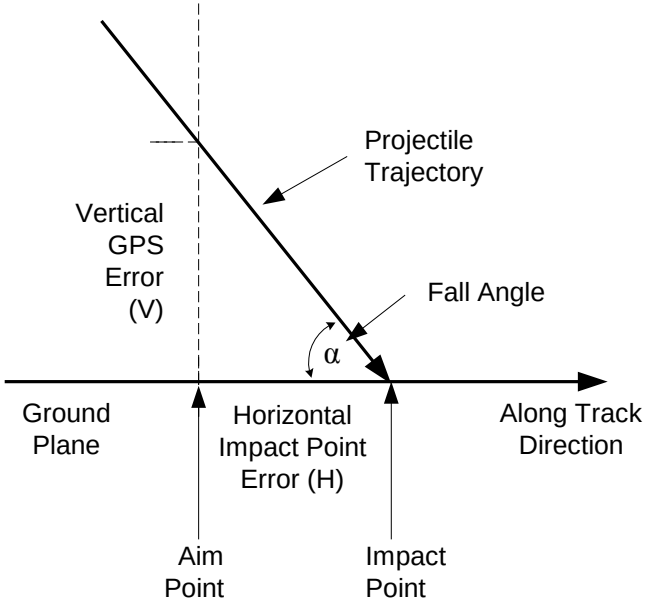


Network Sharing Integration w/ AFATDS



Note: TCM-Cannon personnel will make final determination on all GEISS, AFATDS, and Weapon Platform requirements

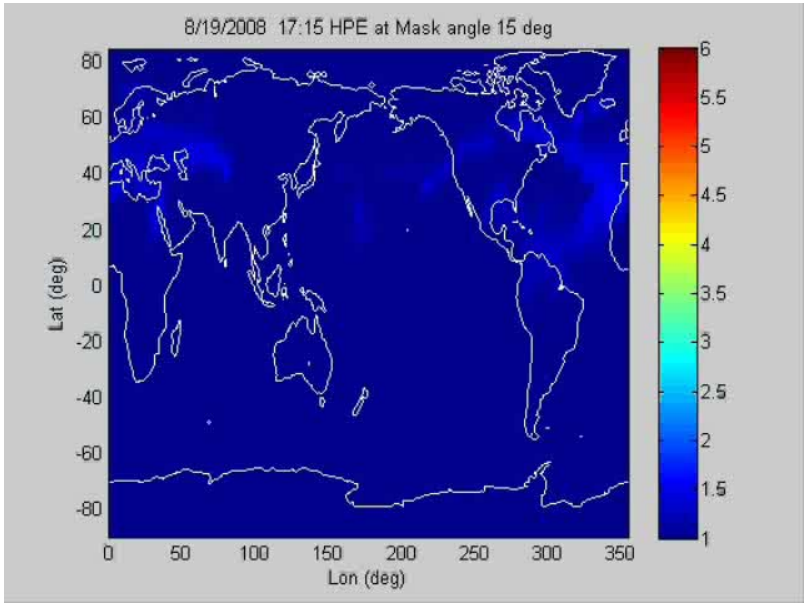
Aim Point Errors

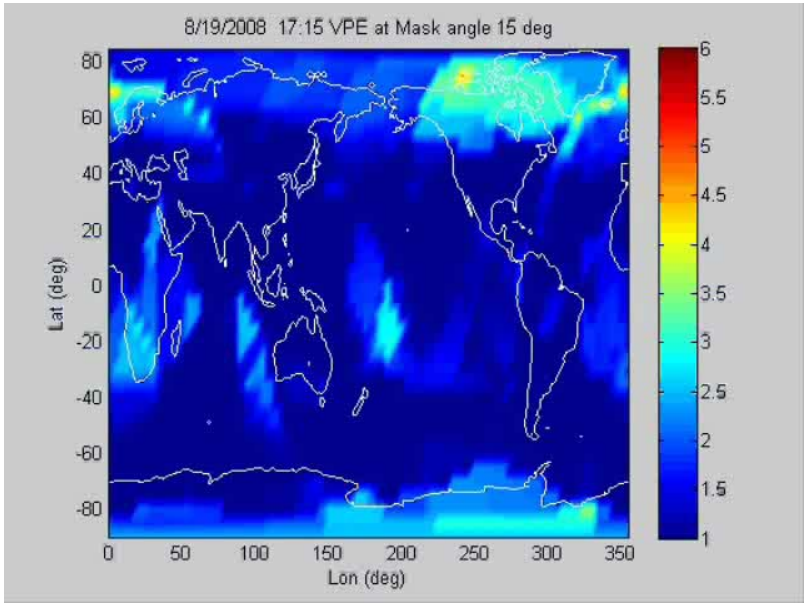


Vertical GPS errors map into along track aim point errors

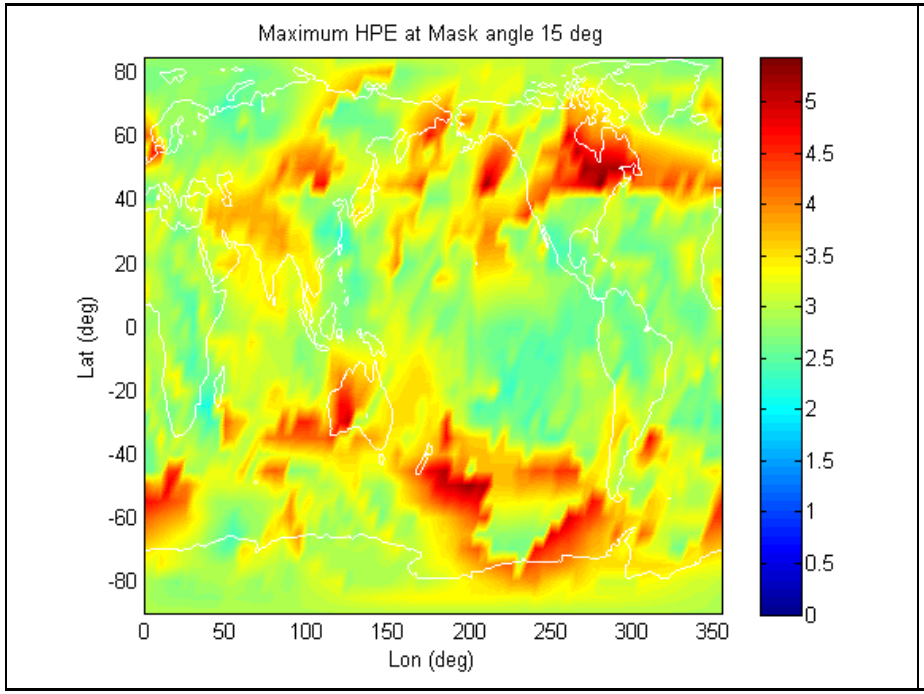
- Horizontal GPS bias errors map into horizontal aim point errors (earth referenced frame)
- Vertical GPS bias errors map into horizontal aim point errors through munition fall angle
  - Result in along track errors

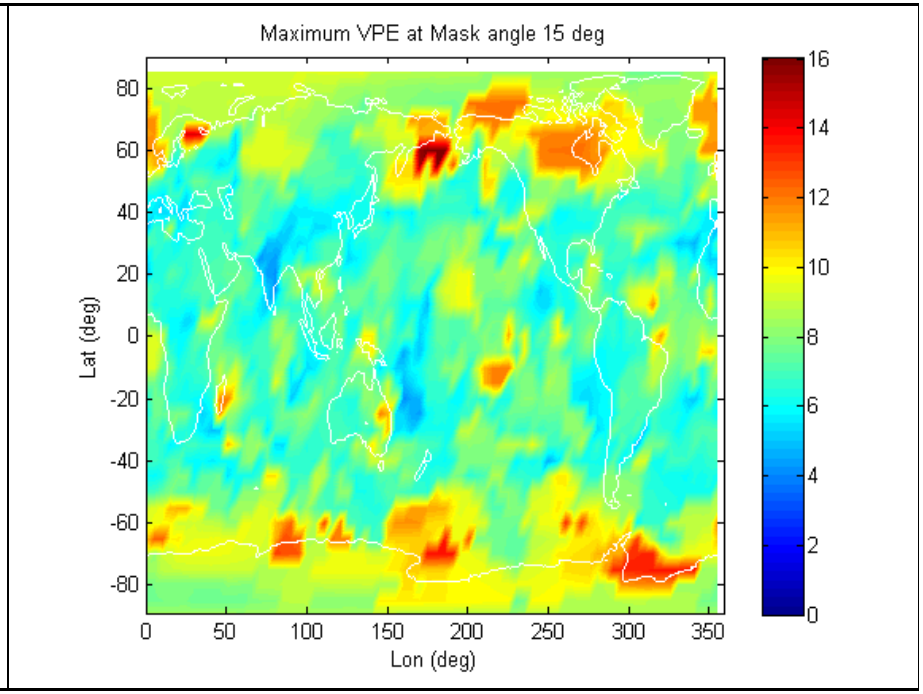
HPE and VPE
Antenna 15 Degree Mask Angle





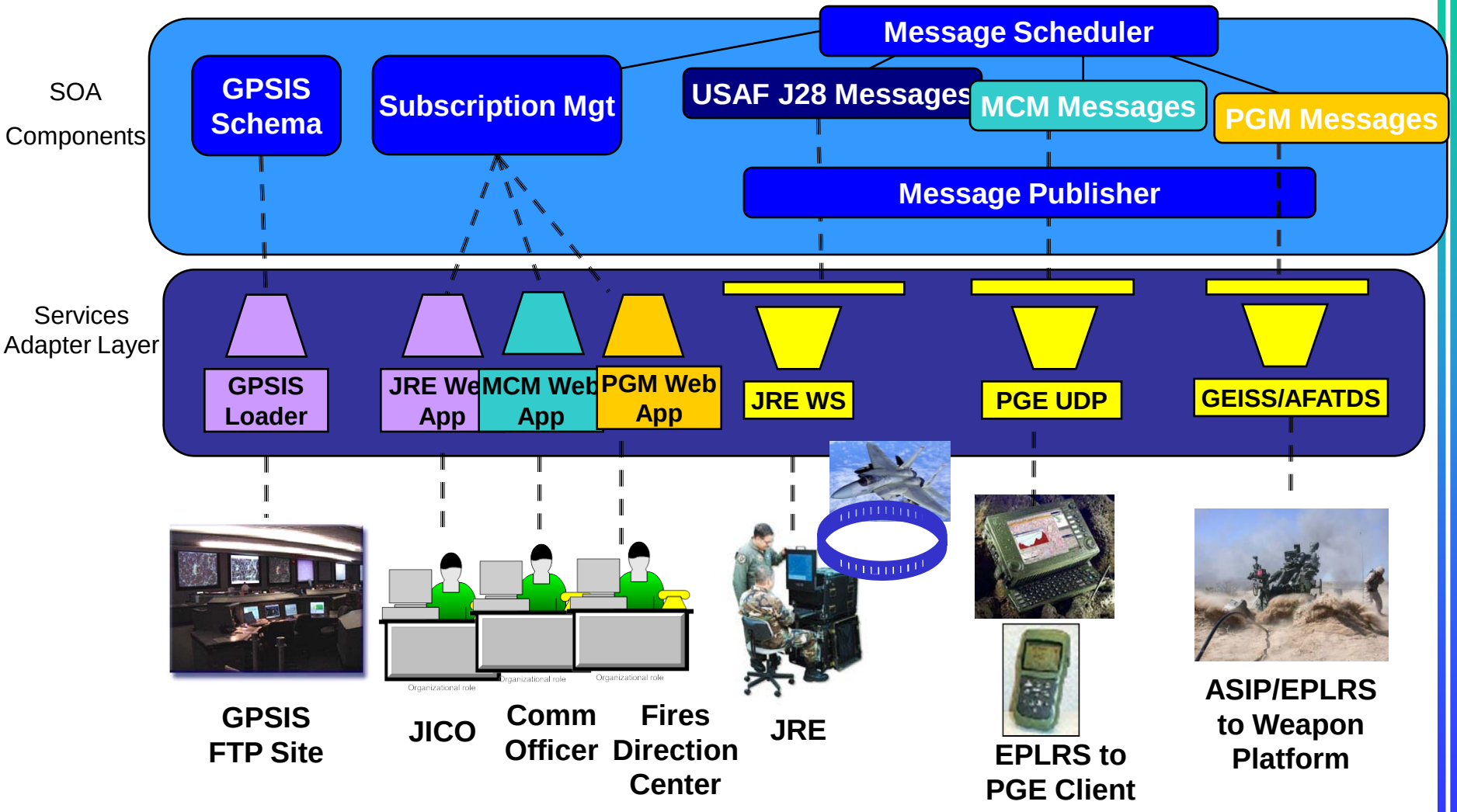
Maximum HPE and VPE Antenna 15 Degree Mask Angle





Note: Different meter error scale on side for HPE vs VPE

GEISS/PGE Integration Option



Scenarios

1. Open Sky (mask angle 5 deg, DAGR default)

   Baghdad 0500Z, 9 Sep 08

   HDOP = 0.71 VDOP= 0.84

2. Far Field Terrain (mask angle 15 deg)

   Baghdad 0500Z, 9 Sep 08

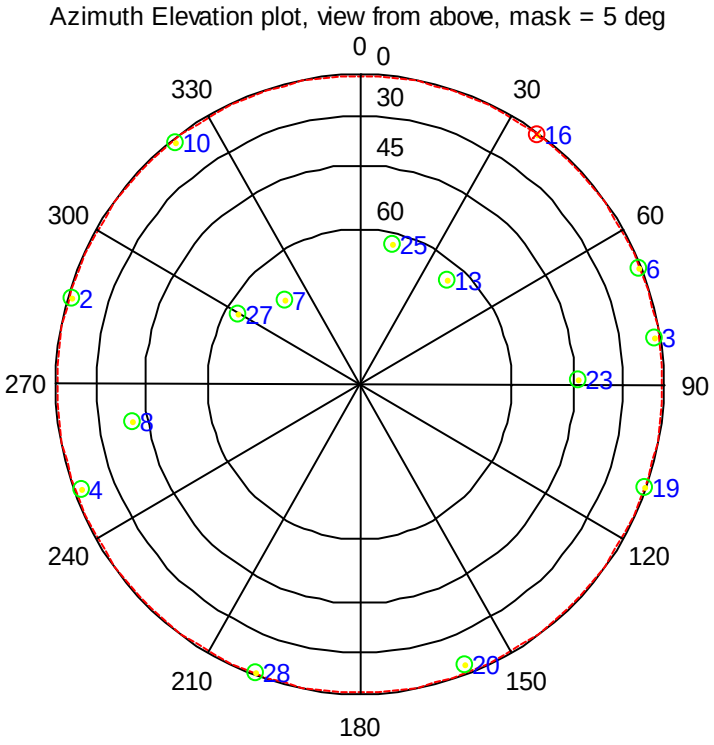
   HDOP = 5.64 VDOP= 9.61 VAPP

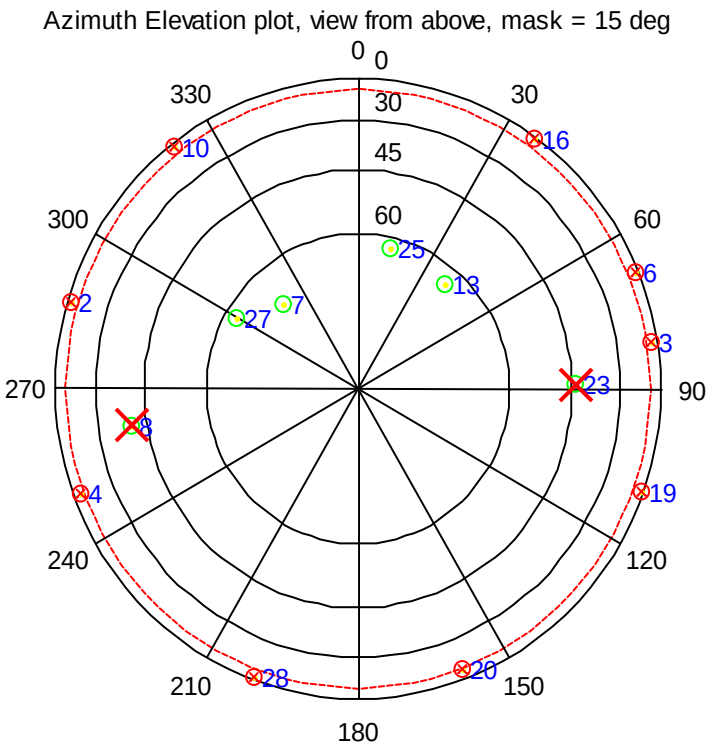
3. Hide Site (mask angle 40 deg) FOM > 1

   Baghdad 0500Z, 9 Sep 08

   HDOP = 0.71 VDOP= 0.84

Scenarios

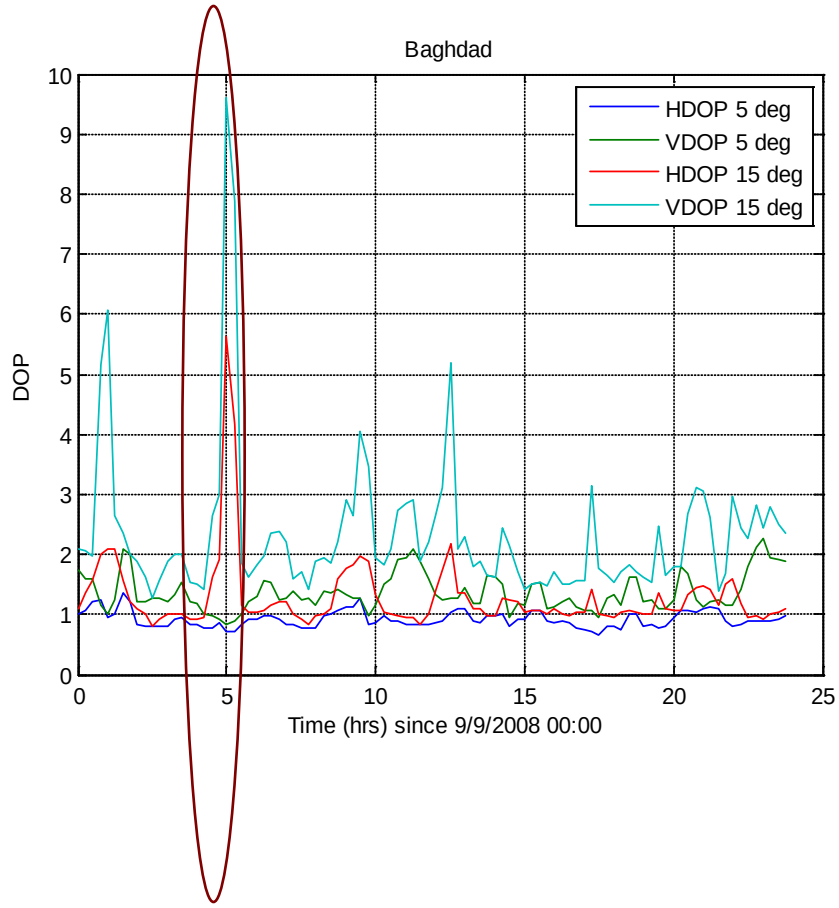




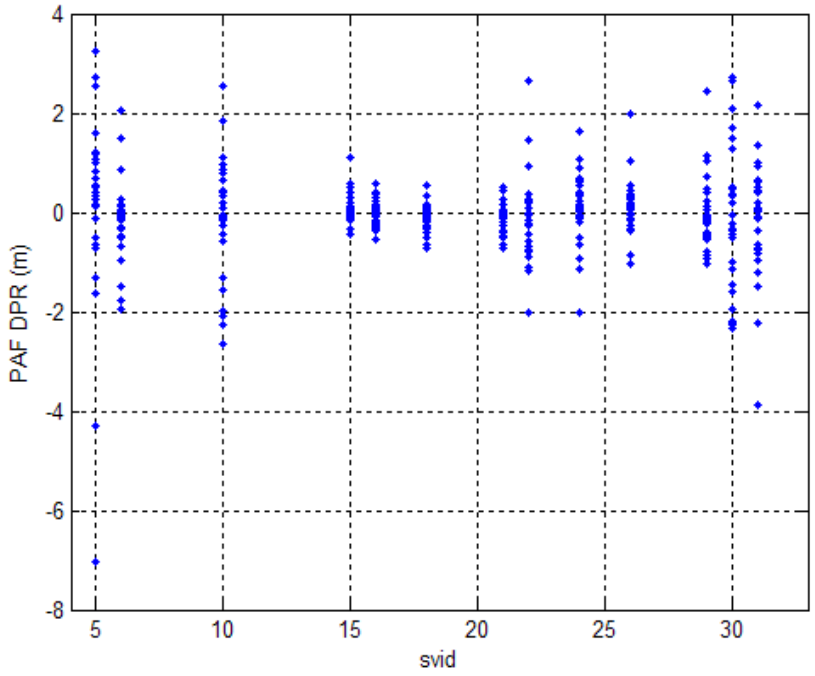
	Mask (degree)				
DOPs	0	5	10	15	20
HDOP	0.65	0.71	1.39	5.64	5.64
VDOP	0.79	0.84	1.72	9.61	9.61
GDOP	1.11	1.20	2.48	13.11	13.11

At mask angles >40 deg, FOM exceeds 1, resulting in no shot

Baghdad Performance Analysis



Time selected

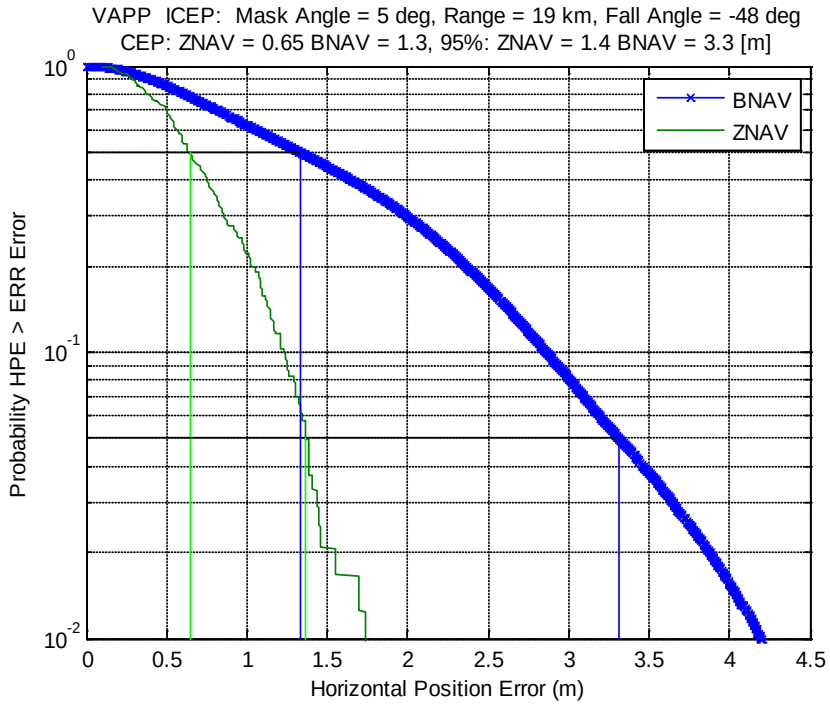


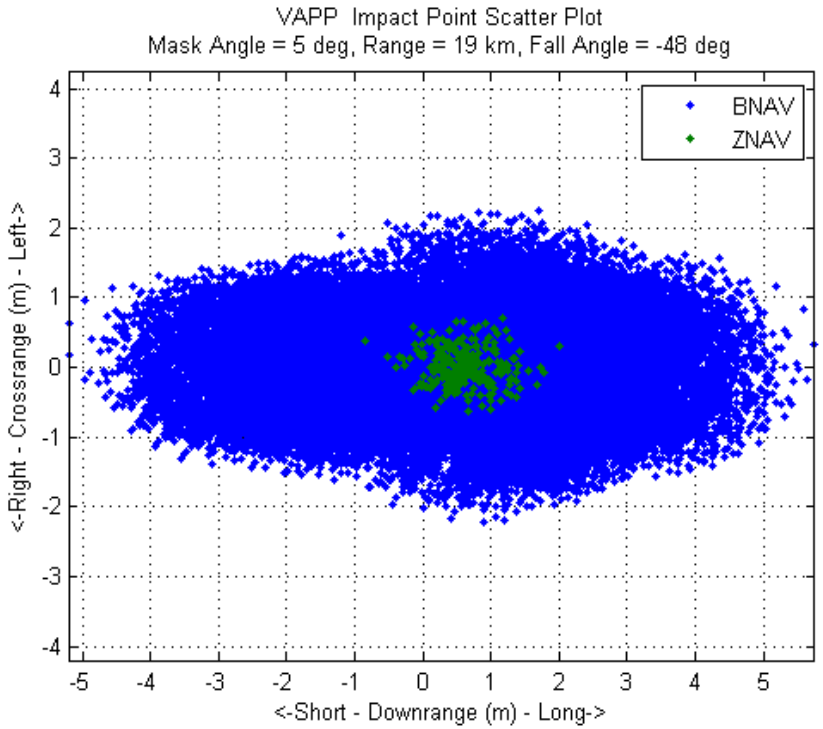
30 Day PAF errors for SVs in view at selected sidereal time

Final VAPP Simulations 5 Bags

navsys CORPORATION

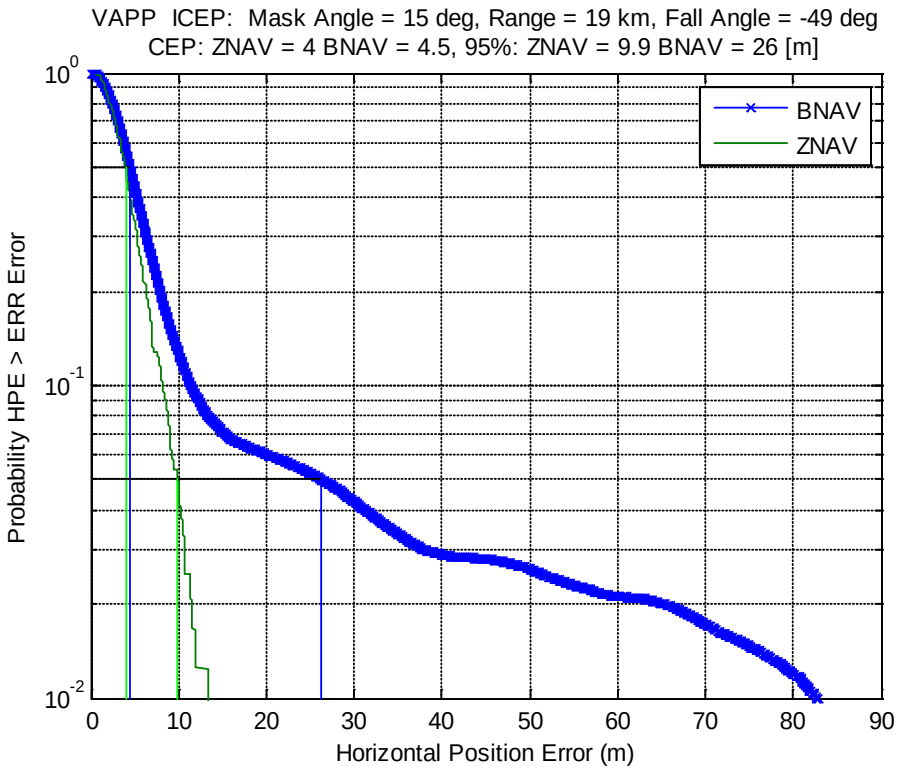
1. Local DAGR Open Sky ICEP & X/Y Plot
5 deg Mask, Baghdad (HDOP=0.71 VDOP=0.84)
Range: 19 km, Fall Angle: 48 deg

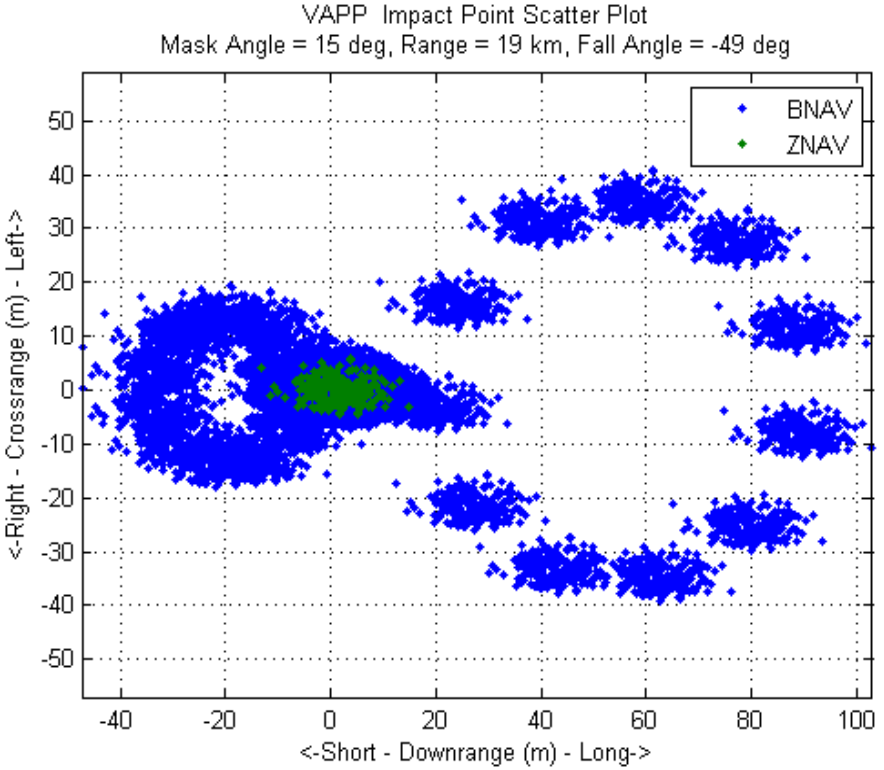




ZNAV CEP =	**0.65m**	**ZNAV 95% =**	**1.4m**
BNAV CEP =	**1.30m**	**BNAV 95% =**	**3.3m**

2. Local DAGR Open Sky ICEP & X/Y Plot
15 deg Mask, Baghdad (HDOP=5.6 VDOP=9.6)
Range: 19 km, Fall Angle: 48 deg





ZNAV CEP = 4.0 m **ZNAV 95% = 9.9 m**

BNAV CEP = 4.5 m **BNAV 95% = 26 m**

3. Mask Angle >40 Deg

- Without GEISS augmentation, FOM >1, no shot
- With GEISS aiding, effective mask angle reduced, allowing precision shot

GEISS Scenarios Summary

Scenario Mask angle	1. Open-Sky 5 deg	2. Far Field Terrain 15 deg	3. Hide Site 40 deg
Local DAGR	OK	Degraded	FOM > 1 No shot
PGE	High Precision	Degraded	FOM > 1 No shot
Iono & Ephemeris N/W Sharing	OK	OK	OK
PGE + Iono Sharing	High Precision	High Precision	High Precision

Conclusion

- GEISS network sharing can enhance number of satellites available for use by GPS-guided projectiles
- USA CECOM sponsoring GEISS research and demos for current and future platforms
- CERDEC/ARDEC providing technical oversight and guidance
- Integration with AFATDS will allow deployment to follow-on Excalibur and PGK projectiles with SW upgrades only