

Target Location Technology for Ground Based Observers

Joint Navigation Conference

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C6: Military GPS/Testing

Alison Brown, Dien Nguyen, Reece Tredway

NAVSYS Corporation

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Contractor Name: NAVSYS Corporation, 14960 Woodcarver Road, Colorado Springs, CO 80921

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What is the Problem?

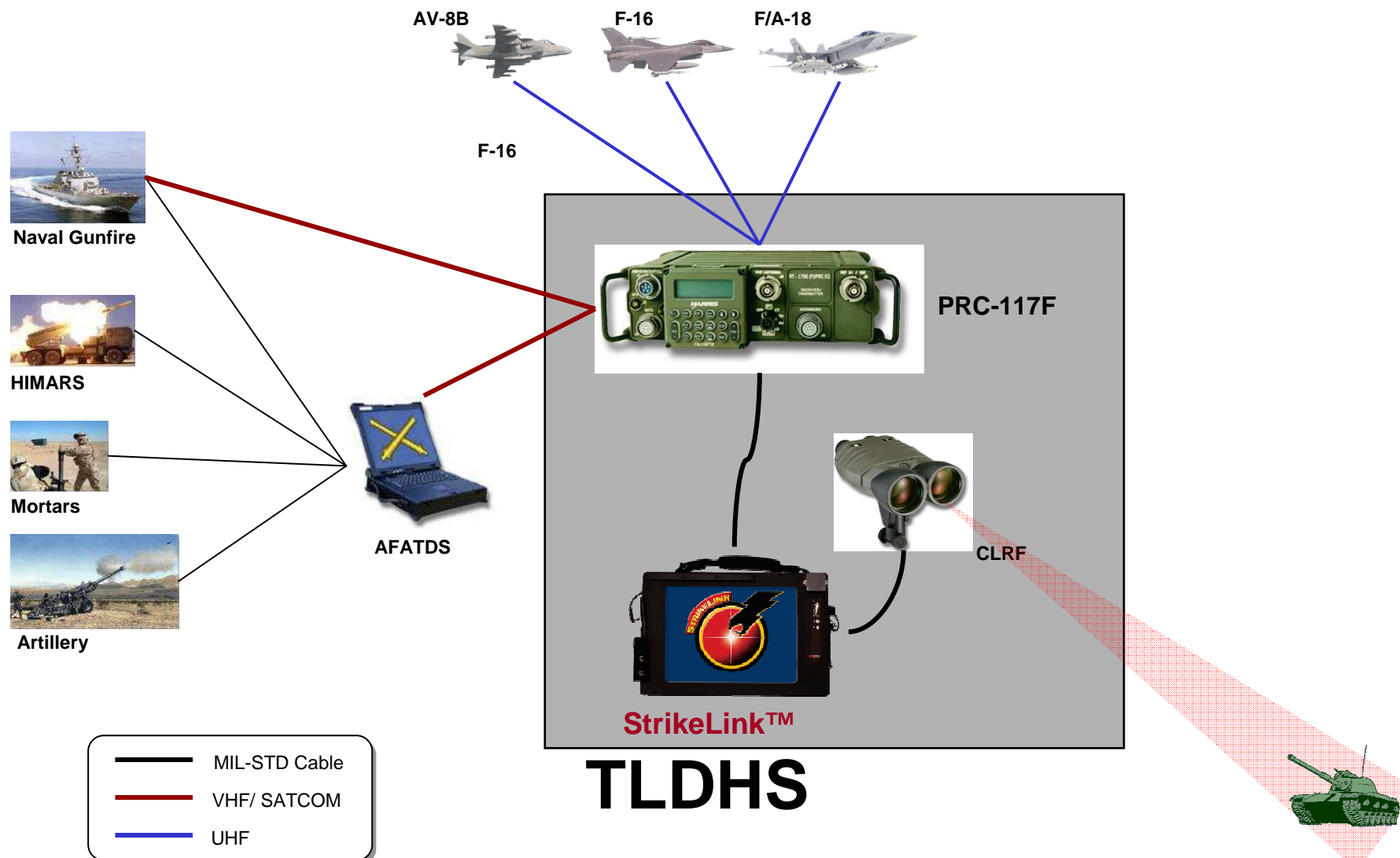
- Ground Based Observers (GBOs) need an enhanced ability to determine the location of targets to be engaged by air, ground or naval surface fire support means
- Precise target coordinates are needed for Precision GPS Munitions
- Azimuth error causes target location errors to degrade with distance from the Ground Based Observers
 - Typical GBO range to target ~ 5-10 Km
- Magnetic azimuth devices are very inaccurate
- High quality inertial azimuth sensors are too large and require too much power for man-portable operations

GBO and Fire Support Observer Target Location, Designation, Hand- off System (TLDHS)



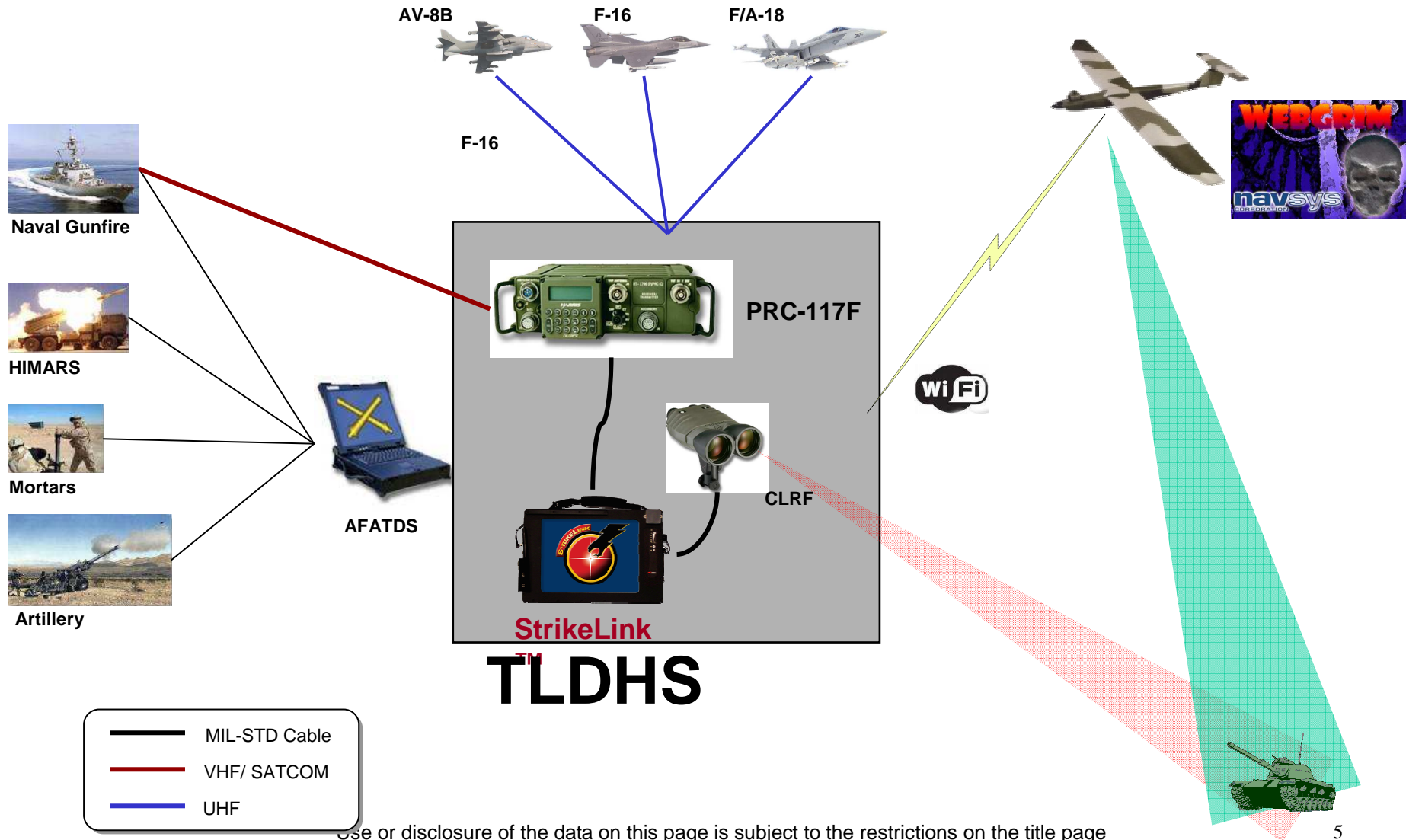
Description: The TLDHS is a man-portable, automated equipment suite providing Fire Support Observer/Controllers the ability to accurately acquire, locate and digitally transmit (hand-off) target data to fire support platforms and agencies

Current GBO Targeting Architecture

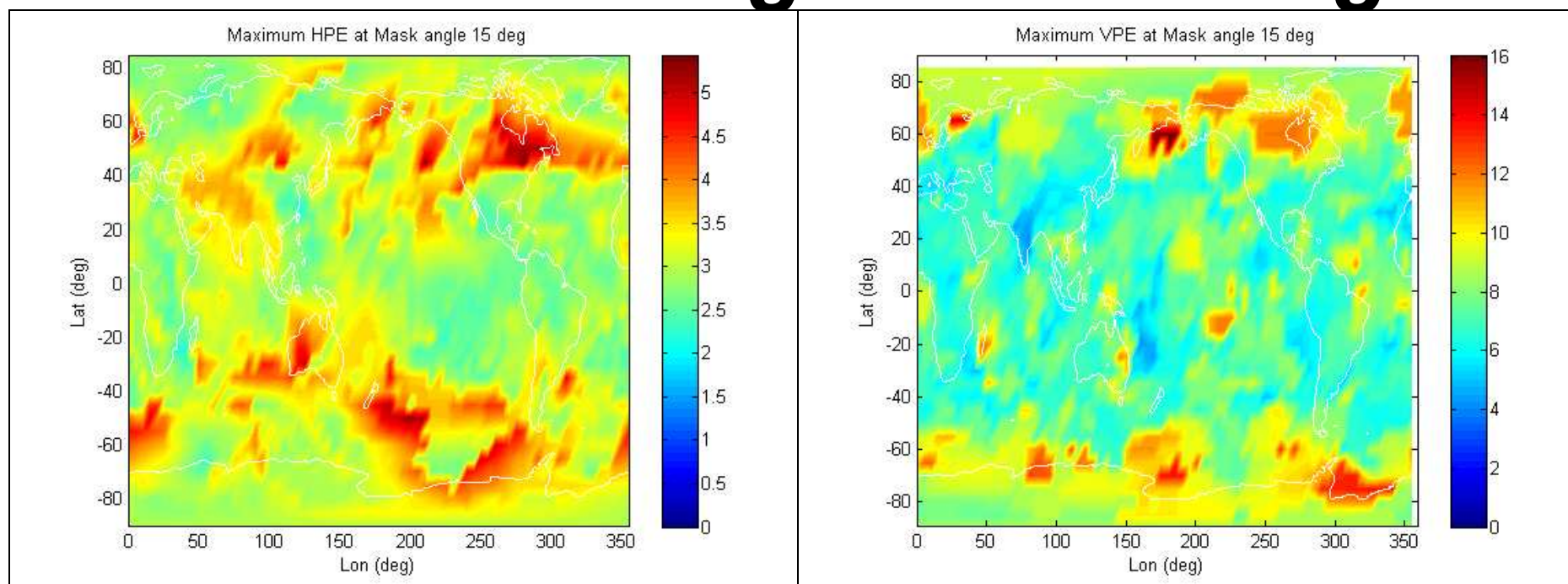


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GBO/UAS Hybrid Targeting Architecture



Maximum Horizontal and Vertical Position Error (HPE/VPE) Antenna 15 Degree Mask Angle

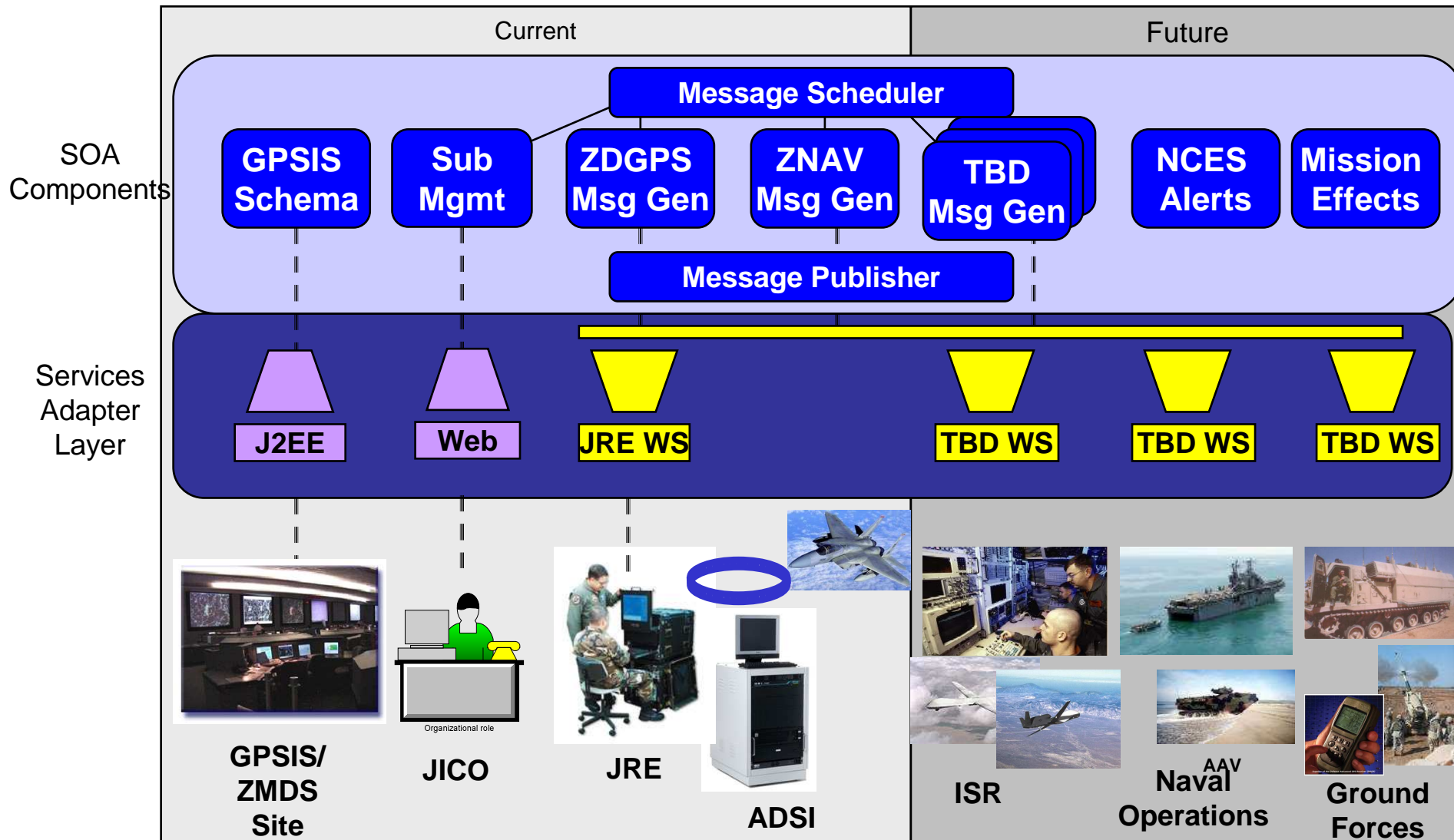


30 day analysis (Aug/Sep 2008) of GPS broadcast position errors

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

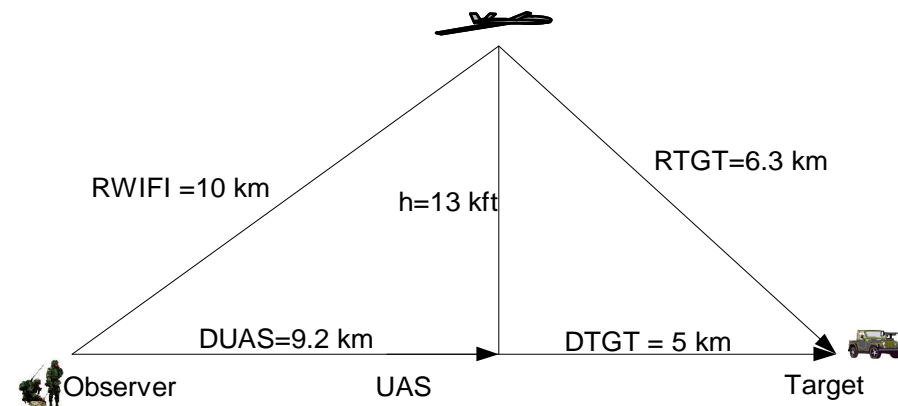
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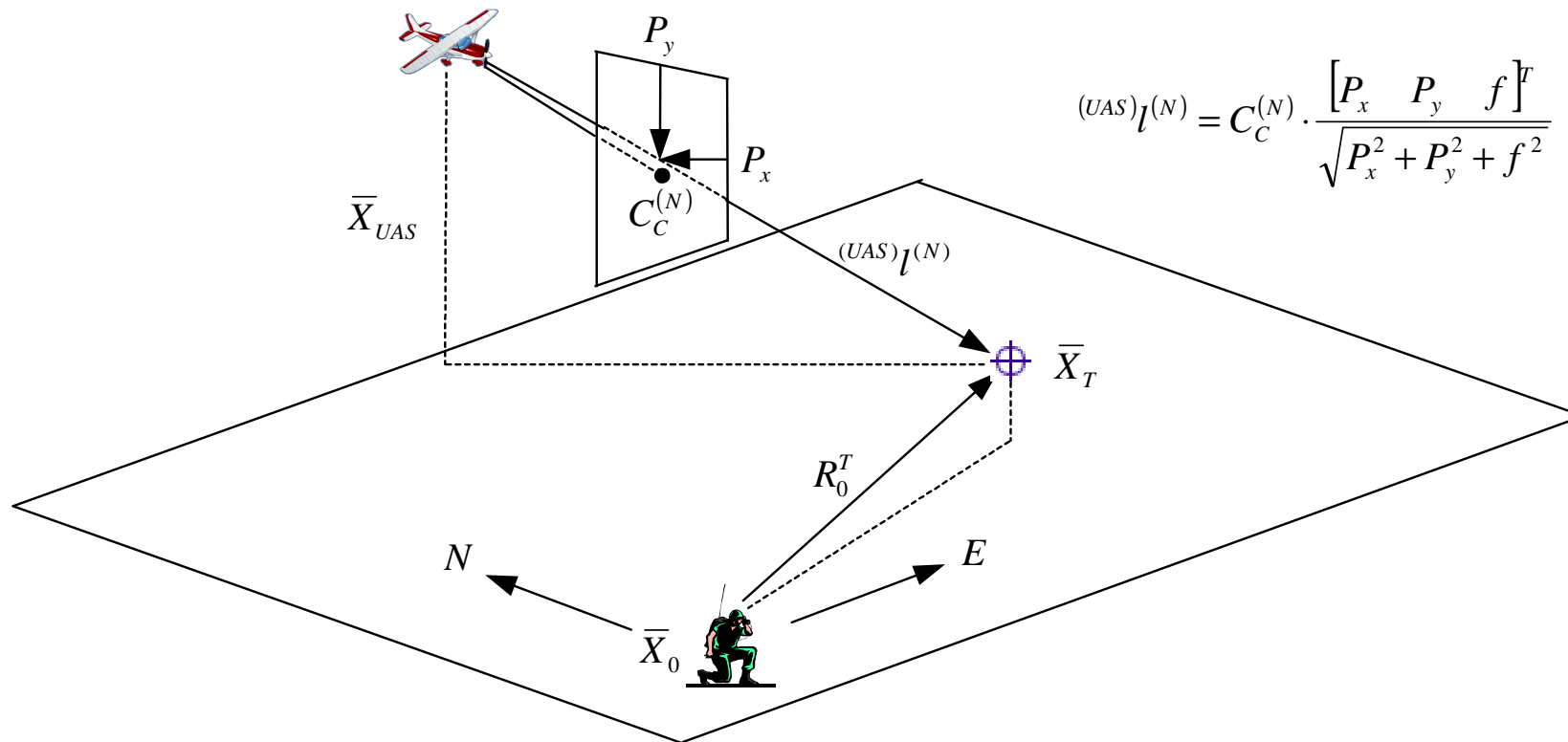
Talon NAMATH SOA



- **Current TLDHS**
 - Uses conventional GPS
 - Magnetic heading sensor
 - Laser rangefinder
- **Enhanced TLDHS**
 - Uses Zero-Age GPS corrections from GPSOC
 - 3-axis IMU for attitude (az/el)
 - Laser Rangefinder
- **UAS Mensurated imagery**
 - Uses Zero-Age GPS corrections from GPSOC
 - 3-axis IMU for attitude (az/el)
 - Assumes range known from DEM or GBO Laser Range

Targeting Sensor	Current TLDHS	Enhanced TLDHS	UAS
GPS Accuracy	8 m	1.5 m	1.5 m
Azimuth Accuracy	10 mils	1 mil	1 mil
Ranging Accuracy	5 m	5 m	4 m
TLE (CEP)	34 m	7 m	6 m
Distance (km)	5km	5km	9.2+5km

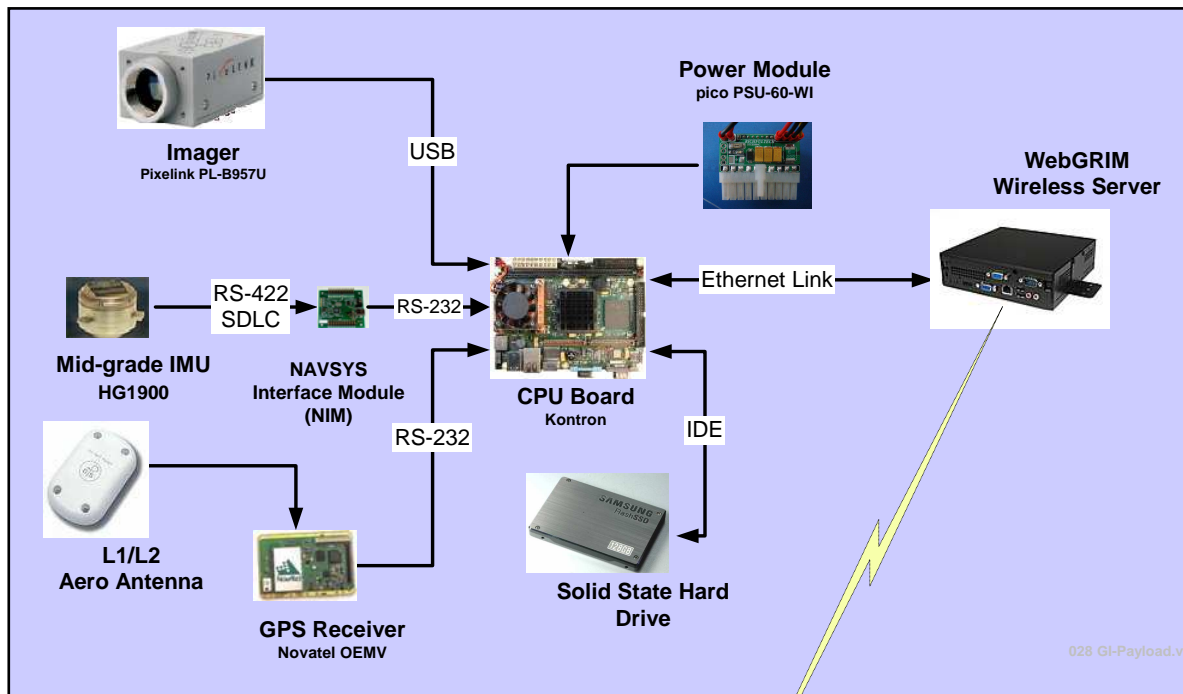




$${}^{(UAS)}l^{(N)} = C_C^{(N)} \cdot \frac{[P_x \ P_y \ f]^T}{\sqrt{P_x^2 + P_y^2 + f^2}}$$

Pixel location of target	: $P_x, P_y \rightarrow {}^{(UAS)}l^{(N)}$	} \hat{X}_T : Target Location
UAS location	: \bar{X}_{UAS}	
GBO location	: \bar{X}_0	
GBO range to target	: R_0^T	

UAS GI-Eye Payload

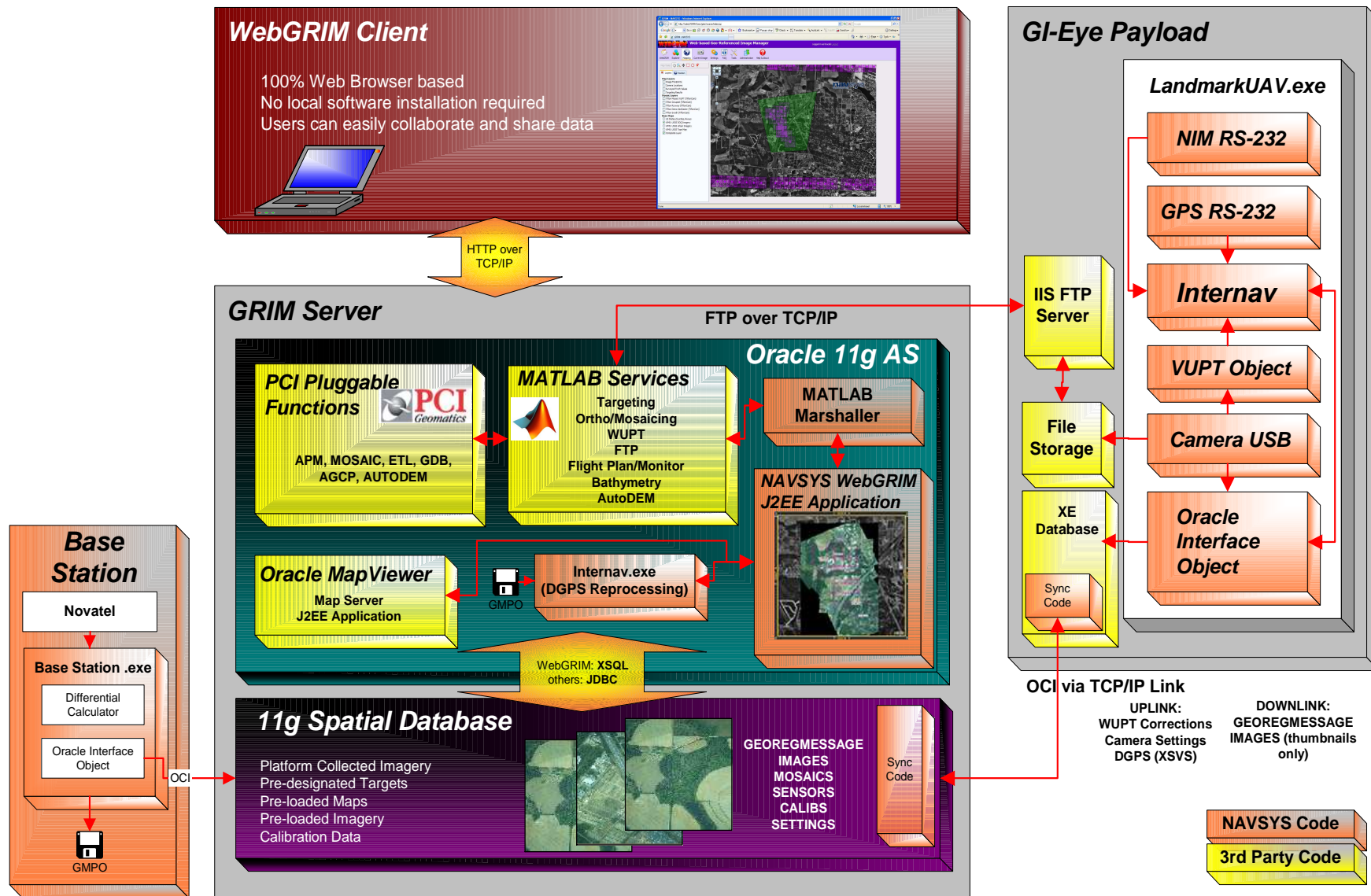


Size	Weight	Power
300 in ²	9 lbs	175 w

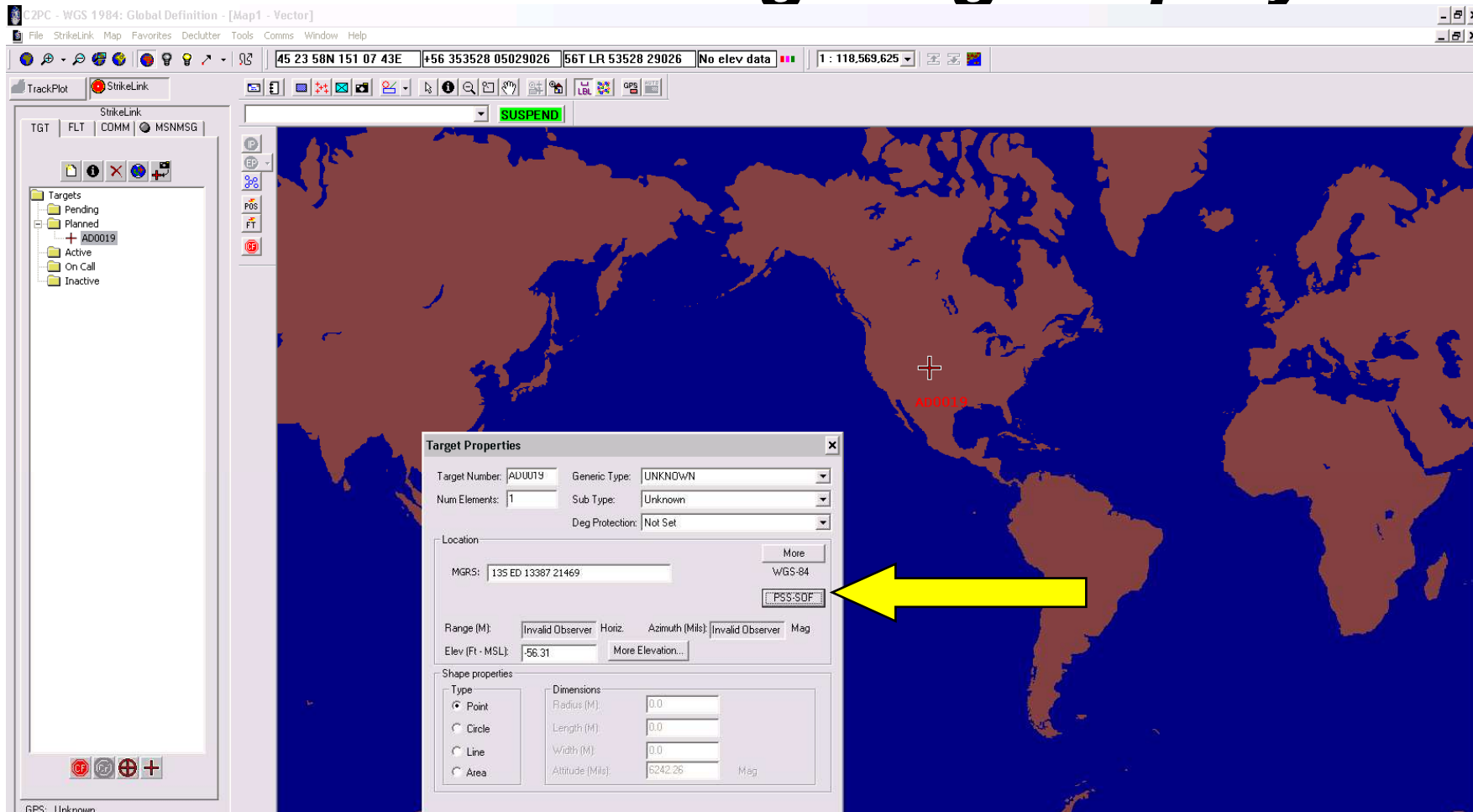


UAS Ground Control
 - Web Browser w/WebGRIM SW
 - Wi-Fi Link to UAS Payload

Overall Web-based Georeferenced Image Manager (WebGRIM) Architecture

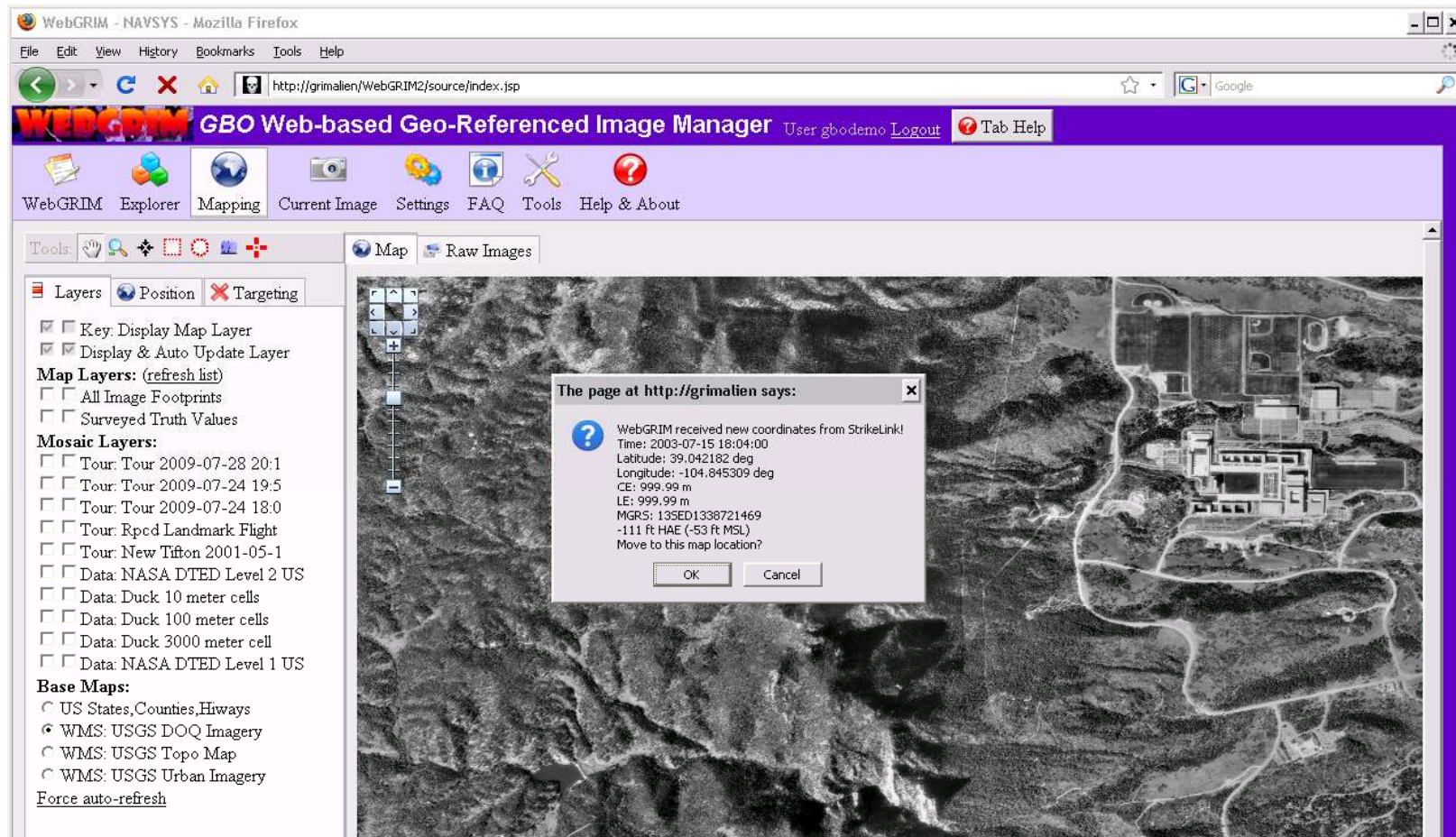


StrikeLink Targeting Display



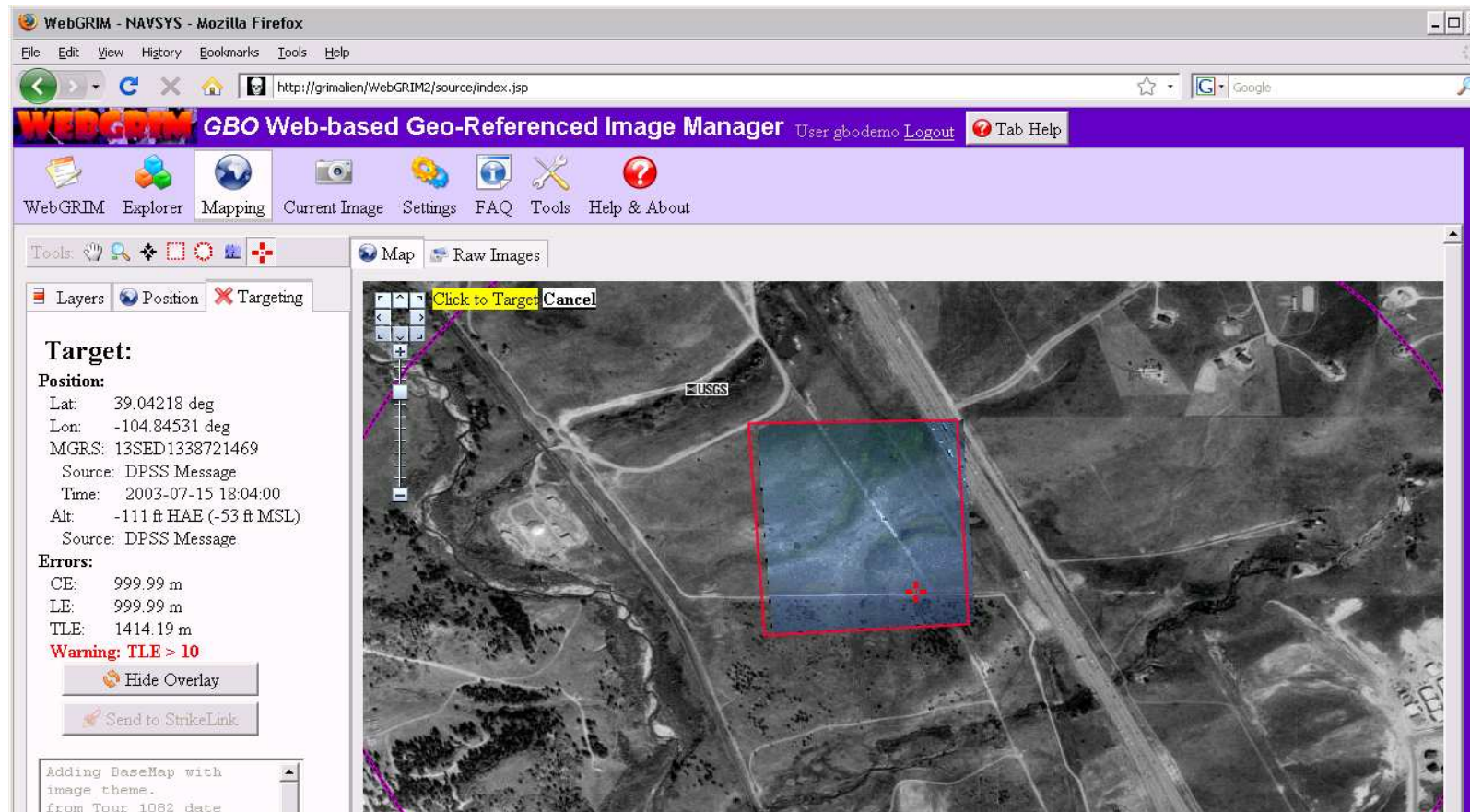
The user generates his target in StrikeLink in the usual fashion, and then clicks the PSS-SOF button to send the COTXML message.

COTXML / WebGRIM Integration



WebGRIM displays the COTXML target coordinates and asks if the user wants to move the map there. The GBO clicks "OK".

COTXML / WebGRIM Integration



WebGRIM brings up the GBO targeting page displays red open cross targeting icon using the Cursor on Target (COTXML) coordinates on the background map with the most recent image from GI-Eye orthorectified and overlaid on the background map layer.

System Integration with StrikeLink

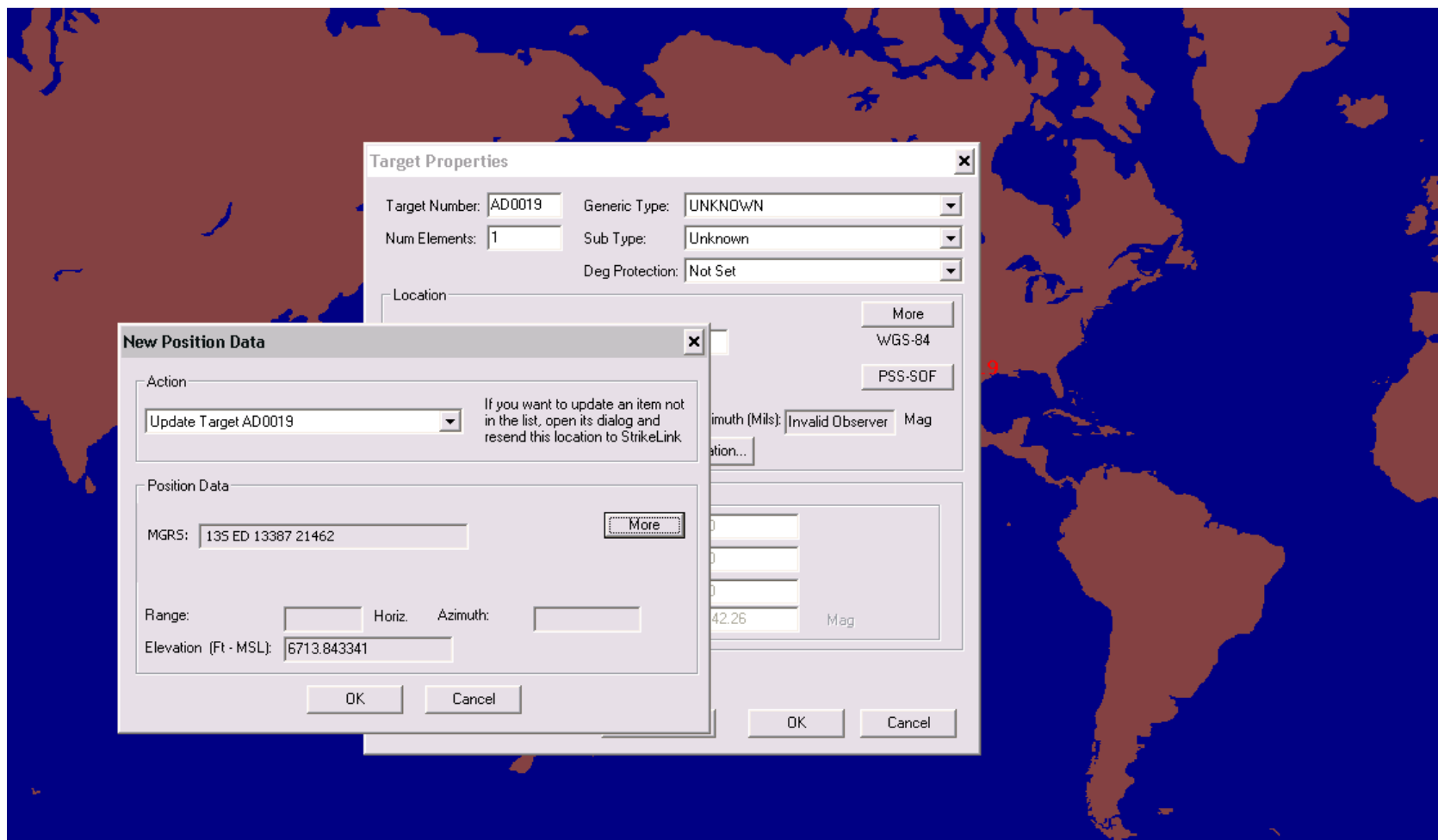
The screenshot shows the WebGRIM interface in a Mozilla Firefox browser. The main window displays a satellite map with a red crosshair. Two panels are highlighted with red boxes, showing target data for 'Test Target'. The left panel includes a 'Click to Target' button and a 'Cancel' button. The right panel is a detailed target information window.

Target: Test Target	
Position:	
Lat:	39.04195 deg
Lon:	-104.84544 deg
MGRS:	13SED1337621444
Source:	DPSS Message
Time:	2010-05-07 15:42:50
Alt:	Not Available
Source:	None
Errors:	
CE:	Not Available
LE:	Not Available
TLE:	Not Available
Warning: No Solution	
<input type="button" value="Hide Overlay"/>	
<input type="button" value="Send to StrikeLink"/>	

Adding BaseMap with image theme.
Best image is 351857
Querying for best and nearby images...

WebGRIM displays LLA & the corresponding CE, LE, & TLE from CoTXML Message. The GBO can update target and send corrected LLA, CE & LE back to StrikeLink via CoTXML.

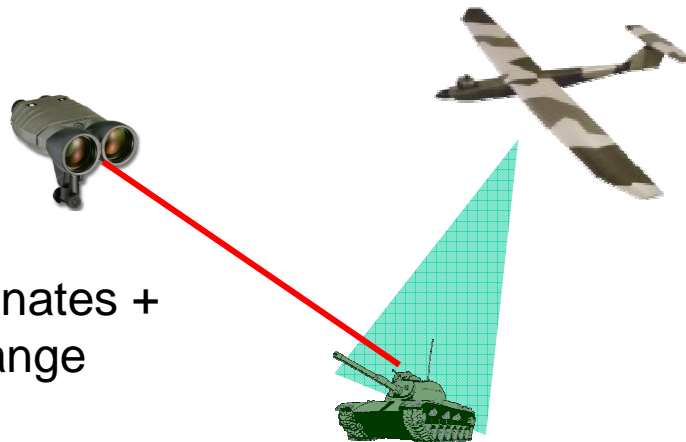
Back at StrikeLink...



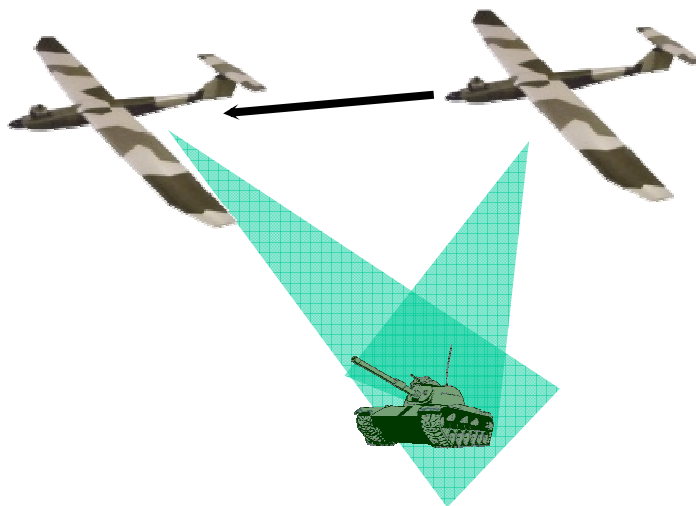
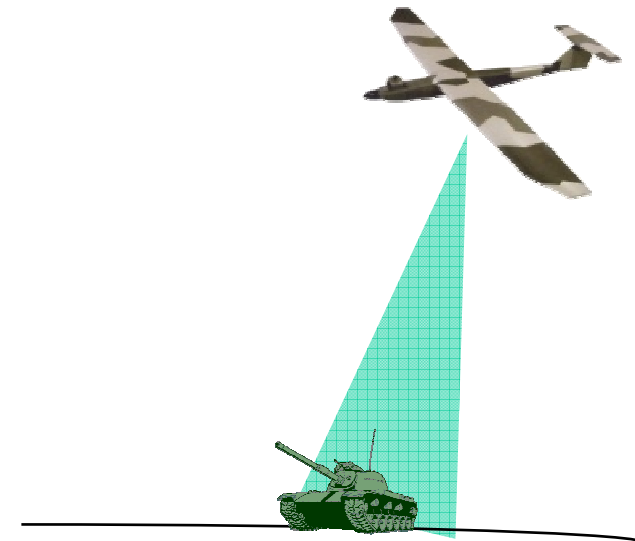
StrikeLink has received the updated coordinates for the target, and offers to modify it's target to match.

GBO/UAS Targeting Options

Pixel coordinates +
GBO Range



Pixel coordinates + Precision DTED



Multiple Image Point Targeting

UAS Pixels + GBO Range

The screenshot shows the WebGRIM application in a Mozilla Firefox browser. The browser address bar displays the URL: `http://grim.navsys.com/WebGRIM30/grim/source/index.jsp`. The application title is "WebGRIM - NAVSYS". The main header reads "WEBGRIM GBO Web-based Geo-Referenced Image Manager". Below the header is a navigation menu with items: WebGRIM, Explorer, Mapping, Settings, FAQ, and Help & About. The interface includes a "Tools" bar with icons for Layers, Position, and Targeting. A "Target: Test Target" panel on the left displays the following information:

Position:
Lat: 39.04195 deg
Lon: -104.84544 deg
MGRS: 13SED1337621444
Source: DPSS Message
Time: 2010-05-07 15:59:40
Alt: Not Available
Source: None

Errors:
CE: Not Available
LE: Not Available
TLE: Not Available

Warning: No Solution

Buttons: Hide Overlay, Send to StrikeLink

Map status: 1/7 2009-07-11 16:41:34.0

The map shows an aerial view of a landscape with a road and a field. A blue square (GBO) is located in the lower-left area. A red crosshair (New Target) is located in the upper-right area. An orange arc (Heading Uncertainty) connects the GBO to the New Target. A red arrow points to a north marker on the map.

- GBO
- New Target
- CoTXML Target
- Heading Uncertainty

GBO range to target calculated from GBO location – CoTXML Target Location (*Requires Target Location in CoTXML)

UAS Pixels + Precision DTED

The screenshot shows the WebGRIM - NAVSYS interface in Mozilla Firefox. The browser address bar shows the URL: `http://bruceb-xp2:7001/WebGRIM30/grim/source/index.jsp`. The page title is "WebGRIM - NAVSYS". The main content area displays a map with a target area highlighted. A red box highlights the "Target: Test Target" information panel on the left. A yellow box highlights the "Target: Test Target" information panel on the right. A legend on the right side of the image identifies the symbols used: a blue square for "GBO", a red crosshair for "Current Target", and a grey crosshair for "Previous Target". The target information panel on the left shows the following data:

Target: Test Target	
Position:	
Lat:	39.03602 deg
Lon:	-104.84149 deg
MGRS:	13SED1371920786
Source:	SST Image 349752
Time:	2009-07-11 16:37:13
Alt:	6669 FT MSL
Source:	DTED L2
Errors:	
CE:	8.1 m
LE:	9.1 m
TLE:	12.18 m

A warning message is displayed below the errors: **Warning: TLE > 10**. Below the warning are buttons for "Hide Overlay" and "Send to StrikeLink". The target information panel on the right shows the same data as the left panel, but with a different layout. It also includes a warning message: **Warning: TLE > 10**. Below the warning are buttons for "Hide Overlay" and "Send to StrikeLink". The map in the center shows a satellite image of a coastal area with a red crosshair symbol indicating the current target location. A legend on the right side of the image identifies the symbols used: a blue square for "GBO", a red crosshair for "Current Target", and a grey crosshair for "Previous Target".

GBO identifies the target on the image and WebGRIM displays the calculated LLA & the corresponding CE, LE, & TLE based on DTED accuracy.

Multiple Image Point Targeting

WebGRIM - NAVSYS - Mozilla Firefox

http://bruceb-xp2:7001/WebGRIM30/grim/source/index.jsp

WebGRIM - NAVSYS

GBO Web-based Geo-Referenced Image Manager

Tools: Layers Position Targeting Debug

Target: Test Target

Position:
Lat: 39.03602 deg
Lon: -104.84149 deg
MGRS: 13SED1371920786
Source: SST Image 349752
Time: 2009-07-11 16:37:13
Alt: 6669 FT MSL
Source: DTED L2

Errors:
CE: 8.1 m
LE: 9.1 m
TLE: 12.18 m

Warning: TLE > 10

Hide Overlay

Send to StrikeLink

(Used 349752).
New best soln: SST TLE was 12.182774724995944.
Adding BaseMap with image theme.
from Tour 2863 date 2009-07-11 16:37:14.000000
Best image is 349753

Target: Test Target

Position:
Lat: 39.03602 deg
Lon: -104.84149 deg
MGRS: 13SED1371920786
Source: SST Image 349752
Time: 2009-07-11 16:37:13
Alt: 6669 FT MSL
Source: DTED L2

Errors:
CE: 8.1 m
LE: 9.1 m
TLE: 12.18 m

Warning: TLE > 10

Hide Overlay

Send to StrikeLink

(Used 349752).
New best soln: SST TLE was 12.182774724995944.
Adding BaseMap with image theme.
from Tour 2863 date 2009-07-11 16:37:14.000000

Transferring data from caprica... : Not Loaded Yet : Not Loaded Yet

If resolution or accuracy not sufficient, GBO continues to click on target in provided images. WebGRIM displays LLA & the corresponding CE, LE, & TLE from MIPT calc.

RMS Targeting Errors (m)			
	N	E	D
Current GBO TLHDS *	22.89	23.58	12.29
Pixel coordinates + GBO Range **	1.52	0.95	9.62

Simulation Parameters	Error (1-sigma)	Units
Range	5.0	m
GBO N/E	1.5	m
GBO Down	3.0	m
Az	10.0	mrad
EI	2.5	mrad
Camera Target Pixel [x, y]*	1.0	Pixel
Camera position N/E*	1.6	m
Camera position Down	2.54	m
Camera Pitch/Roll*	0.65	mrad
Camera Heading	1.78	mrad
* Error Held Constant Throughout Simulation		

* Simulated Results – Range to target: 5 km

** Actual Pixel Coordinates + simulated GBO range observation

Conclusions

- GRIM Geospatial database management provides powerful capability for managing UAS imagery and for search, retrieval and viewing of target-quality imagery
- GBO can request and view UAS imagery through existing Web software or Browser
- GBO/UAS Hybrid System removes target location errors caused by GBO targeting hardware azimuth errors
- Eliminates need for high quality inertial azimuth sensors located with each GBO