

Flight Test Results for Miniature GPS/Inertial Camera Payload

**GNC MAS 2009
Miniature Multi-Function Seekers/Sensors
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Reece Tredway and Alison Brown, NAVSYS Corporation

Dr. Tom Lippmann, Dugout Consulting

NAVSYS Corporation

Founded 1986



Provides specialized GPS products & services for our customers by leveraging our core technologies, unique technical expertise, innovative engineering, strong work ethic, and high standards of excellence

Tier 1 UAS GPS/IMU/Camera Payloads

- **Challenge**

- DoD has an ever-increasing need for miniature, multi-function UAS platform sensors
 - Tier I UAS SWAP limitations present significant engineering challenge
 - Ability to positively identify and precisely locate military targets in real-time is a current shortfall with current Tier 1 UAS

- **Solution**

- Small form-factor lightweight GPS/IMU Micro-Camera payload
 - Provides precision georegistered imagery
 - Moving capabilities currently available in larger Tier II payloads to the smaller UAS payloads

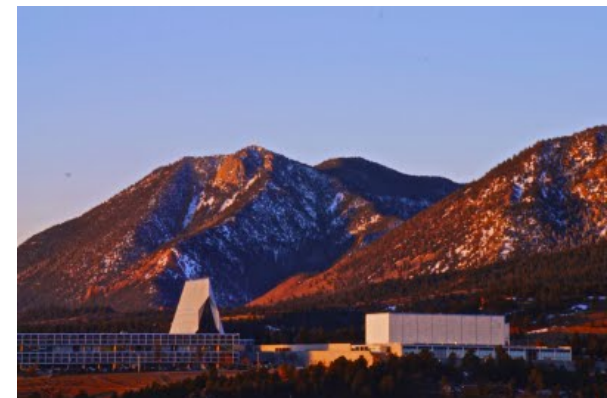
- **Capabilities Georegistered Imagery brings to the Warfighter**

- Targeting
 - StrikeLink Integration
- Mapping
 - Military Mission Planners
 - Near real-time targeting data/Bomb Damage Assessment
 - Low-cost Rapid Coastal Surveys
 - Precision Land Maps
- Bathymetry
 - Army Corp of Engineers
 - High resolution shoreline data for modeling for forecasting
 - Littoral Battlespace Sensing, Fusion, and Integration (LBSF&I)
 - Bathymetry surveys critical for modeling & mission planning operations
 - Navy METOC
 - Bathymetry data from shallow regions in support of littoral operations
 - Wave Modeling



- **Flight Tests at US Air Force Academy**

- Targeting and Mapping Results

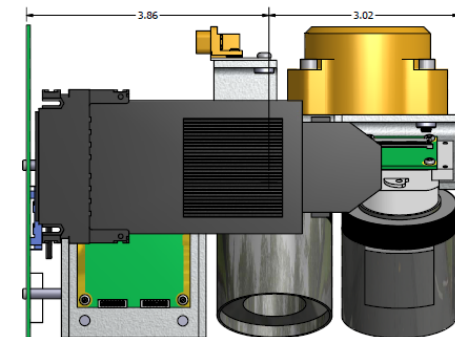
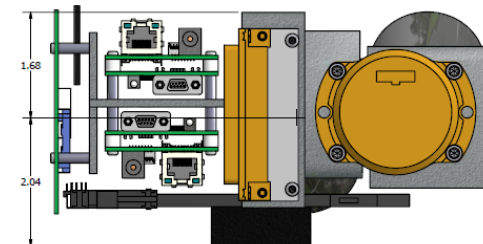




NGA Tactical Surveying and Targeting System (TS2)



FLIR StarSAFIRE III

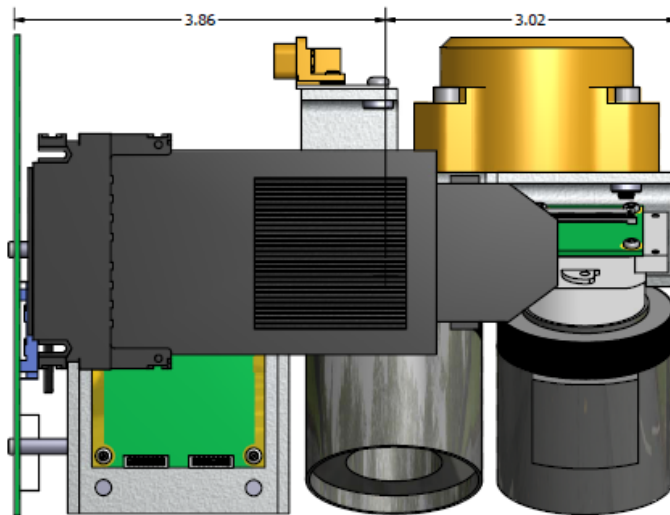
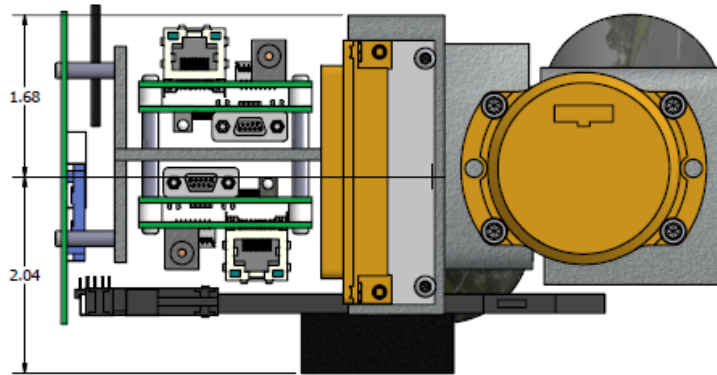


**Micro-Camera
(Dual Camera)**



**Dual GI-Eye System
Flown at USAFA**

Micro-Camera Payload – Tier I



Features

- Operation

In-flight, fully autonomous flight planning

Interface

- Command
- Video Out

Serial over UAV platform wireless link
Serial over UAV platform wireless link

Electrical

- Supply Voltage
- Power

12 Volts
10 W (typical)

Mechanical

- Size
- Weight

3.25" x 4" x 7"
900 grams / 2 lbs

Video

- Payload Camera

Dual side looking 3.1 megapixel color machine vision imaging modules

Operating Envelope

- Range
- Speed
- Operating Altitude

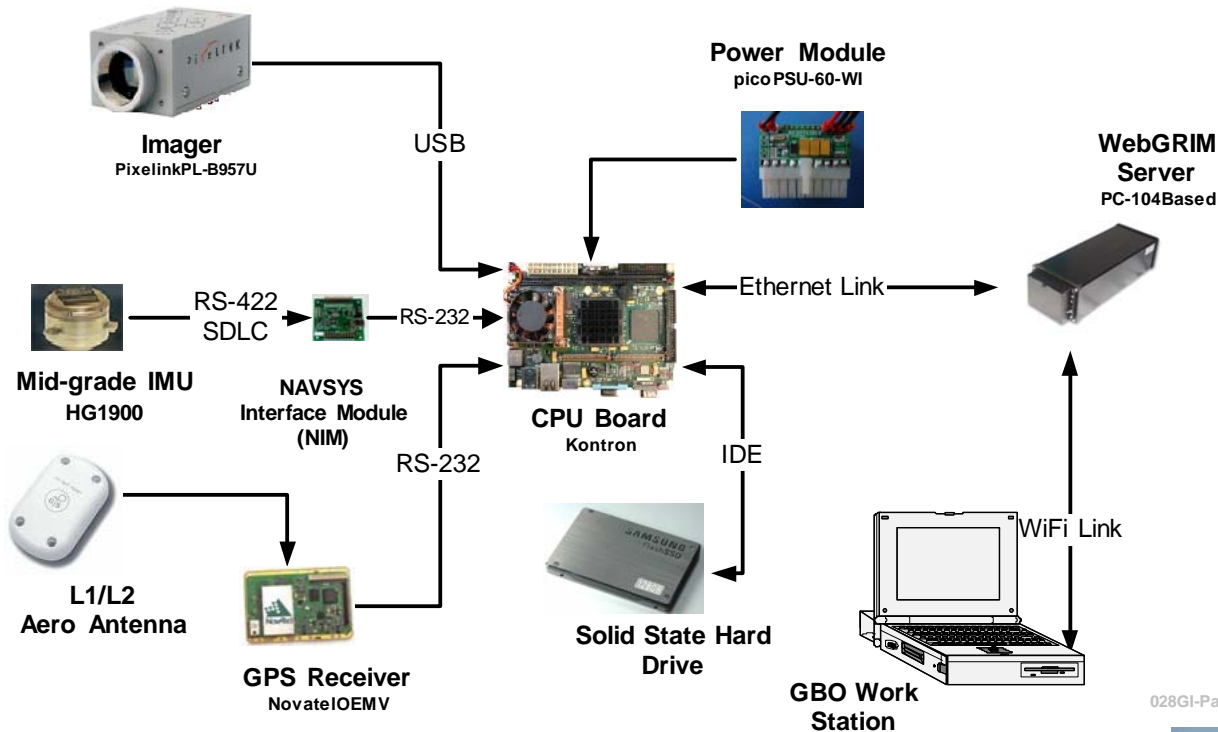
Limited by UAV platform and available memory
Up to 60 mph
500 – 1500 ft AGL

Data Processing

- Bathymetry
- Mapping

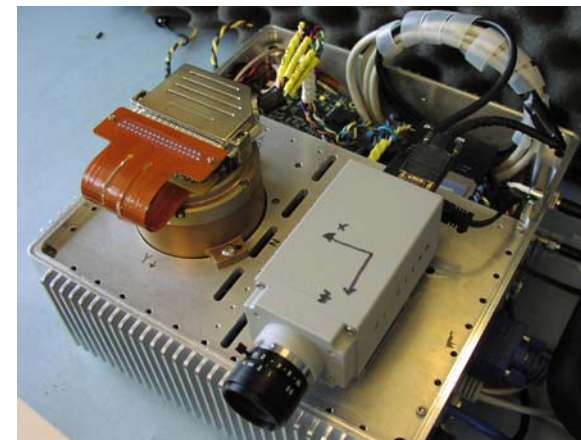
Post process data collected over littoral region
Mapping capability from mosaicked imagery

UAS GI-Eye Payload



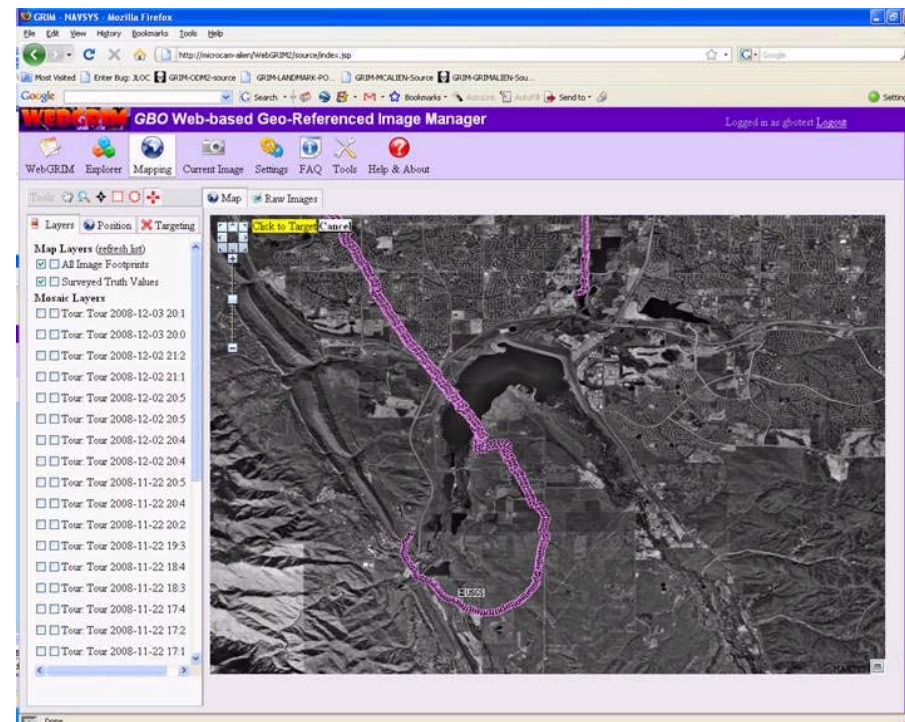
028GI-Payload.vsd

Component	Size	Weight	Power
As shown above	~ 300 Cubic Inches	~ 9 lbs	~ 175 Watts

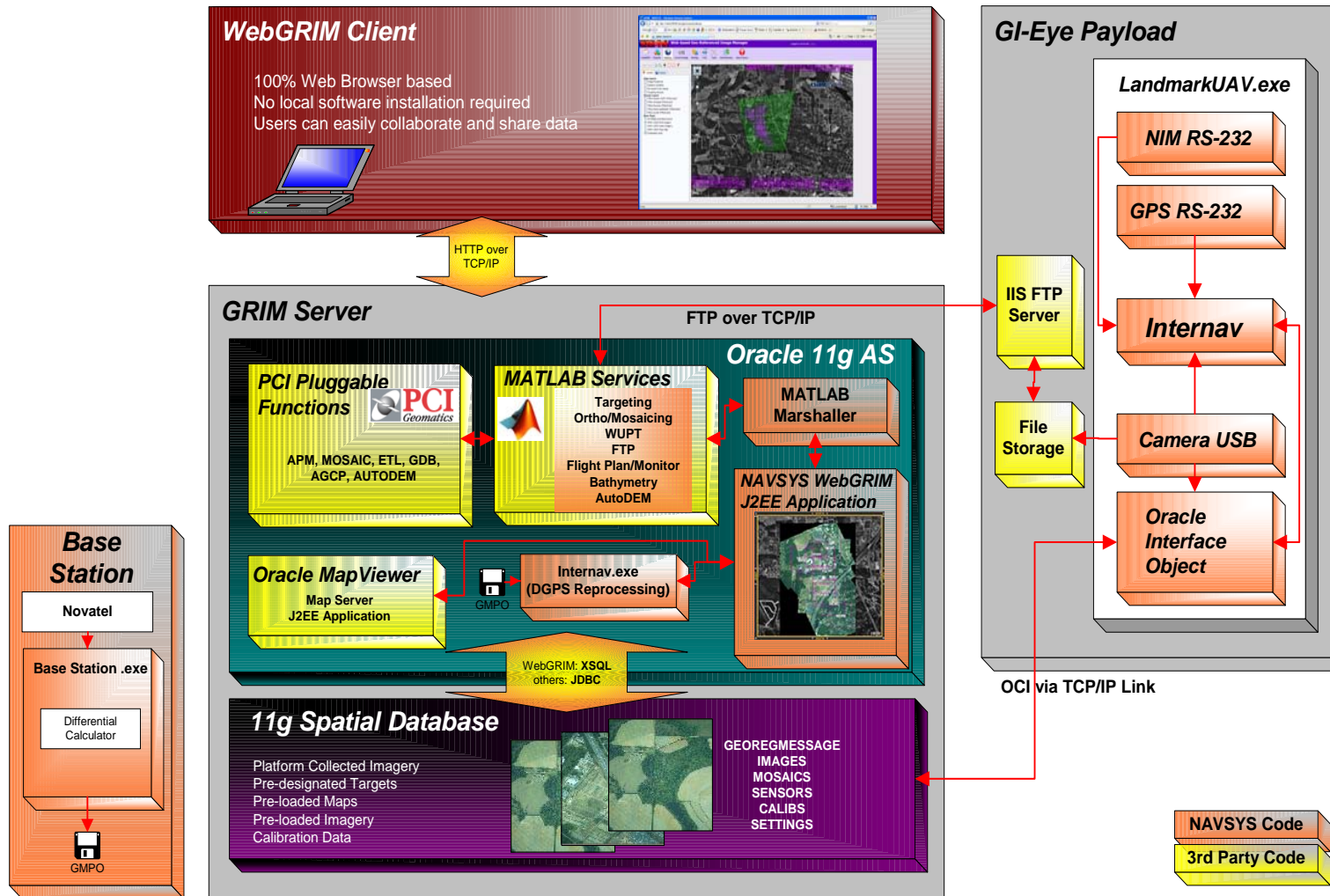


WebGRIM Ground Station Software

- Web Based
 - No new software to install
 - On-line collaboration between multiple users
- Quickly locate & manipulate collected imagery
 - Orthorectification & mosaicking
 - Point and click targeting
- User Customized Tools
 - UAV Flight planning
 - Bathymetry map generation
 - Targeting
 - Auto-DEM generation from collected imagery
- OGC Compliant
 - Display third party maps
 - Acts as Web Mapping Service



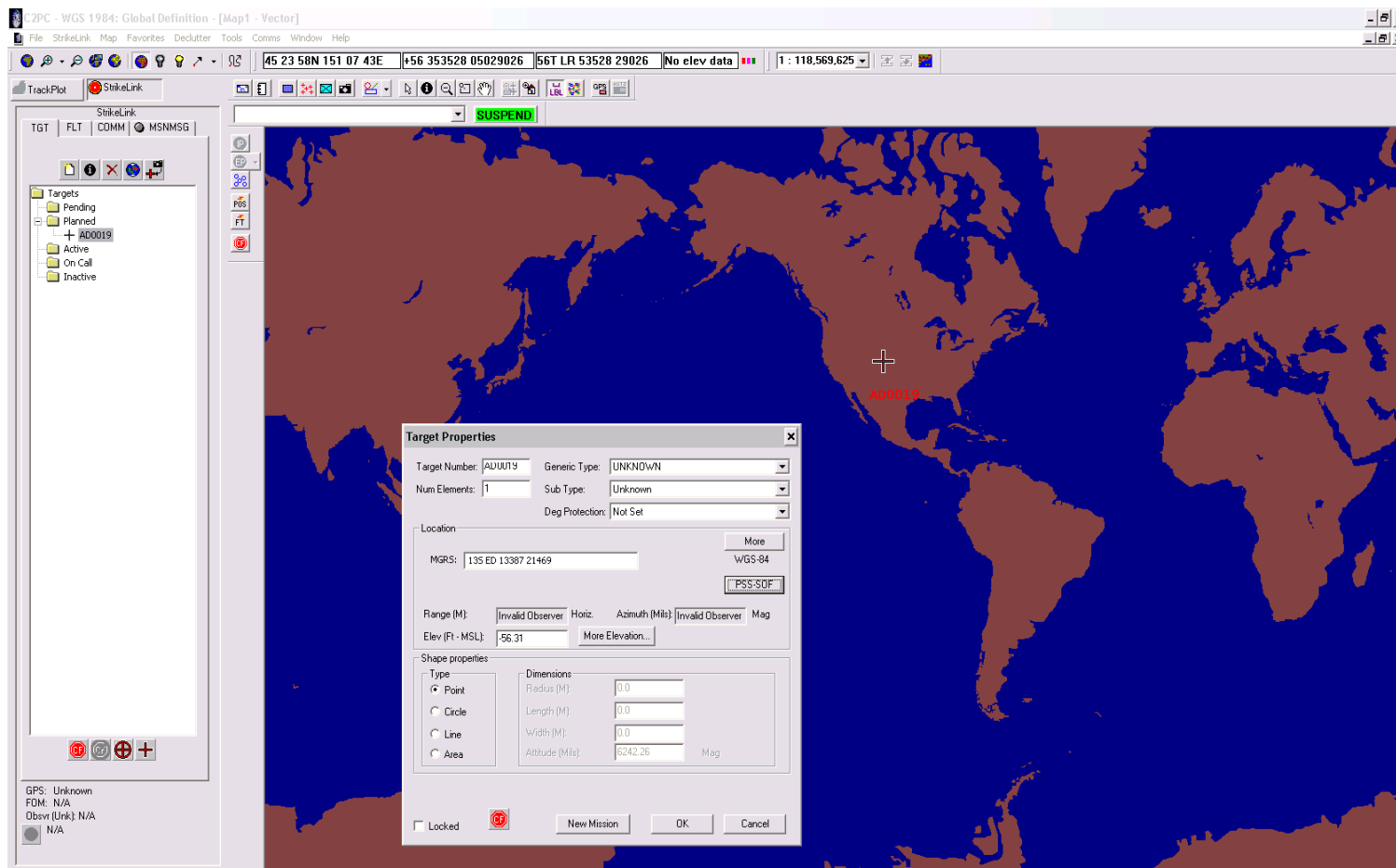
Overall Web-based Georeferenced Image Manager (WebGRIM) Architecture



- Rocky Mountain Aerial Surveys, Inc
Cessna 206G
 - Based in Denver
- Collection Area
 - Northeast section of USAFA
 - 25 NGA surveyed Ground Control Points
- Landmark Payload
 - 1 Hz images, looking Nadir
- Micro-Camera Payload
 - 2 Hz images, 30 degrees off Nadir
- Post processed images used to:
 - Test single and multi-shot targeting through WebGRIM
 - Collect imagery for AutoDEM processing and mapping
 - Validate WUPT navigation algorithms

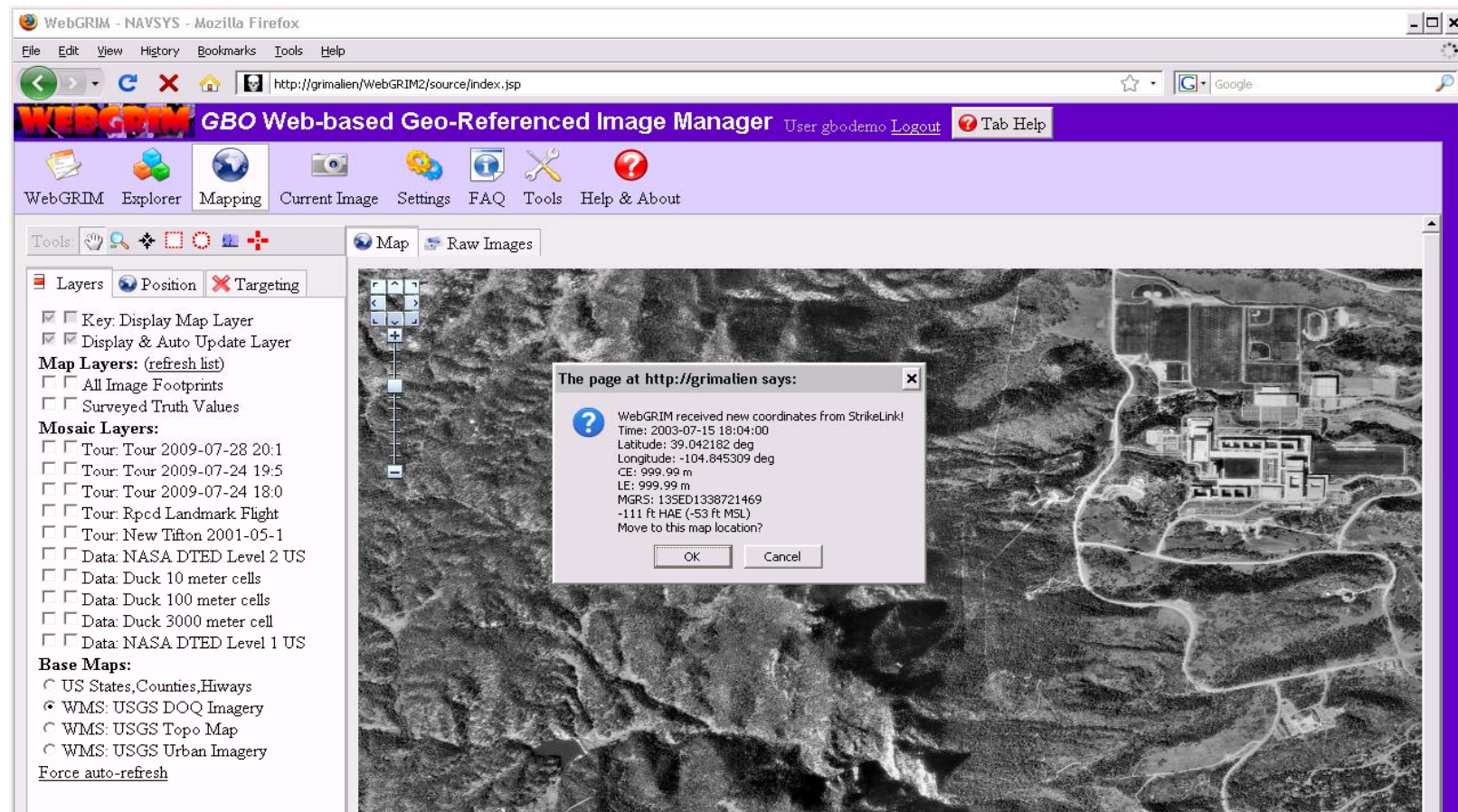


StrikeLink/WebGRIM Integration



The user generates his target in StrikeLink in the usual fashion, and then clicks the PSS-SOF button. WebGRIM intercepts this COT XML message...

StrikeLink/WebGRIM Integration



WebGRIM displays the StrikeLink coordinates and prompts user to move the map display

Web Based DPSS Pages & StrikeLink Integration

The screenshot displays the WebGRIM web application interface. The browser window title is "WebGRIM - NAVSYS - Mozilla Firefox" and the address bar shows "http://grimalien/WebGRIM2/source/index.jsp". The application header includes "GBO Web-based Geo-Referenced Image Manager" with a user "gbdemo" and a "Logout" link. The main interface features a toolbar with icons for "WebGRIM", "Explorer", "Mapping", "Current Image", "Settings", "FAQ", "Tools", and "Help & About". Below the toolbar is a "Tools" section with icons for "Map" and "Raw Images". The central area is a map showing a grayscale aerial view with a red square highlighting a target area. A red crosshair is visible within the red square. A yellow tooltip with the text "Click to Target Cancel" is positioned over the red crosshair. To the left of the map is a "Layers" panel with "Position" and "Targeting" tabs. The "Targeting" tab is active, displaying the following information:

Target:
Position:
Lat: 39.04218 deg
Lon: -104.84531 deg
MGRS: 13SED1338721469
Source: DPSS Message
Time: 2003-07-15 18:04:00
Alt: -111 ft HAE (-53 ft MSL)
Source: DPSS Message

Errors:
CE: 999.99 m
LE: 999.99 m
TLE: 1414.19 m
Warning: TLE > 10

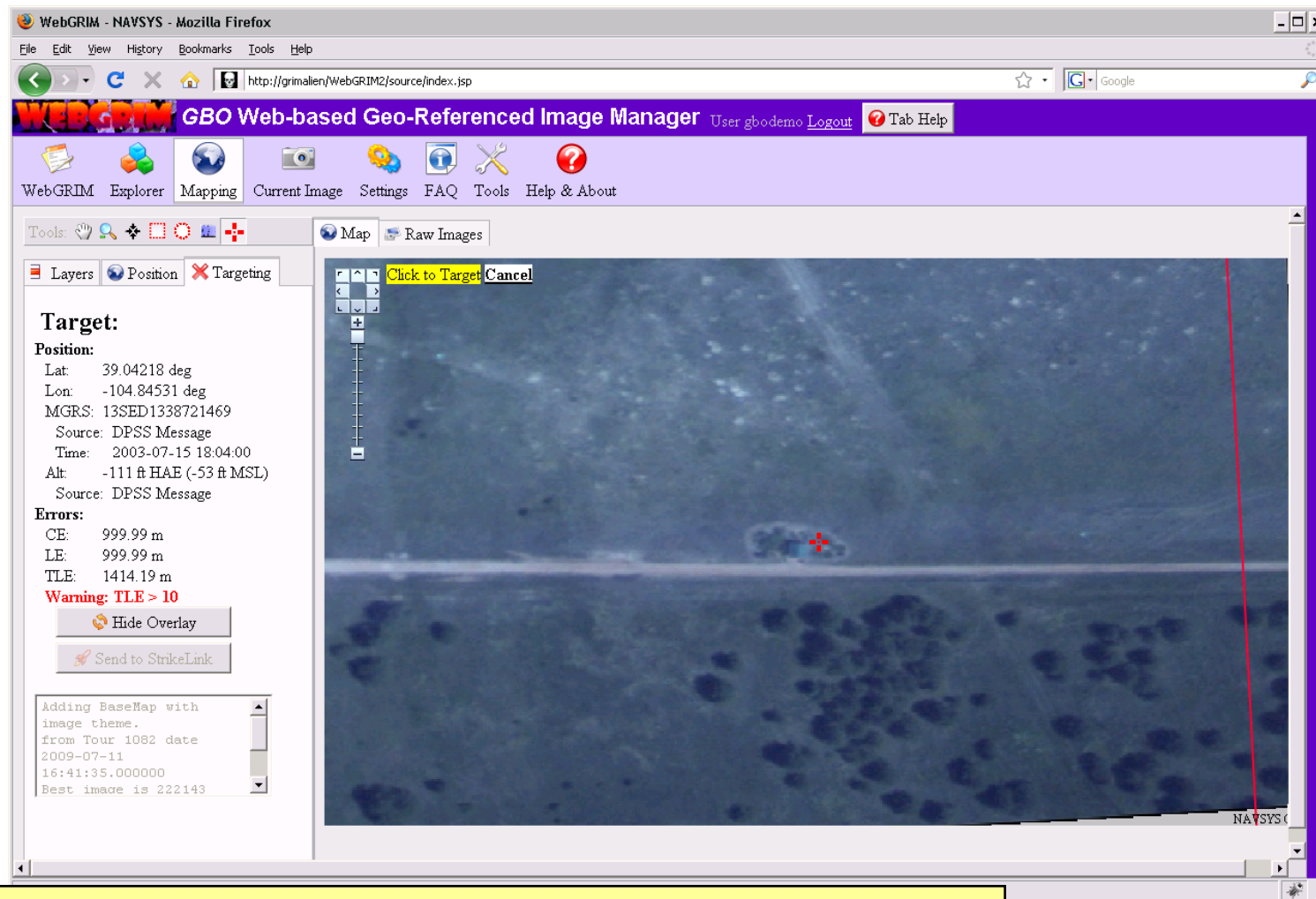
Buttons: "Hide Overlay" and "Send to StrikeLink".

At the bottom of the "Targeting" panel is a log window with the following text:

```
Adding BaseMap with  
image theme.  
from Tour 1082 date  
2009-07-11  
16:41:35.000000  
Best image is 222143
```

DPSS page displays red open cross targeting icon using the CoTXML coordinates on the background map with the most recent image from GI-Eye overlaid on the background map layer

Web Based DPSS Pages and StrikeLink Integration



User can zoom in and select target feature

Web Based DPSS Pages & StrikeLink Integration

The screenshot displays the WebGRIM web application interface. The browser window title is "WebGRIM - NAVSYS - Mozilla Firefox" and the address bar shows "http://grimalien/WebGRIM2/source/index.jsp". The page header includes "WEBGRIM GBO Web-based Geo-Referenced Image Manager" and a "Logout" link. The interface features a central map area with a "Click to Target" button and a "Cancel" button. A red box highlights the targeting data panels on the left and right sides of the map. The left panel shows the following information:

Target:
Position:
Lat: 39.04215 deg
Lon: -104.84534 deg
MGRS: 13SED1338521466
Source: Tour 1082 BestImg 222143
Time: 2009-07-11 16:41:35
Alt: 6734 FT MSL
Source: DTED L2

Errors:
CE: 11.2 m
LE: 18 m
TLE: 21.2 m
Warning: TLE > 10

Buttons: Hide Overlay, Send to StrikeLink

The right panel shows the following information:

Target:
Position:
Lat: 39.04215 deg
Lon: -104.84534 deg
MGRS: 13SED1338521466
Source: Tour 1082 BestImg 222143
Time: 2009-07-11 16:41:35
Alt: 6734 FT MSL
Source: DTED L2

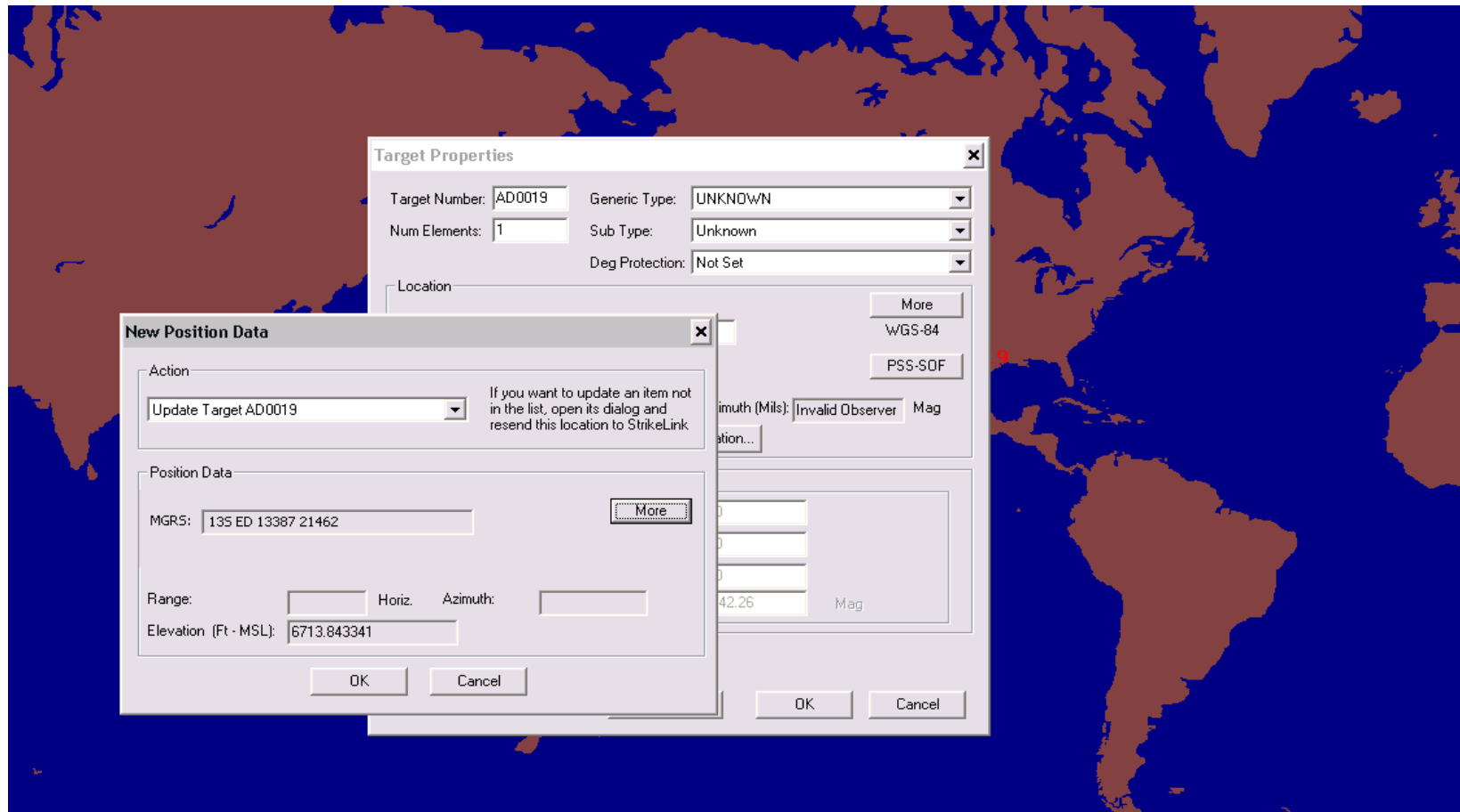
Errors:
CE: 11.2 m
LE: 18 m
TLE: 21.2 m
Warning: TLE > 10

Buttons: Hide Overlay, Send to StrikeLink

The map area shows a satellite image of a landscape with a red crosshair indicating the target location. A status bar at the bottom of the map area displays: "Already displaying best image. Adding BaseMap with image theme. from Tour 1082 date 2009-07-11".

WebGRIM displays latitude longitude, & altitude & the corresponding CE, LE, & TLE. GBO can send LLA, CE & LE back to StrikeLink via CoTXML. If resolution or accuracy not sufficient, user continues on to raw images.

Back at StrikeLink...

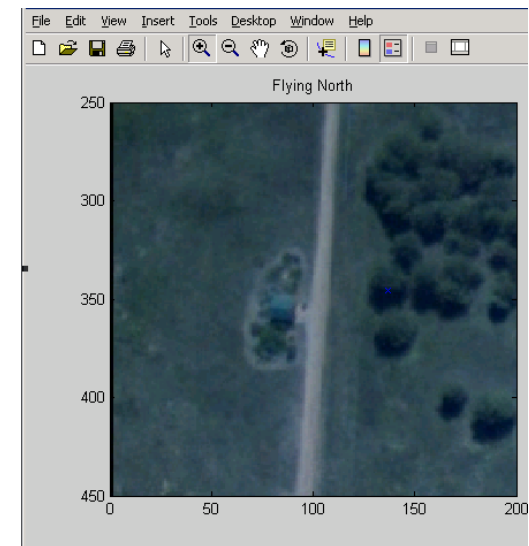
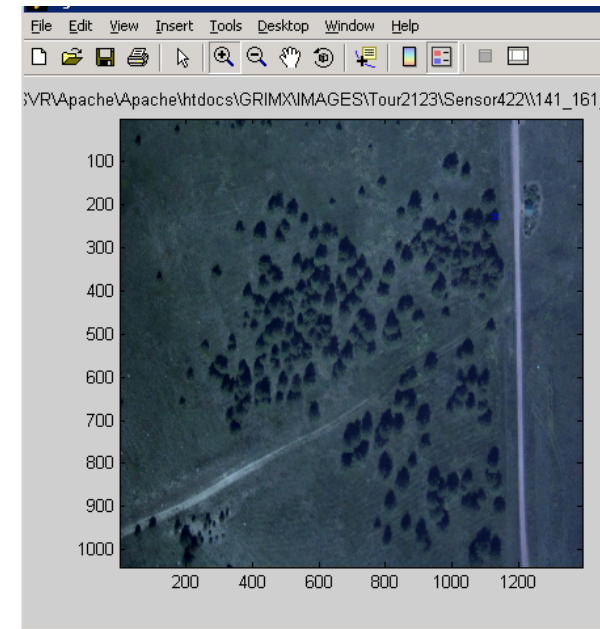


StrikeLink has received the updated coordinates for the target, and offers to modify it's target to match.

Single Shot Targeting Results

- Targeting Accuracy
 - Accuracy when flying at Tier I UAV Altitude ranges
 - DGPS post processed – Wi-Fi link not available in test aircraft

Image Time	Target ID	North Error	East Error	Down Error
576249	1	-0.26	1.98	-1.15
576250	1	-0.21	-0.83	-1.14
576251	1	1.35	-1.63	-1.14
576252	1	5.97	-2.324	-1.14
576236	2	-2.32	-0.51	2.13
576237	2	-2.78	-1.79	2.13
576238	2	-1.92	0.24	2.13
576239	2	-1.47	0.25	2.13
576240	2	1.85	-0.61	2.13
576241	2	2.21	-0.1	2.13
578502	2	-1.18	4.26	2.13
578503	2	-2.43	9.68	2.13
578504	2	-2.36	5.44	2.13
578505	2	-2.83	3.85	2.13
578506	2	-3.08	2.16	2.13
578507	2	-2.83	-2	2.13
RMS (m)		2.54	3.37	1.93



UAS Based Mapping

WebGRIM - NAVSYS - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://grim.navsys.com/WebGRIM2/source/index.jsp

Most Visited grim API Documentation WebGRIM-source WebGRIM-build MCAlien GrimAlien qpoxdoo » Playground:...

WebGRIM - NAVSYS

WebGRIM Landmark Web-based Geo-Referenced Image Manager User grimest Logout Tab Help

WebGRIM Explorer Mapping Fast Image Settings Monitor FAQ Tools Help & About

Tools: Map

Layers Position

- Key: Display Map Layer
- Display & Auto Update Layer

Map Layers: (refresh list)

- Camera Locations
- Image Footprints
- Surveyed Truth Values
- Targeting Results

Mosaic Layers:

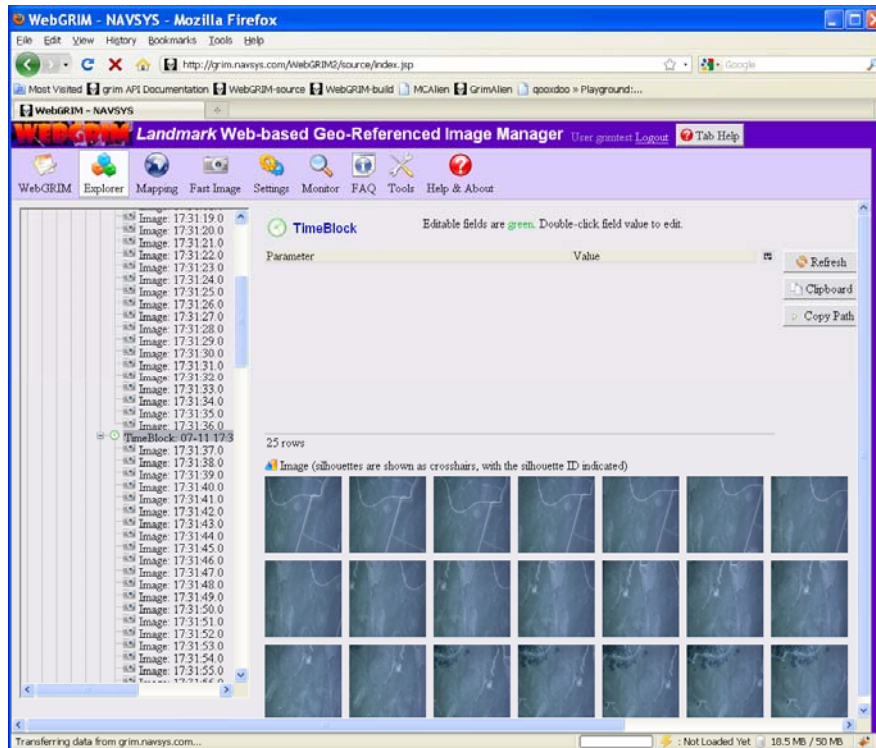
- WUPT20090711Big (PixelLINK)
- Tifton Grouped (TiftonCam)
- Tifton Swath (TiftonCam)
- Tifton Highway (TiftonCam)
- Tifton Runway (TiftonCam)
- Aardvark20090711 (PixelLINK)
- Tour: Rpcd MC CamCal 20090
- Tour: RUGGEDDELL-XP_2009
- Tour: Landmark Flight Rese
- Tour: Rpcd MC Flight Test
- Tour: Rpcd Landmark Flight
- Tour: Rpcd Microcamera Cal
- Tour: Mobile Short Lever A
- Tour: Mobile Long Lever Ar
- Tour: Rpcd MicroCam Mobile
- Tour: Rpcd MicroCam Mobile
- Tour: Tour 2009-06-12 17:1
- Tour: Rpcd LANDMARK Came

Toggle layer display on map. Hold down Ctrl while selecting this checkbox to force a refresh.

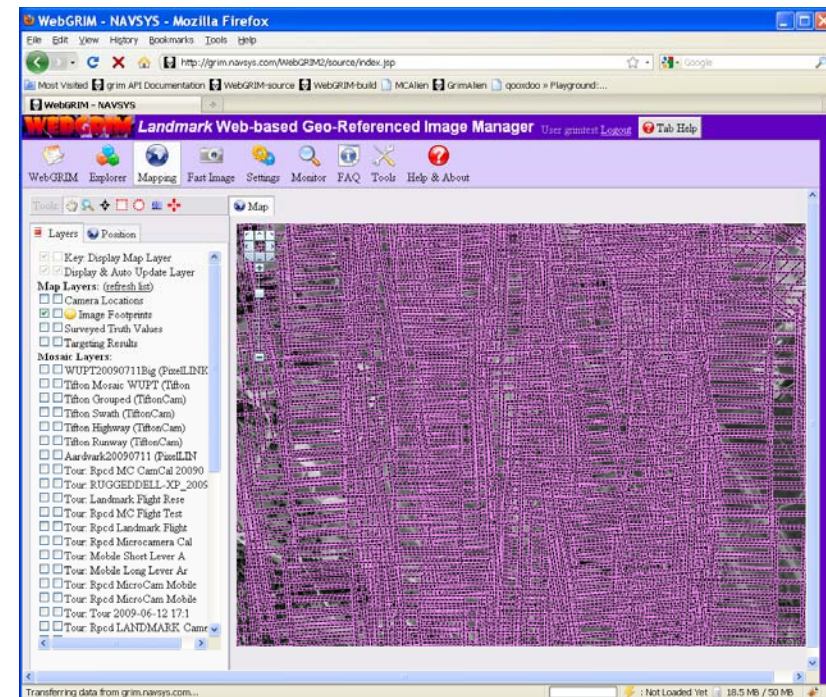
USGS NAVSYS

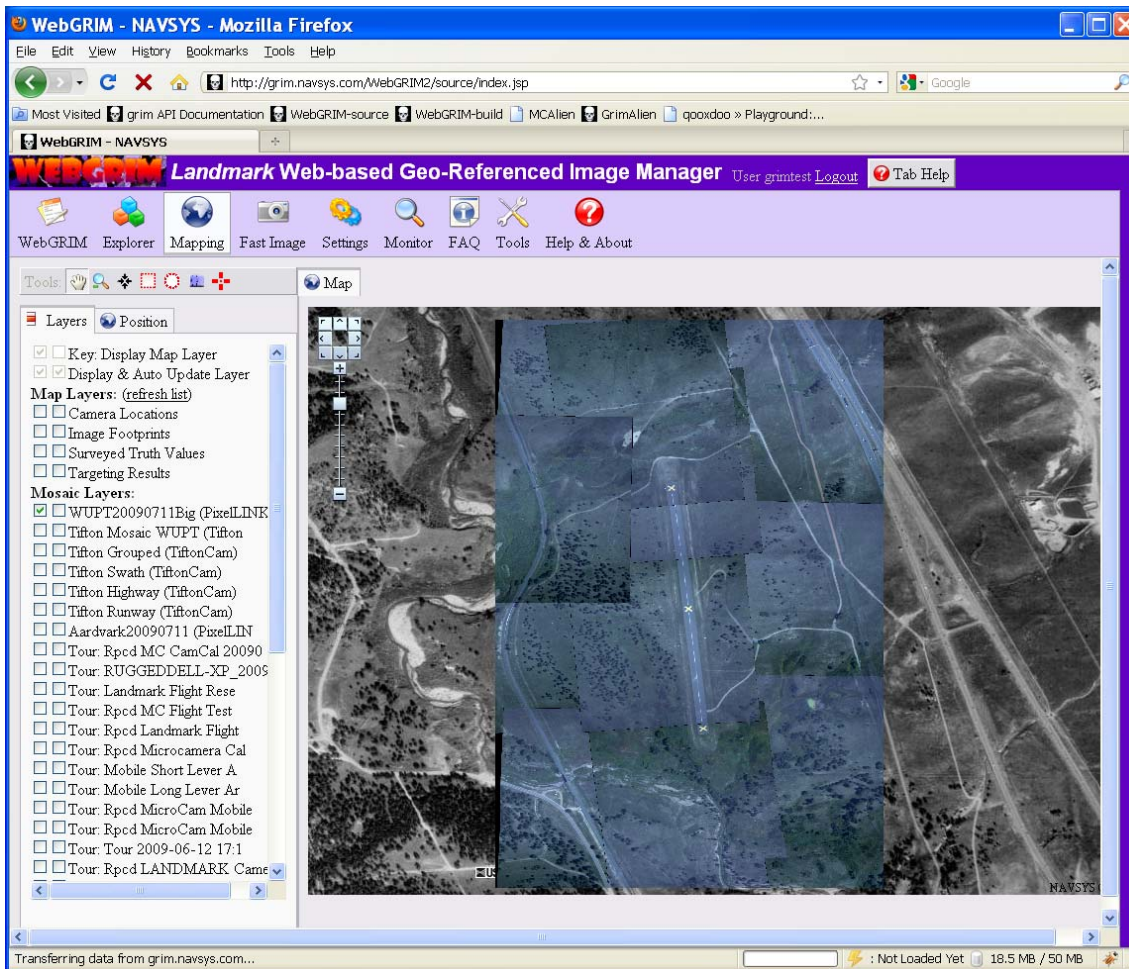
Transferring data from grim.navsys.com... : Not Loaded Yet 18.5 MB / 50 MB

UAS Based Mapping



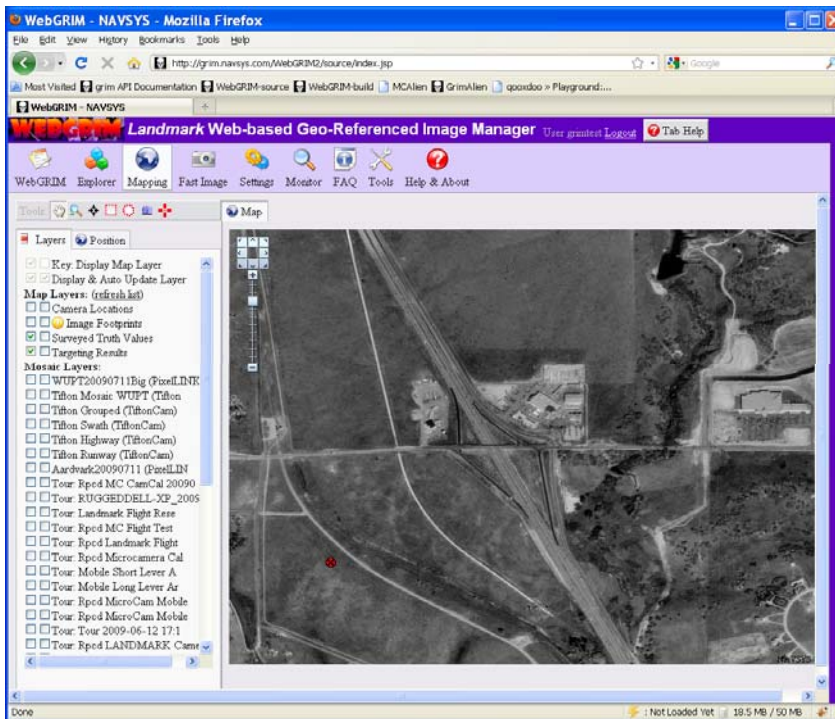
- Image management software
 - Single flight test generates 1000's of images
 - Manual image selection not possible





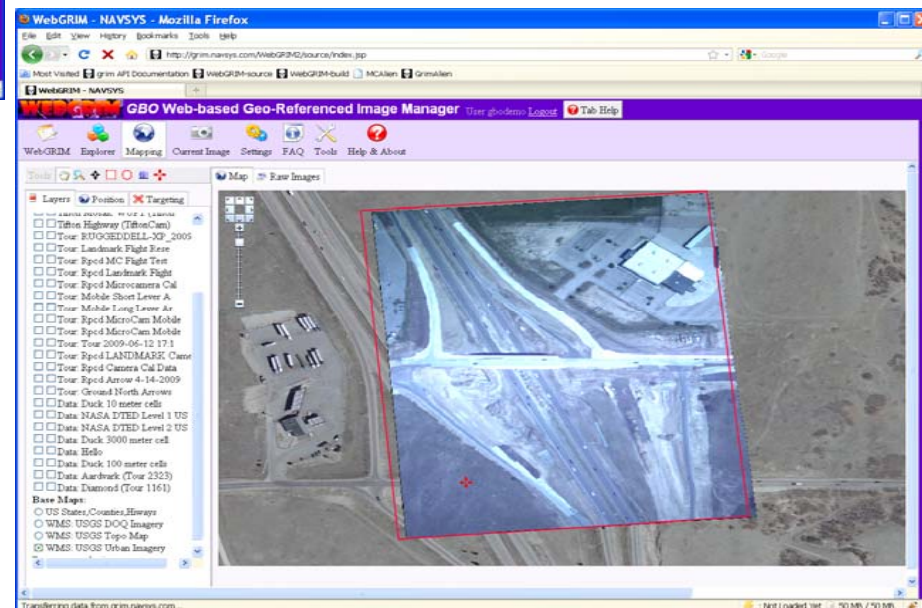
- Map Creation
 - WebGRIM software selects images that overlay user AOI
 - Imagery loaded into single GeoRaster to create map mosaic

UAS Based Mapping



- **Time-Sensitive Layer**

- USGS Background Map
- New bridge construction

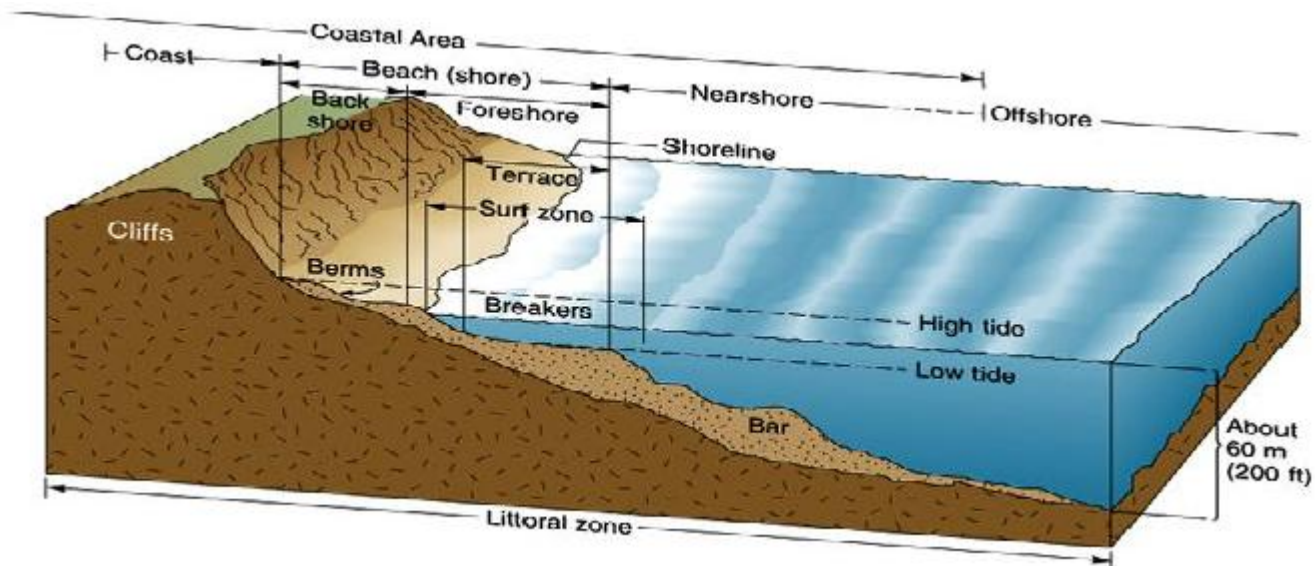
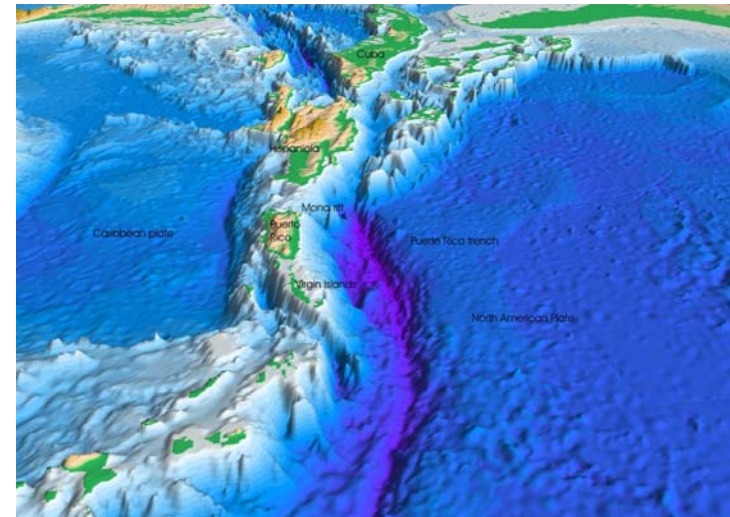


Bathymetry

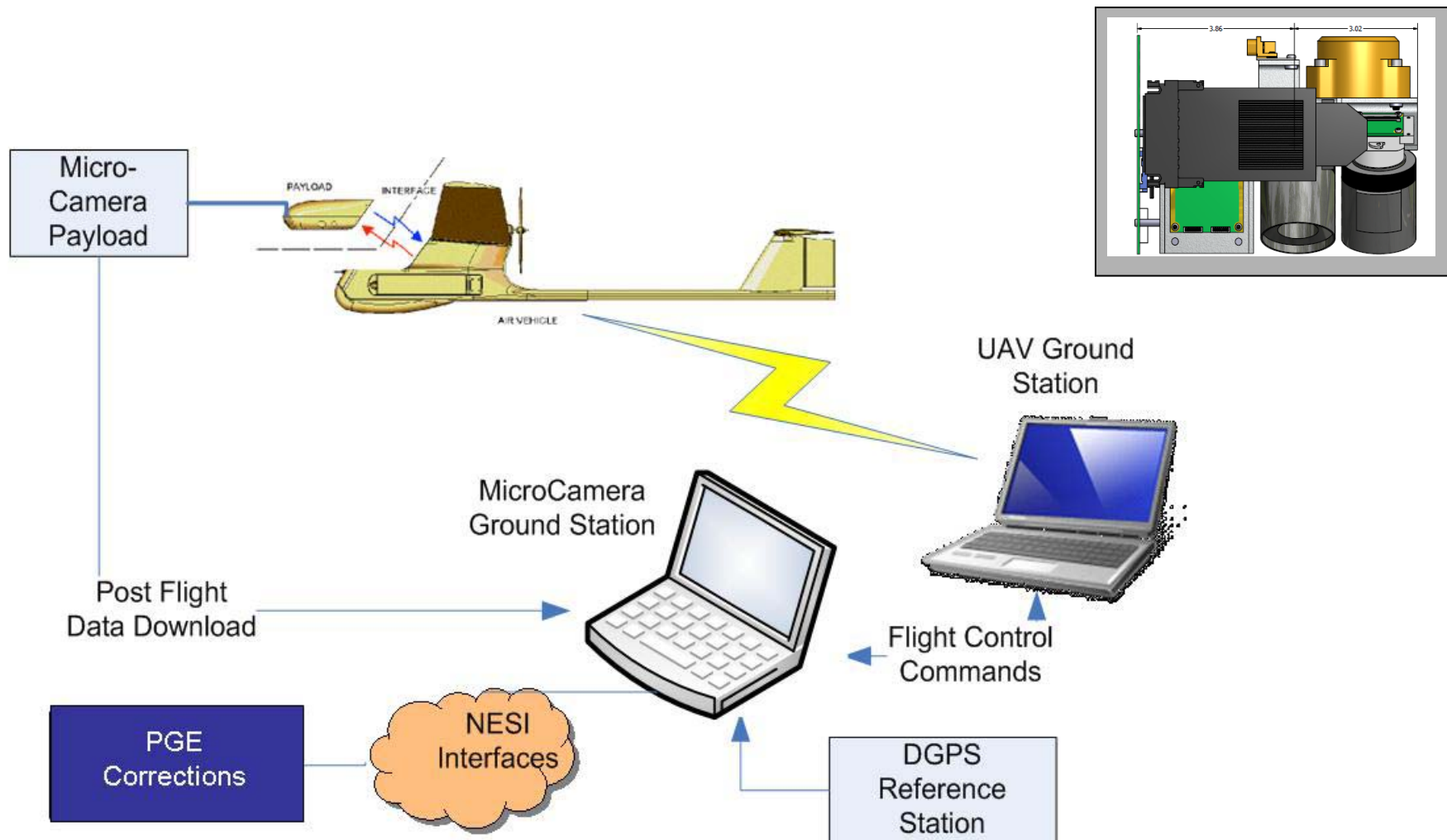
Underwater equivalent to topography

Littoral Zone

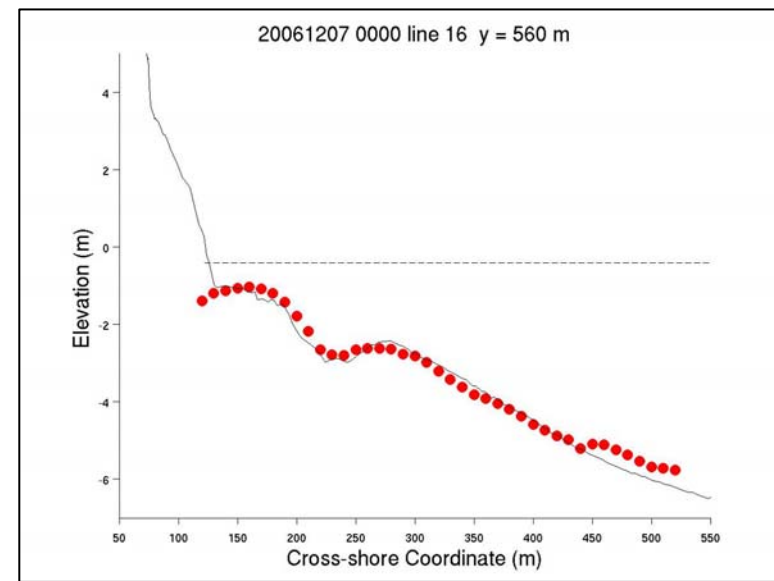
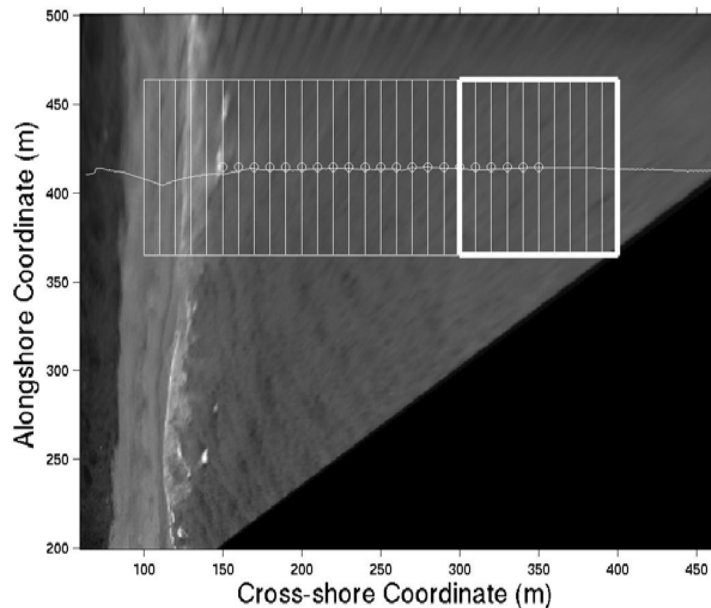
Permanently submerged ocean region extending from high water mark to shoreline areas



NAVSYS Micro-Camera



- **DepthWizard Software**
 - Computer software for estimating water depth in shallow regions (0.5 - 30 m) from time series of airborne imagery
 - Uses spectral (FFT) inversion techniques based on the physics of surface gravity waves
 - Presently MATLAB code → C-coded GUI



- Tier 1 UAS Georegistered Imagery
 - Mapping
 - Targeting
 - Bathymetry

