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

Joint Armaments Conference 2010
May 18, 2010

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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
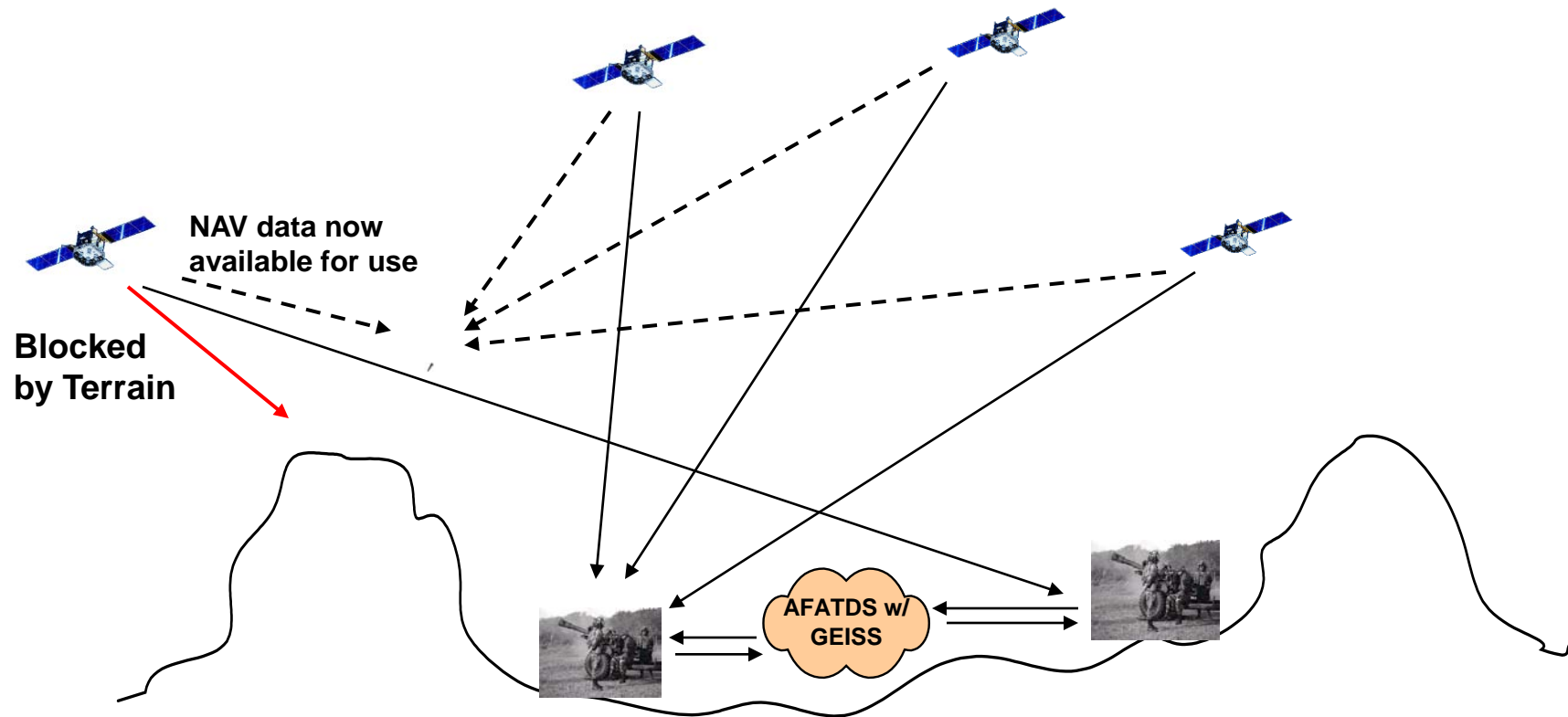
GPS-Guided Munitions that Could Benefit from GEISS

- 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

Can't be used – not initialized

Blocked by Terrain
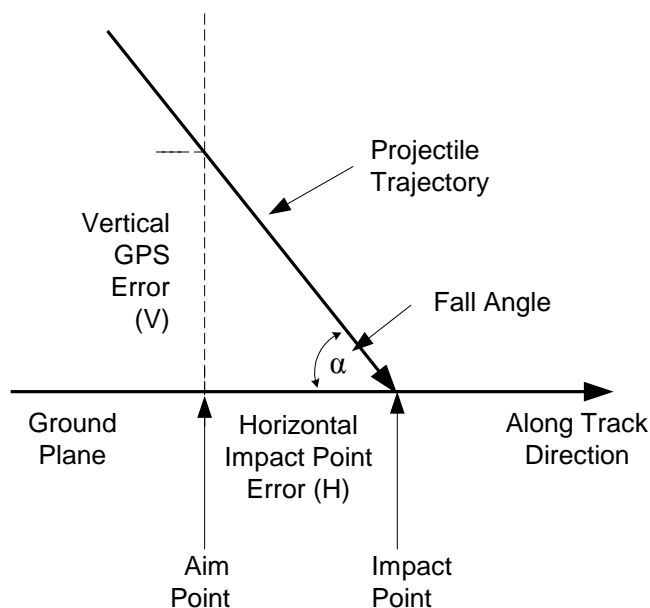
PGM Performance w/ GEISS
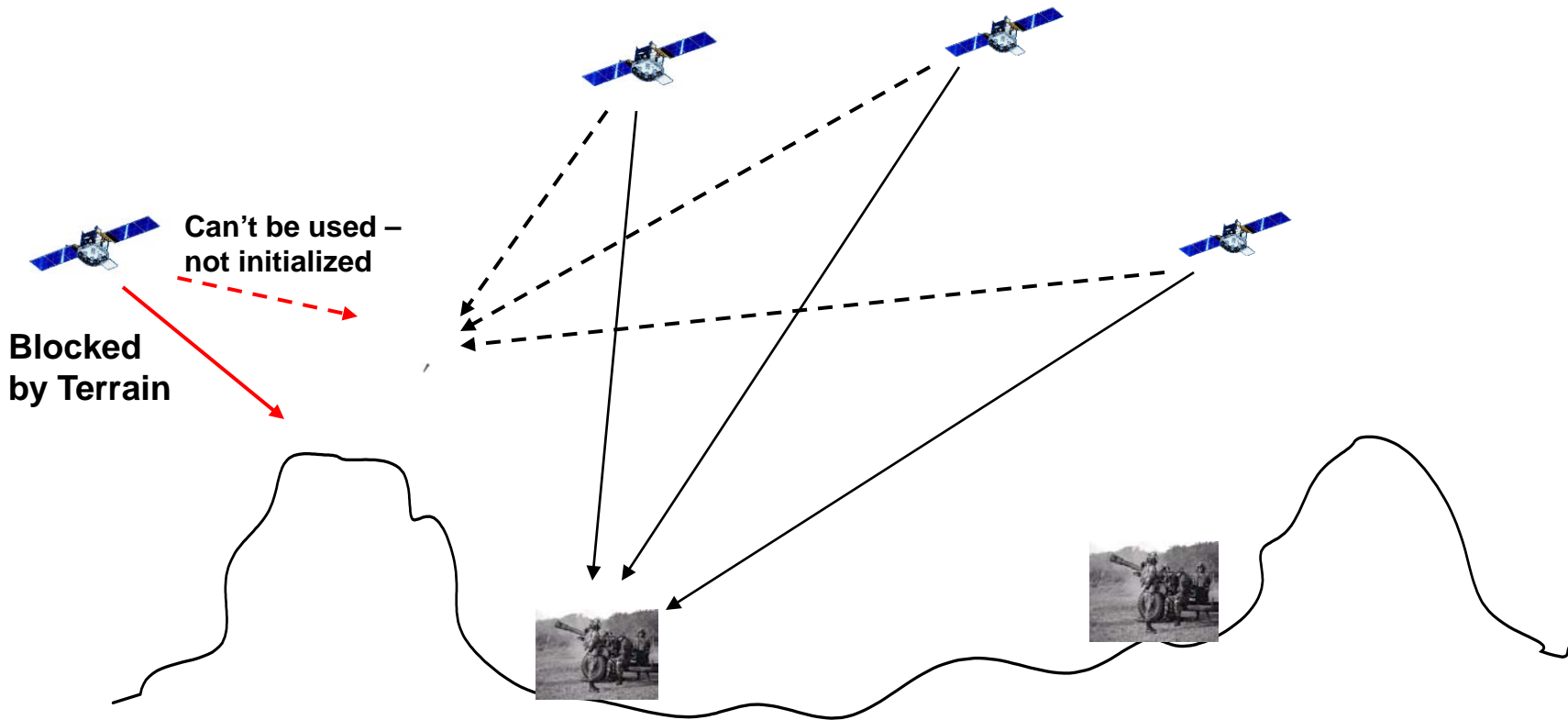
- GEISS "combines" satellite information from each WP GPS receiver and supplies the complete set to each WP through AFATDS for munitions initialization

- This allows even initially blocked satellites to be used in flight when available

NAV data now available for use

Blocked by Terrain

AFATDS w/ GEISS

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Option to sync with PGE data when SIPRNET connected

GPS Ephemeris & Ionospheric Sharing Service (GEISS)

Fills in missing Iono/ Ephemeris present in other systems

AFATDS

DAGR PIK

Weapons Platform

DAGR PIK

Weapons Platform

DAGR PIK

Weapons Platform

DAGR PIK

Weapons Platform

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

Aim Point Errors

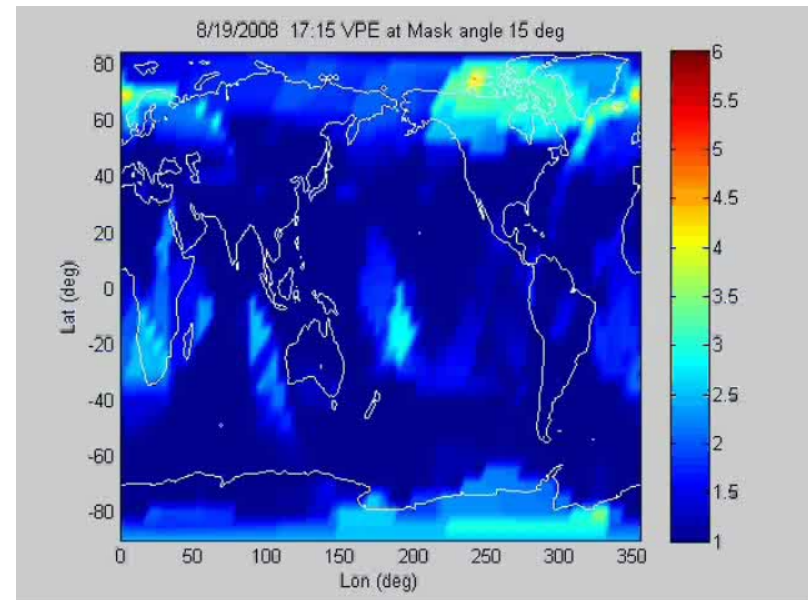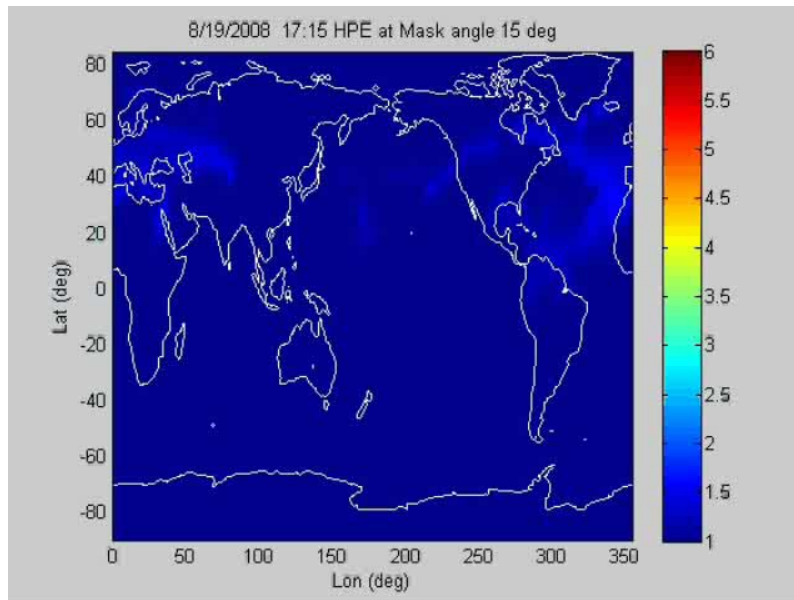Vertical GPS errors map into along track aim point errors

- 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
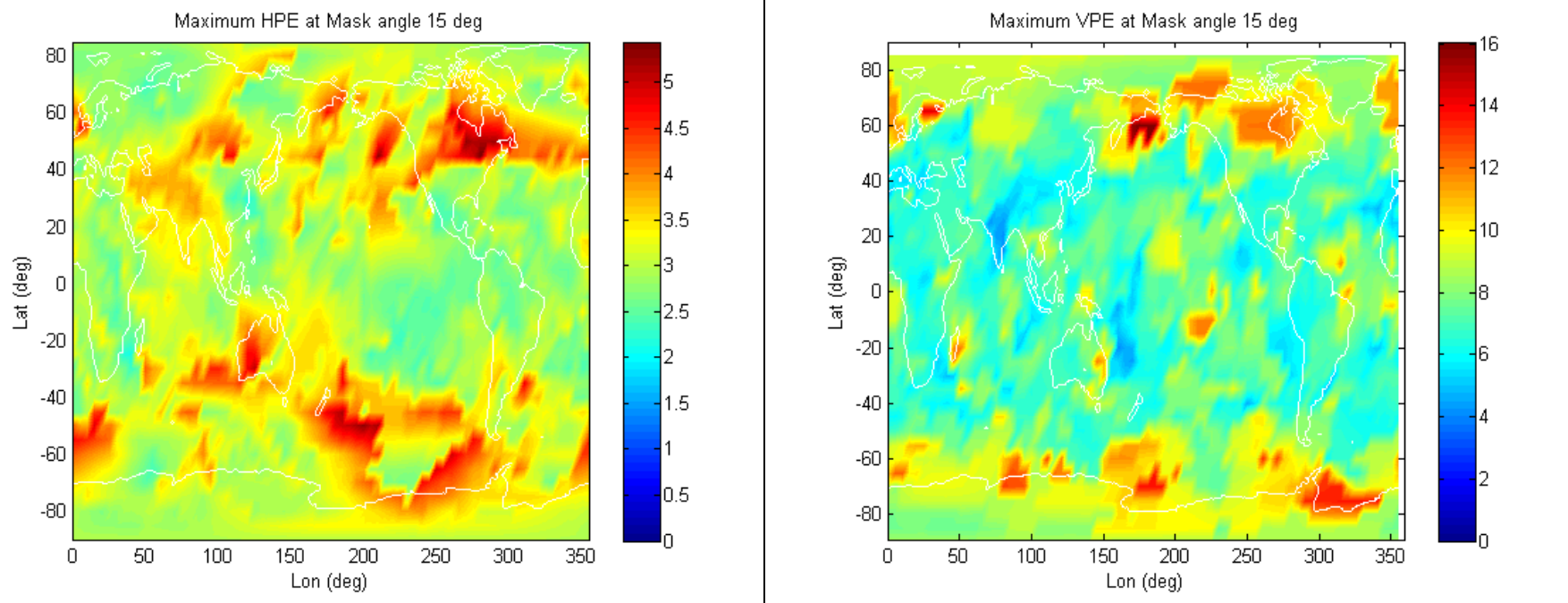 - Result in along track errors
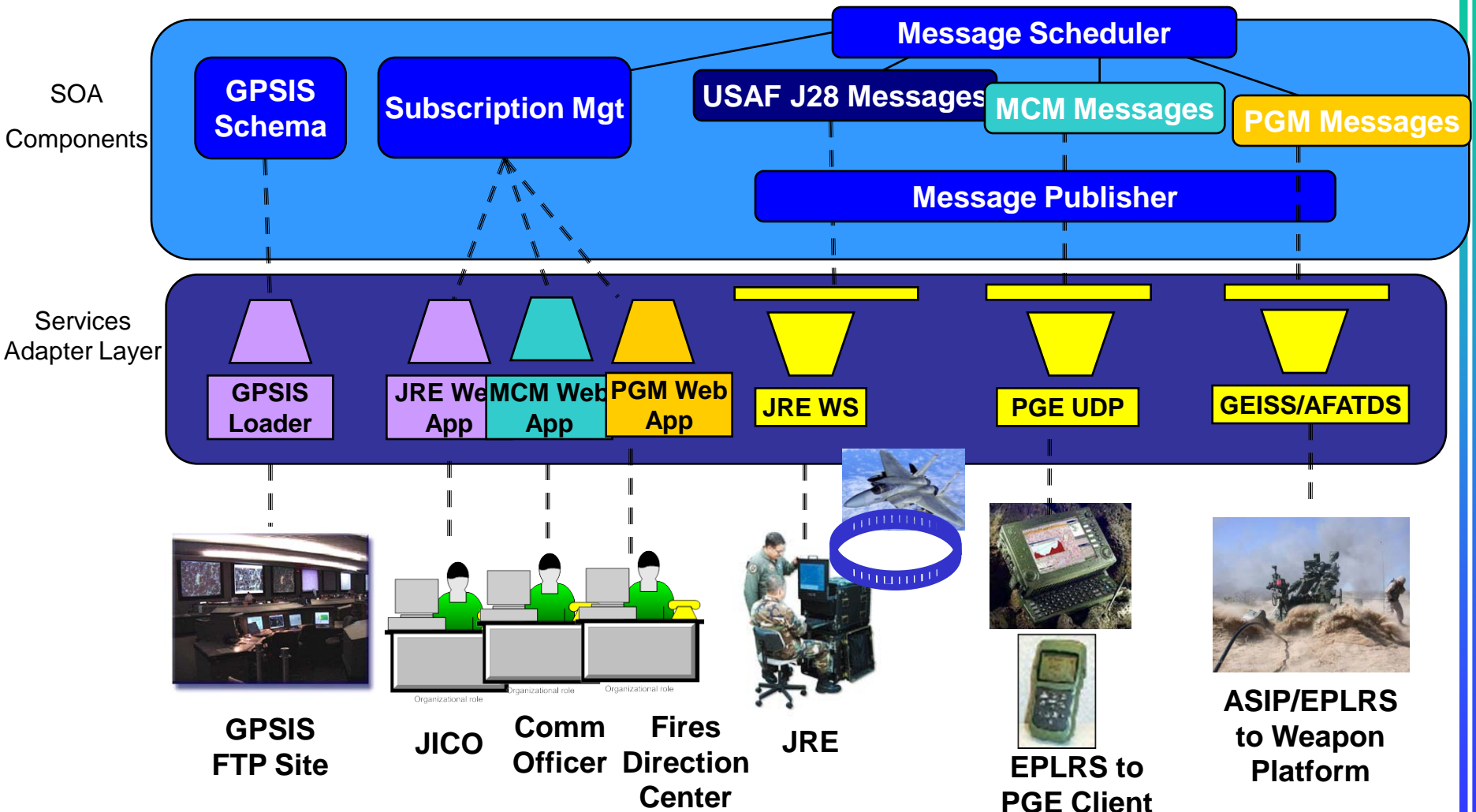
HPE and VPE
Antenna 15 Degree Mask Angle

Maximum HPE and VPE Antenna 15 Degree Mask Angle

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

GEISS/PGE Integration Option

SOA Components

- **Message Scheduler**
- **GPSIS Schema**
- **Subscription Mgt**
- **USAF J28 Messages**
- **MCM Messages**
- **PGM Messages**
- **Message Publisher**

Services Adapter Layer

- GPSIS Loader
- JRE Web App
- MCM Web App
- PGM Web App
- JRE WS
- PGE UDP
- GEISS/AFATDS

GPSIS FTP Site — JICO — Comm Officer — Fires Direction Center — JRE — EPLRS to PGE Client — ASIP/EPLRS to Weapon Platform
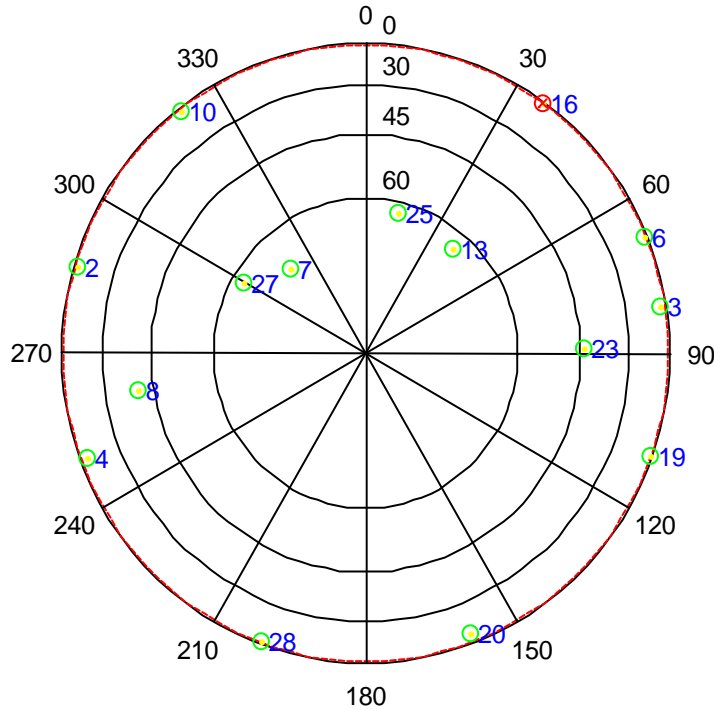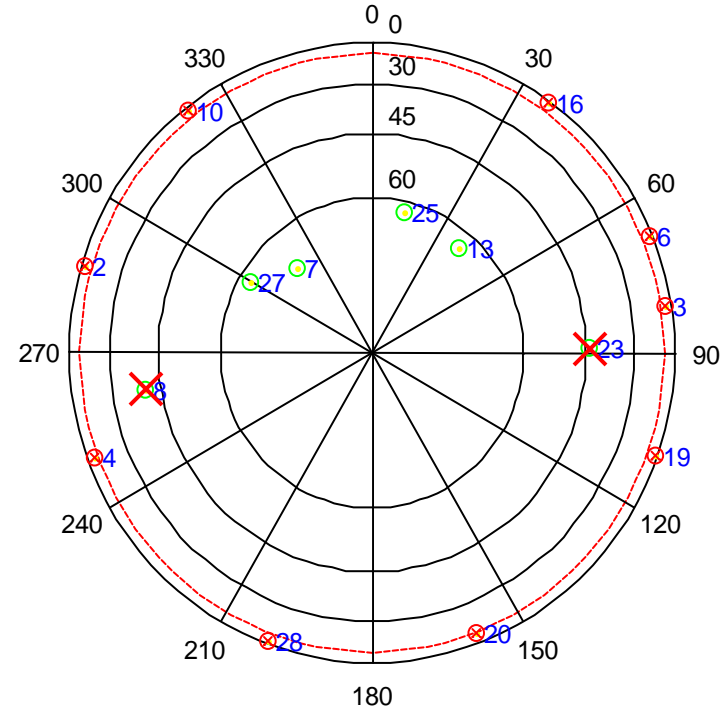
Scenarios

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

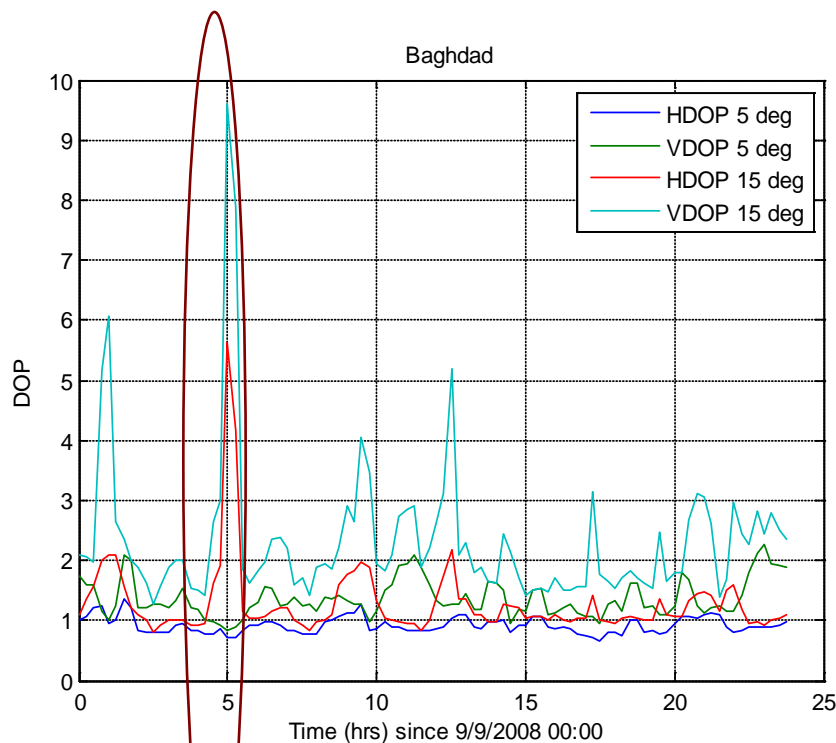Azimuth Elevation plot, view from above, mask = 5 deg

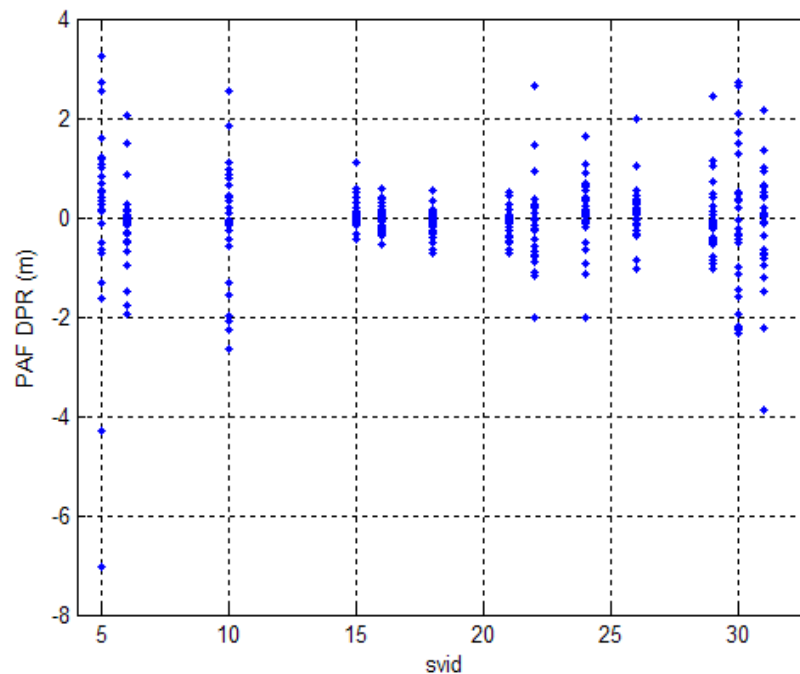Azimuth Elevation plot, view from above, mask = 15 deg

	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
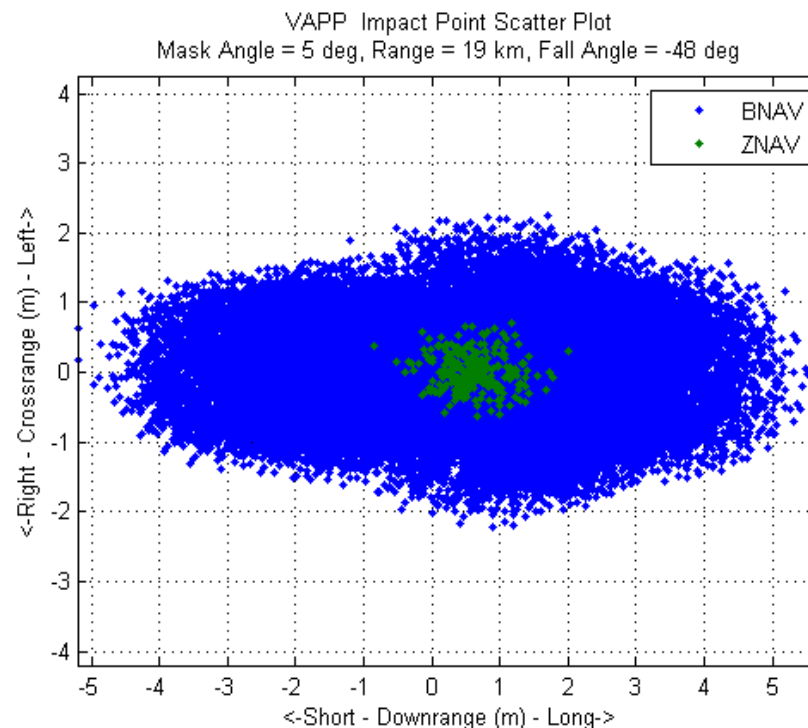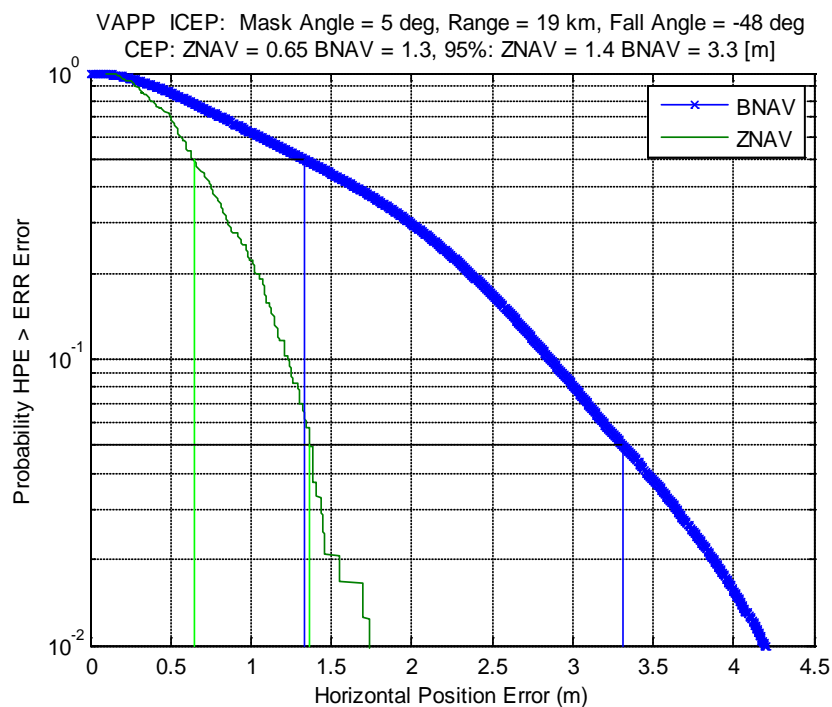
Baghdad Performance Analysis

Time selected

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

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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

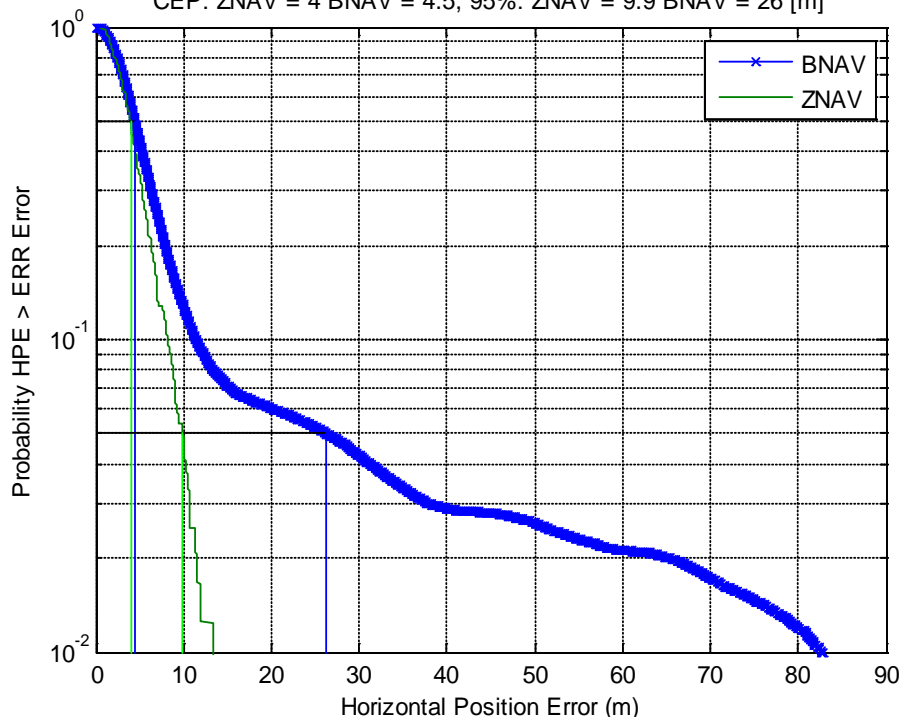VAPP ICEP: Mask Angle = 5 deg, Range = 19 km, Fall Angle = -48 deg
CEP: ZNAV = 0.65 BNAV = 1.3, 95%: ZNAV = 1.4 BNAV = 3.3 [m]

VAPP Impact Point Scatter Plot
Mask Angle = 5 deg, Range = 19 km, Fall Angle = -48 deg

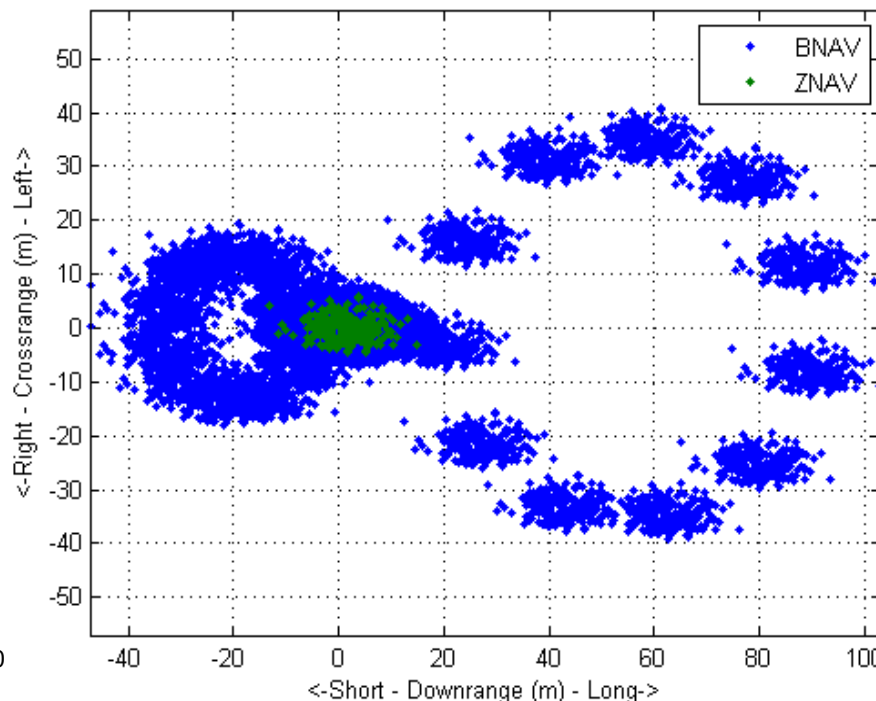|			
ZNAV CEP =	**0.65m**	**ZNAV 95% =**	**1.4m**
BNAV CEP =	**1.30m**	**BNAV 95% =**	**3.3m**

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

VAPP ICEP: Mask Angle = 15 deg, Range = 19 km, Fall Angle = -49 deg
CEP: ZNAV = 4 BNAV = 4.5, 95%: ZNAV = 9.9 BNAV = 26 [m]

VAPP Impact Point Scatter Plot
Mask Angle = 15 deg, Range = 19 km, Fall Angle = -49 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