46th Annual Targets, UAVs, and Range Operations Symposium

Telemetry Solutions for Targets and Unmanned Aerial Vehicles (UAVs)

John Watson
October 2008

www.dynetics.com

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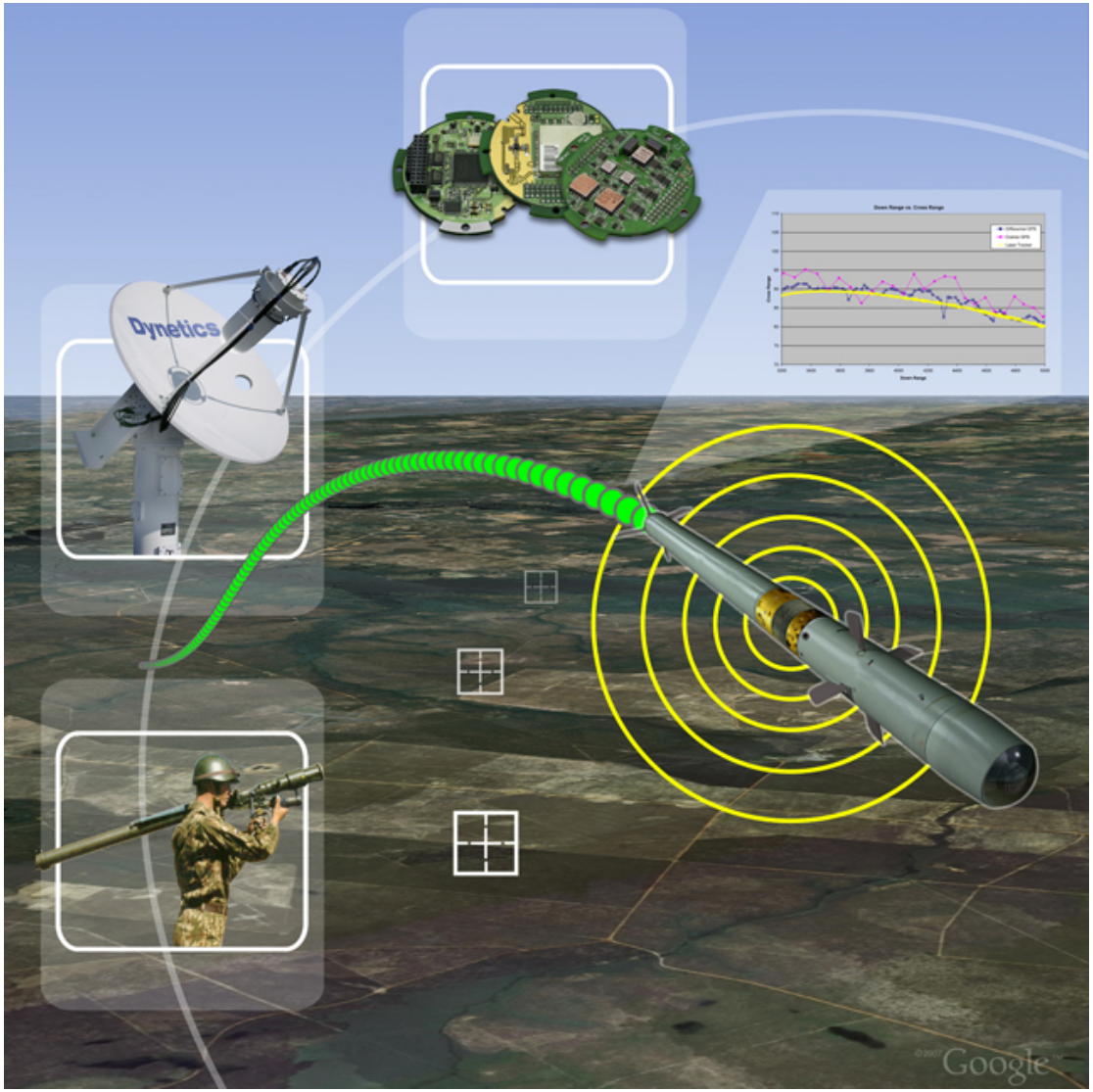
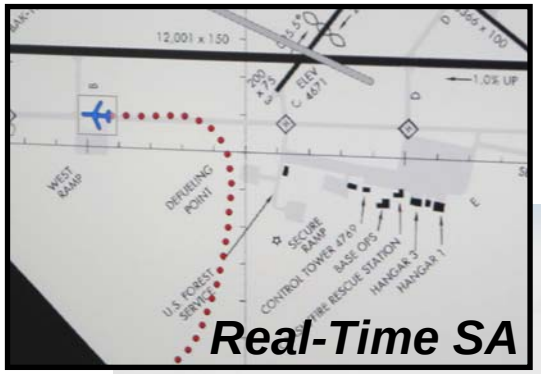
Dynetics' Legacy in Missile Test and Evaluation (T&E)

- **Dynetics' History Is Missile T&E; We Entered the Telemetry Business Because of Our Missile Expertise**
- **Our Customer Base Drove Us to Develop Missile Instrumentation That Covers a Wide Range of Applications With Minimal NRE**
- **This Means Dynetics' Instrumentation Products Must Be:**
  - **Physically Very Small…Fit Into Any Size Missile**
  - **Modular…Seamlessly Configurable**
  - **Flexible…Large Field Programmable Gate Array (FPGA)-Based Design**
  - **State-of-the-Art (SOTA)…Employ the Latest T&E Technologies**
  - **Secure…Ensure Customer Data Are Not Compromised**



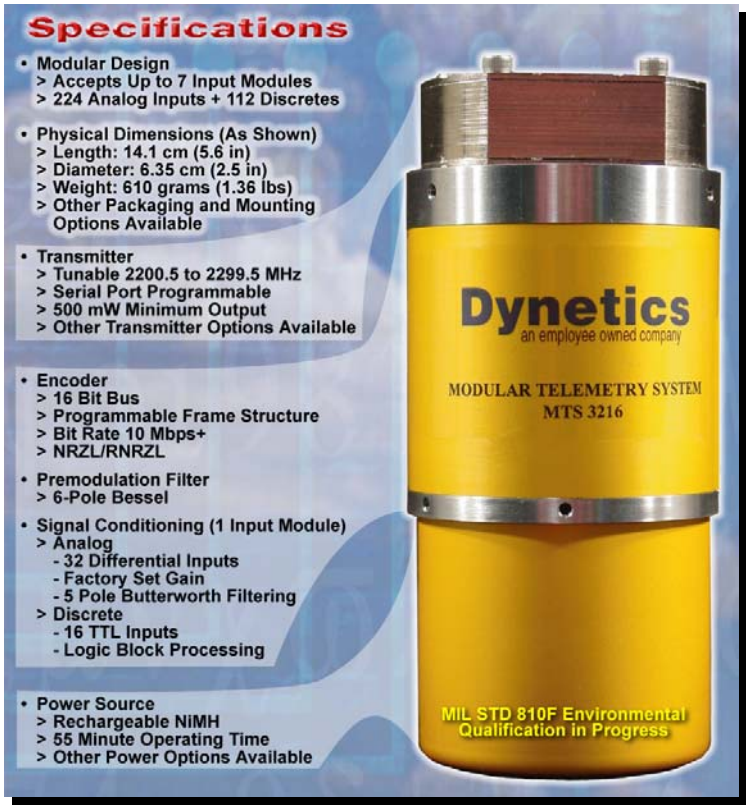
Dynetics' Legacy in UAV T&E

- Dynetics' Background Was Flight Test, Performance Analysis, and Simulation for UAVs
- Quality Flight Test Data Are Critical to Support Analysis and Simulation
- We Expanded Into Instrumentation for UAVs Because of Our Flight Test and Analysis Work
- Tailored Instrumentation Solution Based on the Need for Data Products With Limited Space, Weight, and Power (SWaP)
- Test Equipment Has an Impact on the Effectiveness of Time on the Flight Line
- Dynetics' Instrumentation Products Have the Right Features: Reliability and Flexibility
  - Physically Small
  - Modular…Seamlessly Configurable, Distributed Architecture
  - Flexible…Powerful Onboard Software That Can Be Quickly Customized for New Capabilities
  - Commercial-Off-the-Shelf (COTS)…Modern Embedded Components Reduce NRE
  - Real-Time…Situational Awareness for Flight Test Coordination and Safety…Data Monitoring in the Hands of the Test Conductor
  - Remote Operation Via Bidirectional Data Link



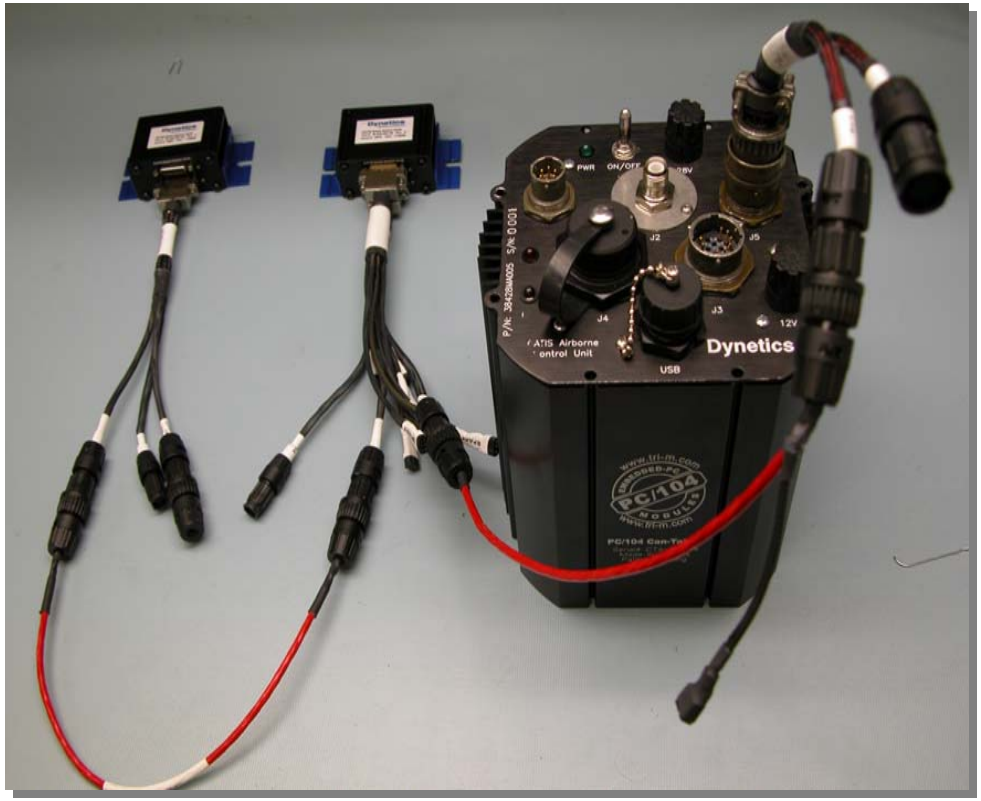
Dynetics' Telemetry Solutions

Missiles/Small Targets



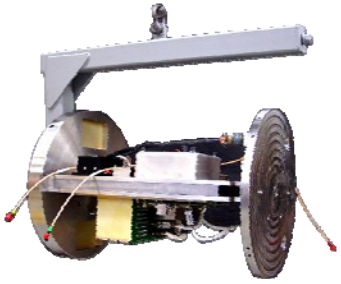
Modular Instrumentation System (MIS)

Unmanned Aerial Vehicles (UAVs)



Open Architecture for Telemetry and Instrumentation System (OATIS)

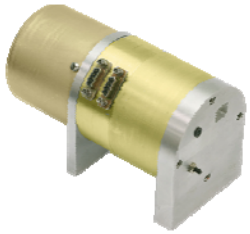
Modular Instrumentation Evolution



Medium- and Long-Range Missile Telemetry Systems

2003 Development of Miniaturized System

MANPADS Testing Occurs



Data Logger Developed

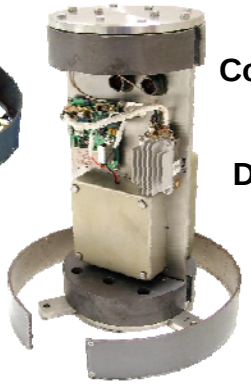
Encryption Module Developed

Ground Support Station

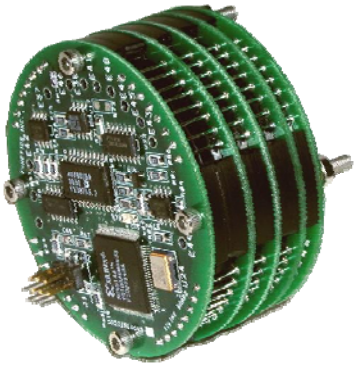
1990

The Evolution of Dynetics' MIS Program

Backup Telemetry Collection Role



Control Test Vehicle (CTV) Developed



DHS Orders 40+ Telemetry Systems

Flight of High-Dynamic Global Positioning System (GPS) and Enhanced Inertial Measurement Unit (IMU)

Army ASE ~40 Telemetry/GPS

Modular Telemetry System

- Compact Design
- Similar Performance/Characteristics
- Integrated IMU
- Warhead Tests Now Feasible

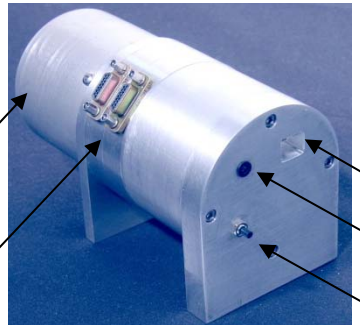
MIS

Missile Telemetry With Integrated Antennas

Integrated IMU Module

Radar Instrumentation With Fiber Optic Input/Output

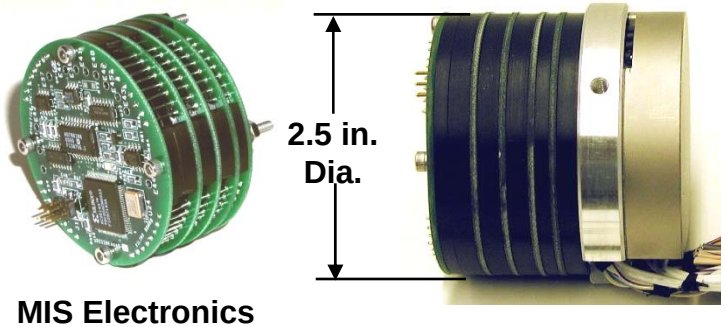
Integrated GPS Module



MIS 1216 Data Logger

Modular Telemetry System

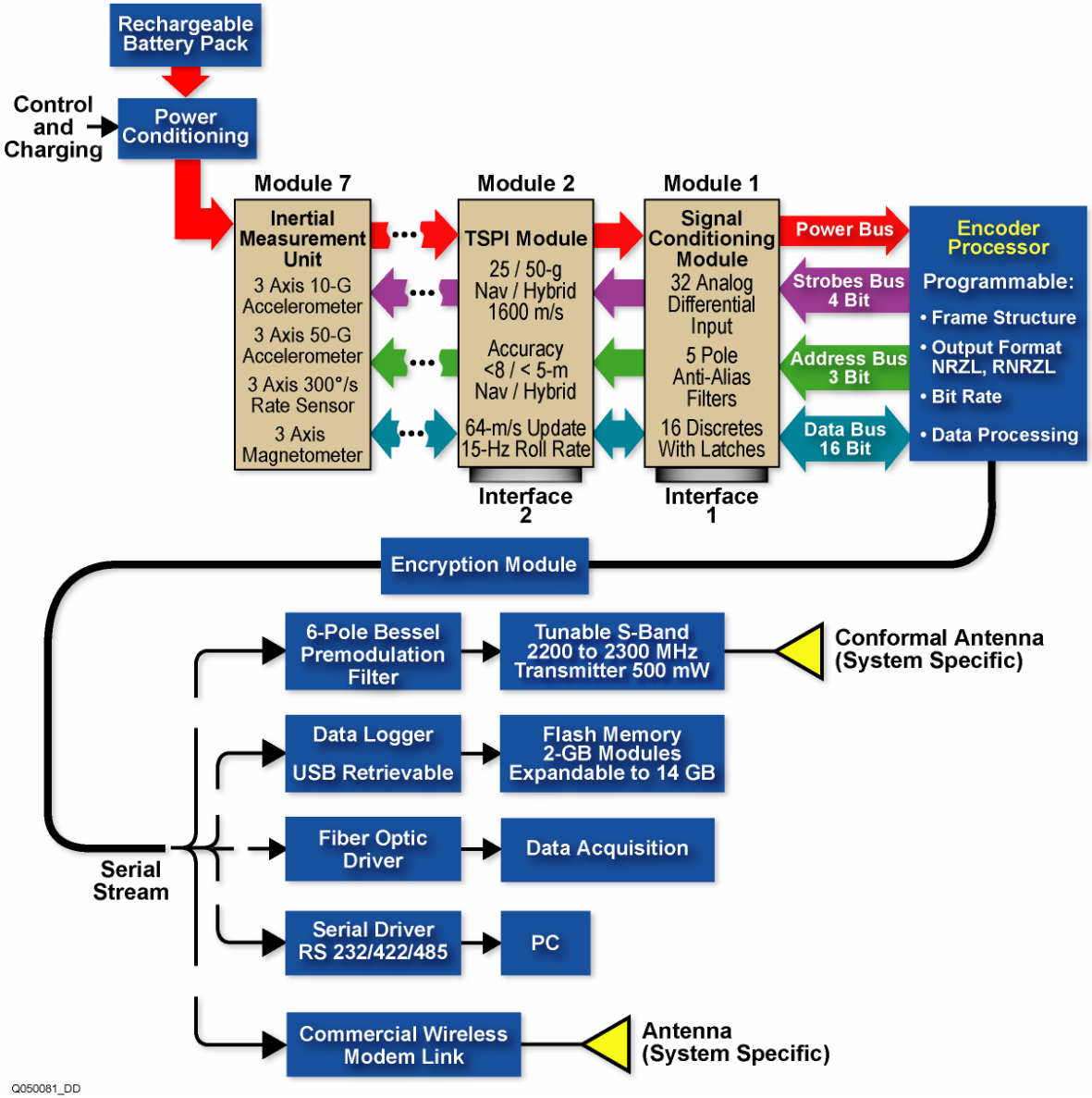
Ring Laser Gyroscope Module



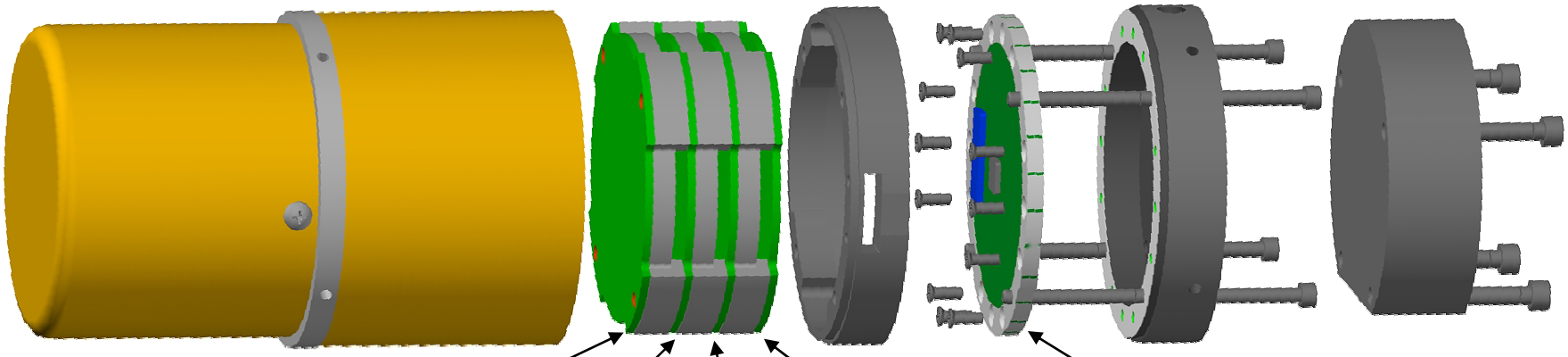
MIS Electronics

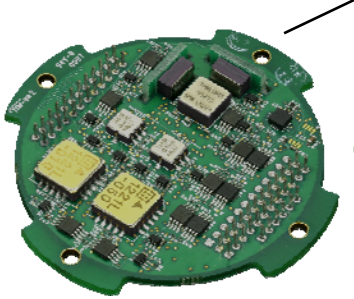
Rocketball Data Logger

MIS (Continued)

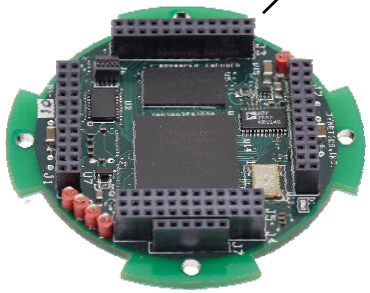


MIS (Concluded)

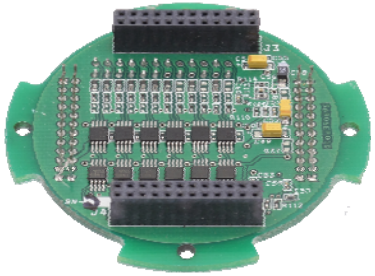




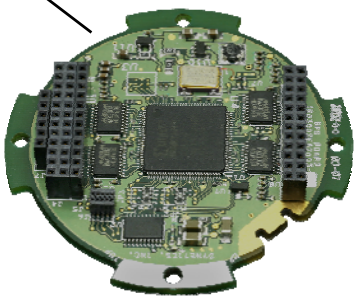
Enhanced IMU Module



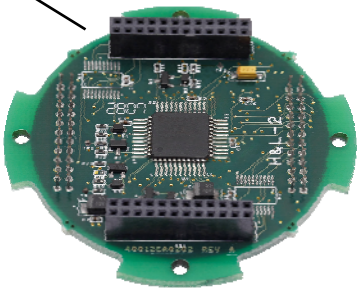
Basic and Enhanced Encoder Module



Multipurpose Serial Input/Output Module



High-Dynamic GPS Module



Encryption Module

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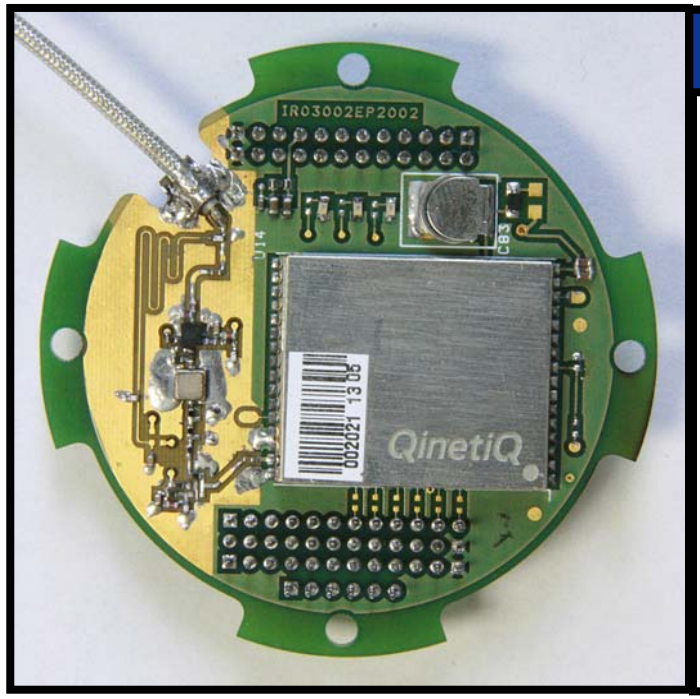
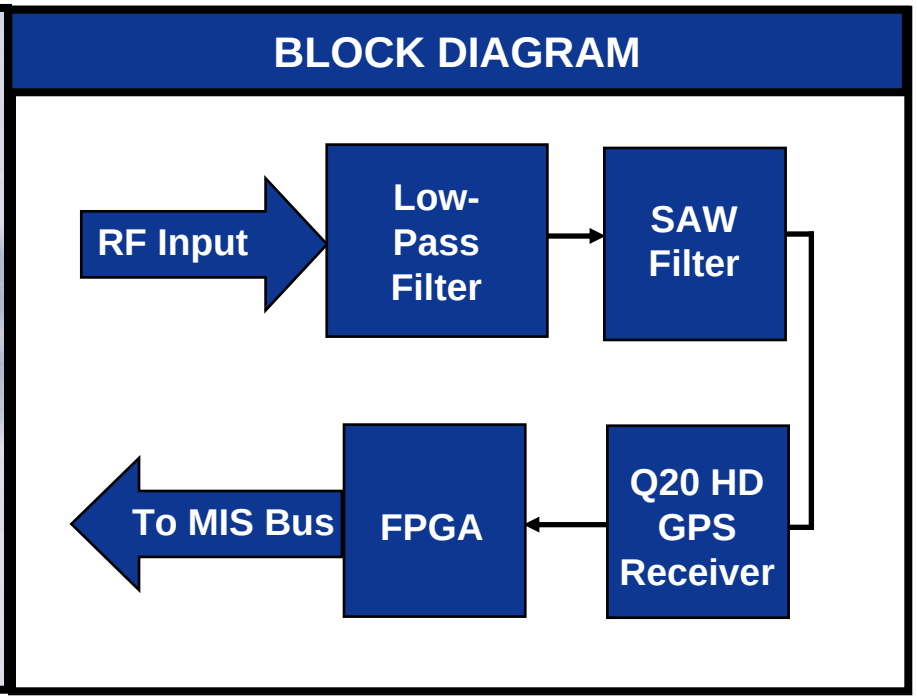
High-Dynamic GPS Receiver Module

High-Performance, State-of-the-Art, Ultra-Compact GPS Unit Providing High-Dynamic Tracking Capability





- Onboard Real-Time GPS Positioning
- Acquisition and Tracking Under Very High Accelerations With Fast Time to First Fix
- High-Accuracy Differential Positioning Capable in Real Time or for Post-Mission Analysis
- High Update Rate: 64 ms

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GPS Operational Configurations

- **GPS Sensor Mode**
  - 8-Hz PVTM Updates (Single-Ended Navigation Solution)
  - 15.625-Hz 8003 Updates (Onboard)
  - 50g+ Acceleration
  - 5000-ft/s Velocity
  - 30-ft 3-ft/s Resolution
  - 5-Satellite Fix in 7 s
- **GPS Navigation Mode**
  - 8-Hz PVTM Updates
  - 15.625-Hz MACM Updates (Onboard)
  - 25g+ Acceleration
  - 5000-ft/s Velocity
  - 40-s Cold Time to First Fix
- **Demonstrated GPS Position Accuracy**
  - Real-Time Position Solution: 10 to 30 m
  - Differential Processing: 5 m
  - Carrier Phase Processing: < 40 cm

Target System Instrumented With MIS Data Logger

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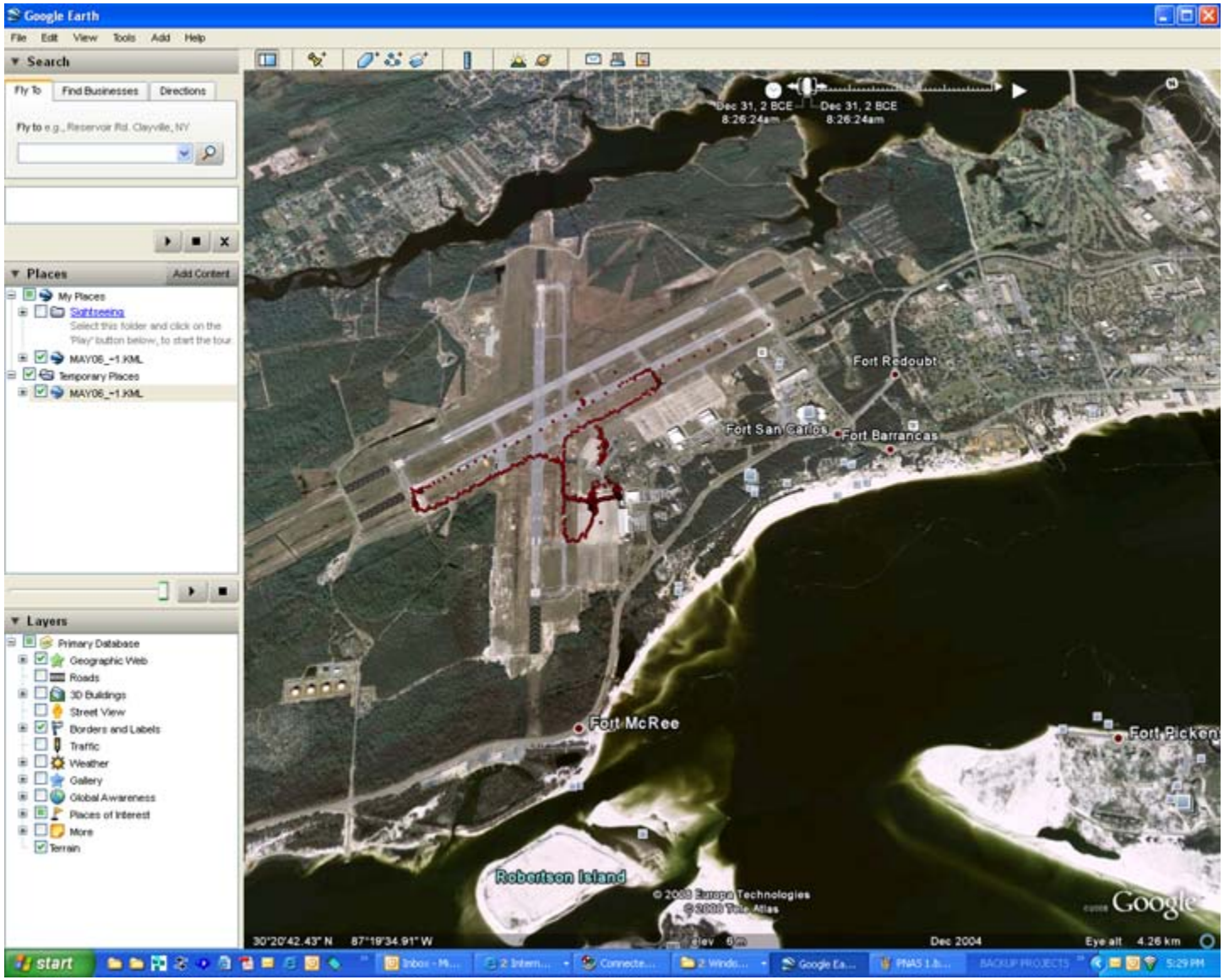
Target System Testing on Gulf Coast



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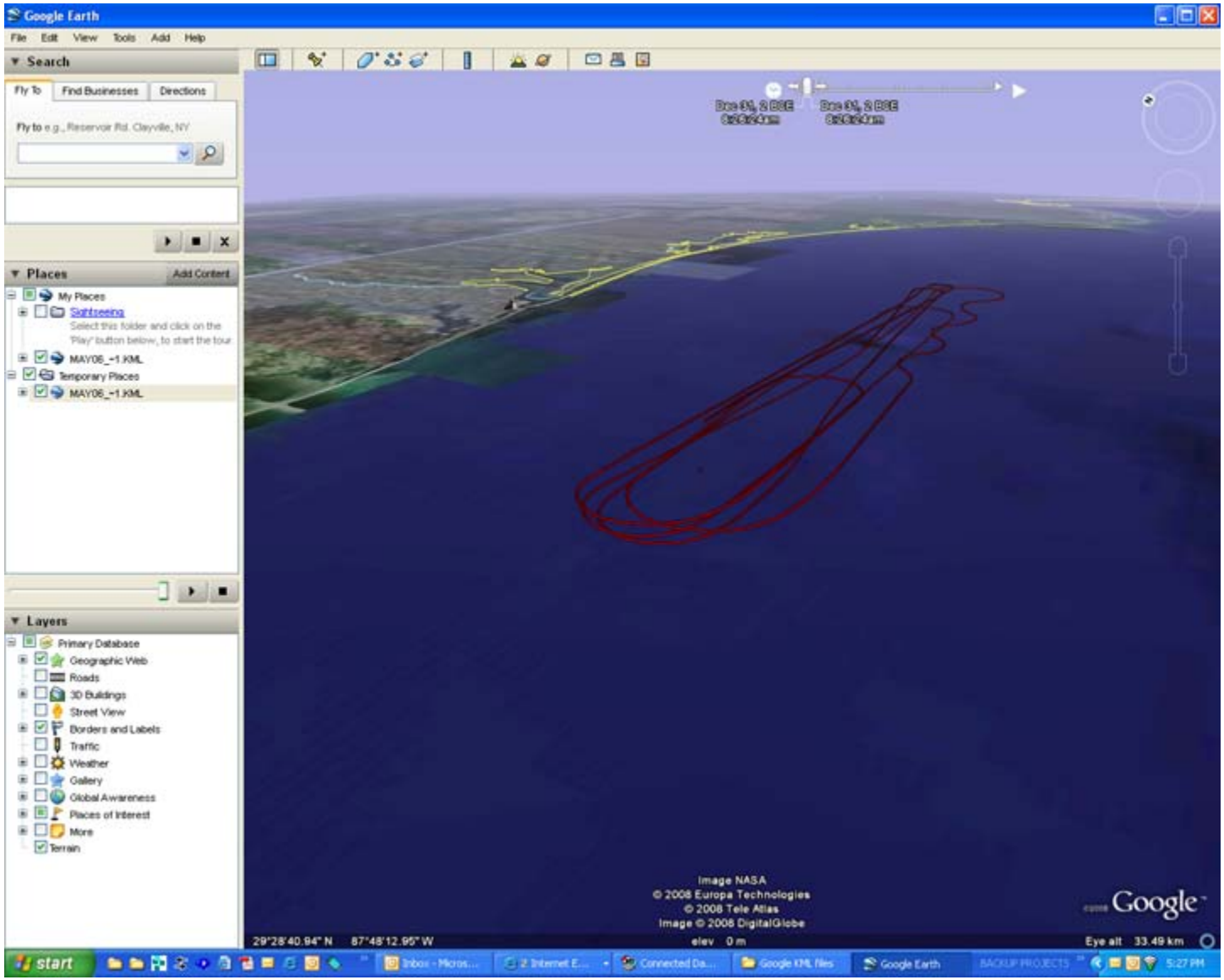
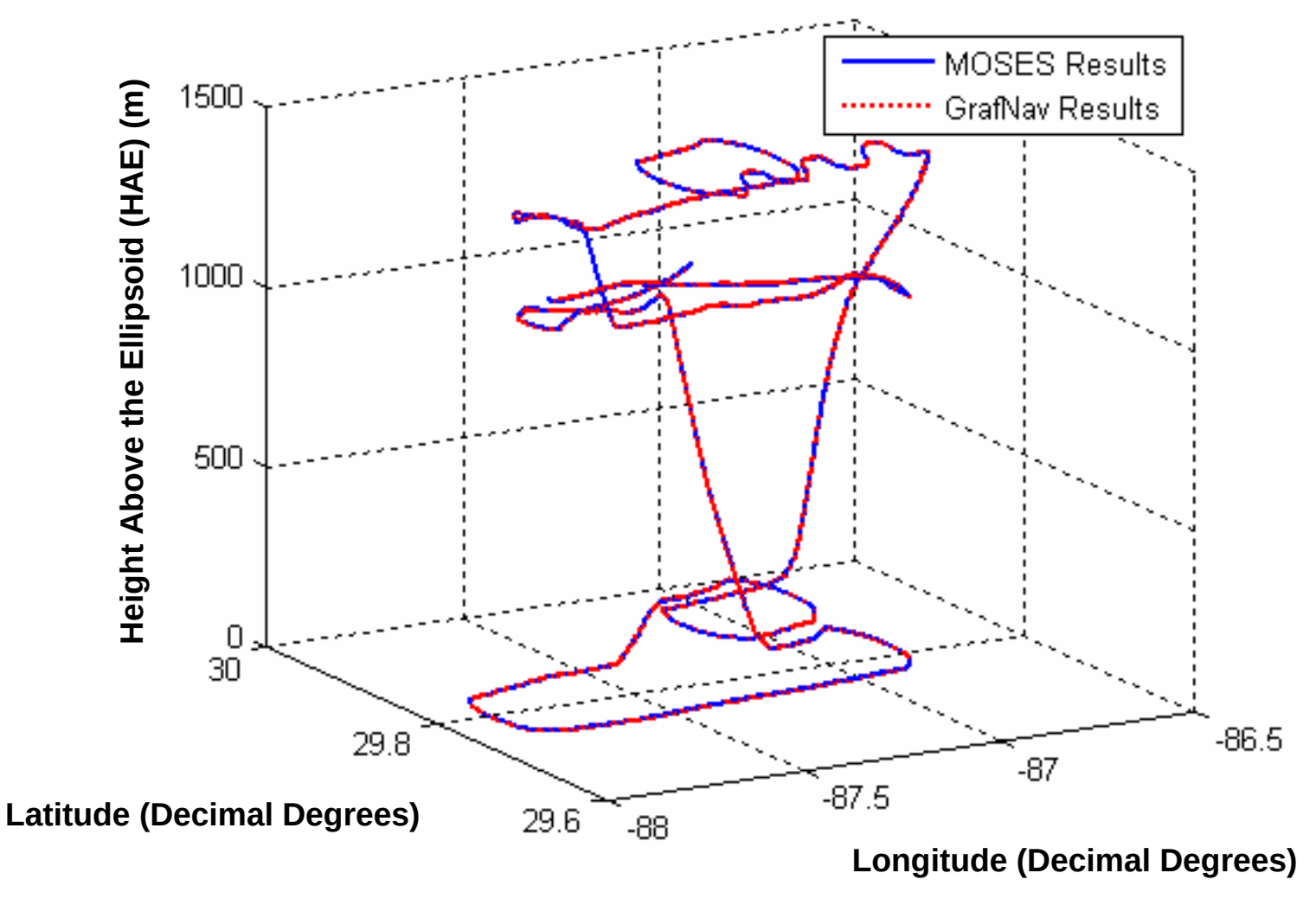
Target System Testing on Gulf Coast (Concluded)



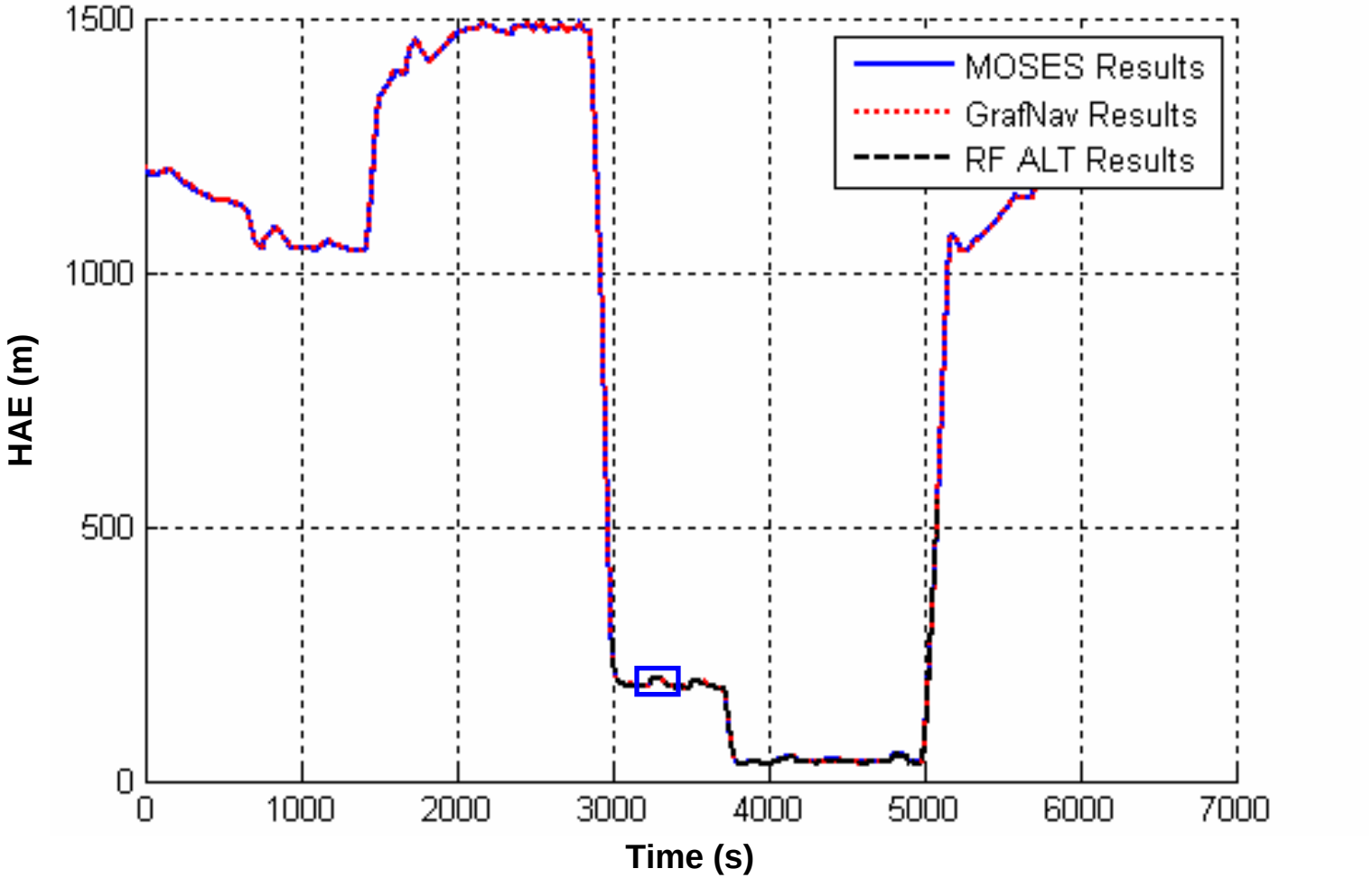
GPS Position Results

Towed Test May 2008 Comparison Results
3D Position



GPS Position Results Versus Radio Frequency (RF) Altimeter (Navigation Mode)

Towed Test May 2008 Comparison Results
HAE
Relative to Reference Antenna
GPS Base Time: 314125.5441 s



GPS Position Results Versus Radio Frequency (RF) Altimeter (Navigation Mode) (Concluded)

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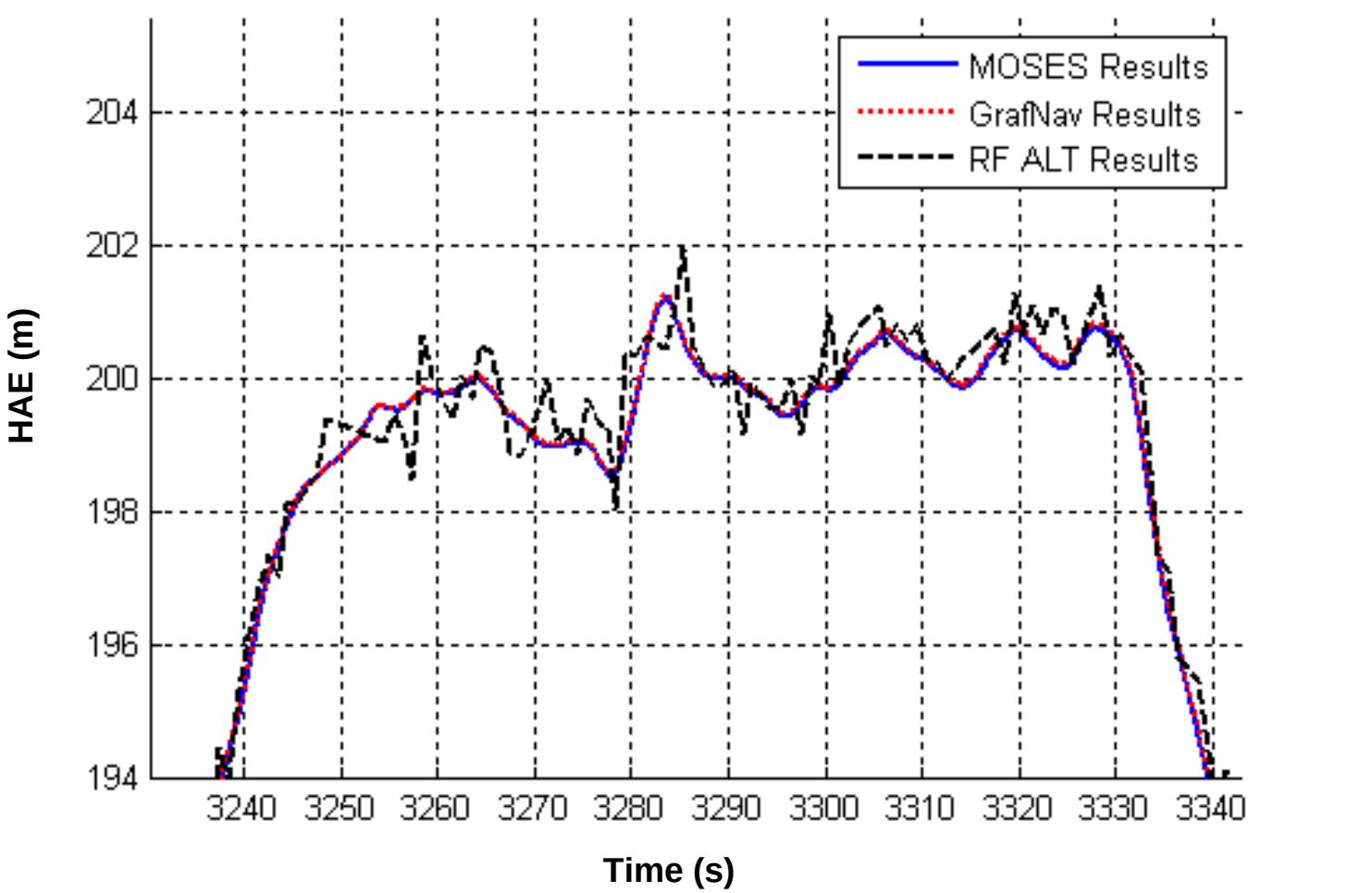
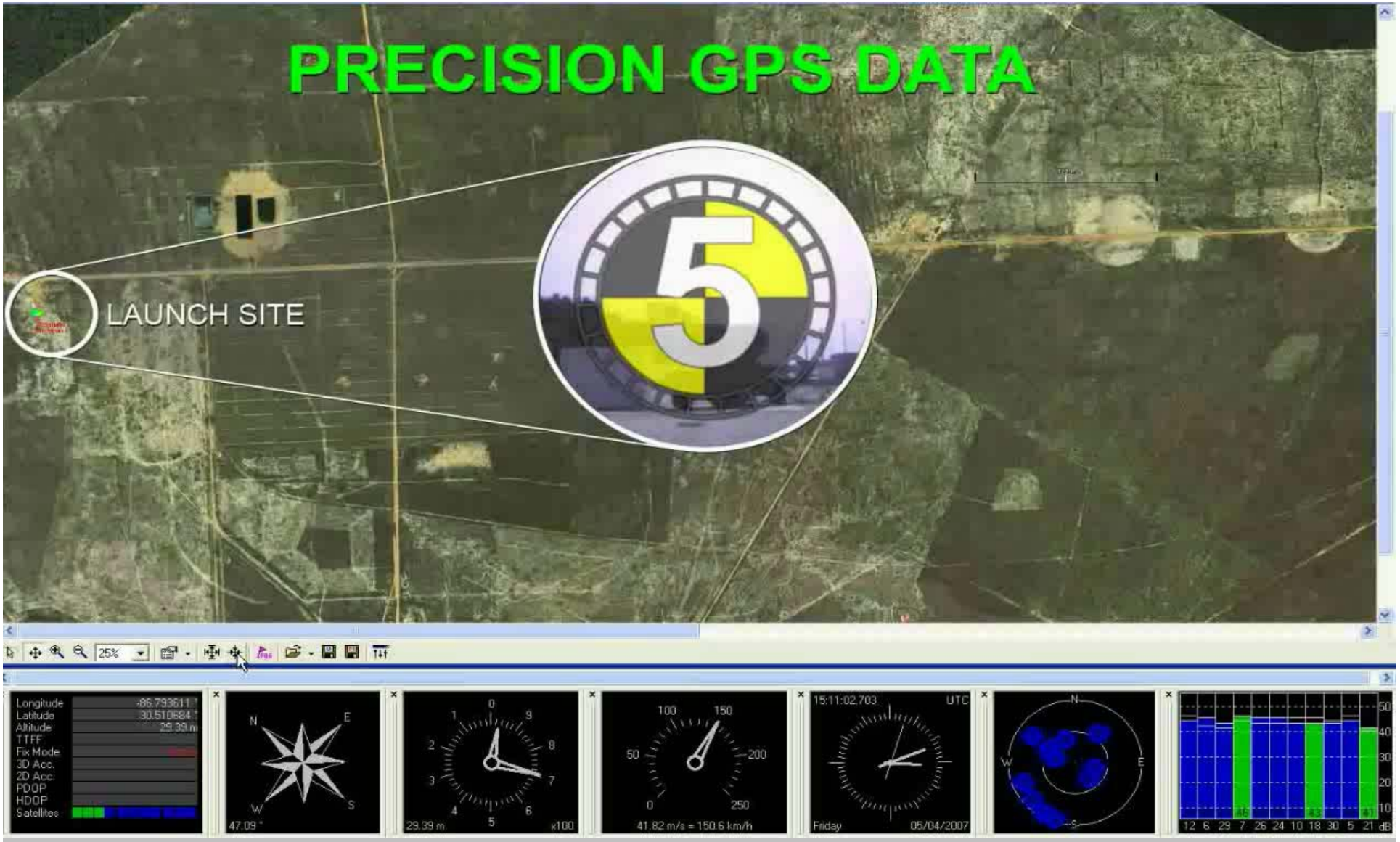


PRECISION GPS DATA



GPS Summary | **Heading** | **Altitude** | **Velocity** | **GPS Time** | **Satellite Constellation** | **Satellite Signal to Noise**

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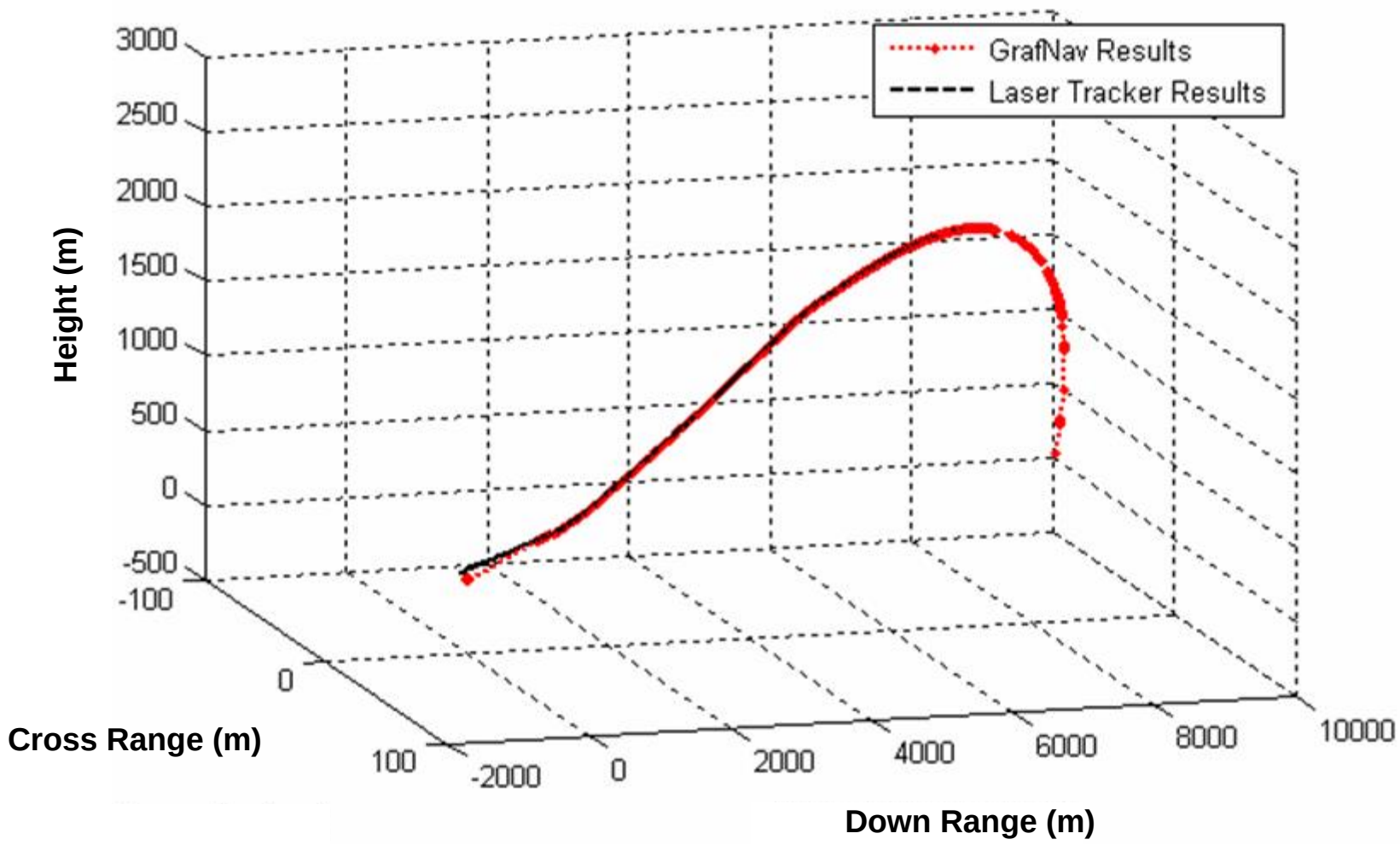
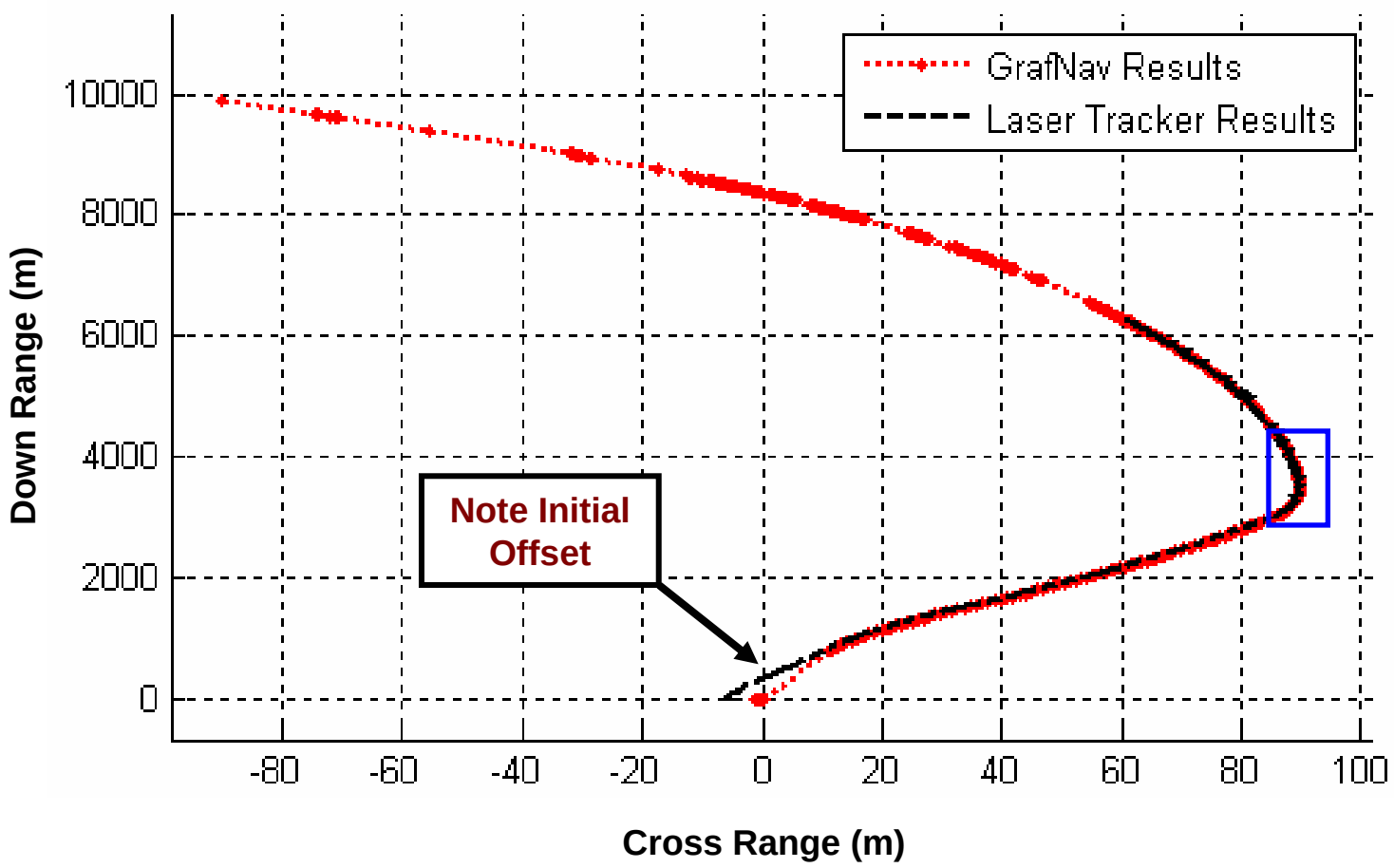
GPS Position Results Versus Laser Tracker Results (Sensor Mode)

Eglin May 2007 Comparison Results
3D Position



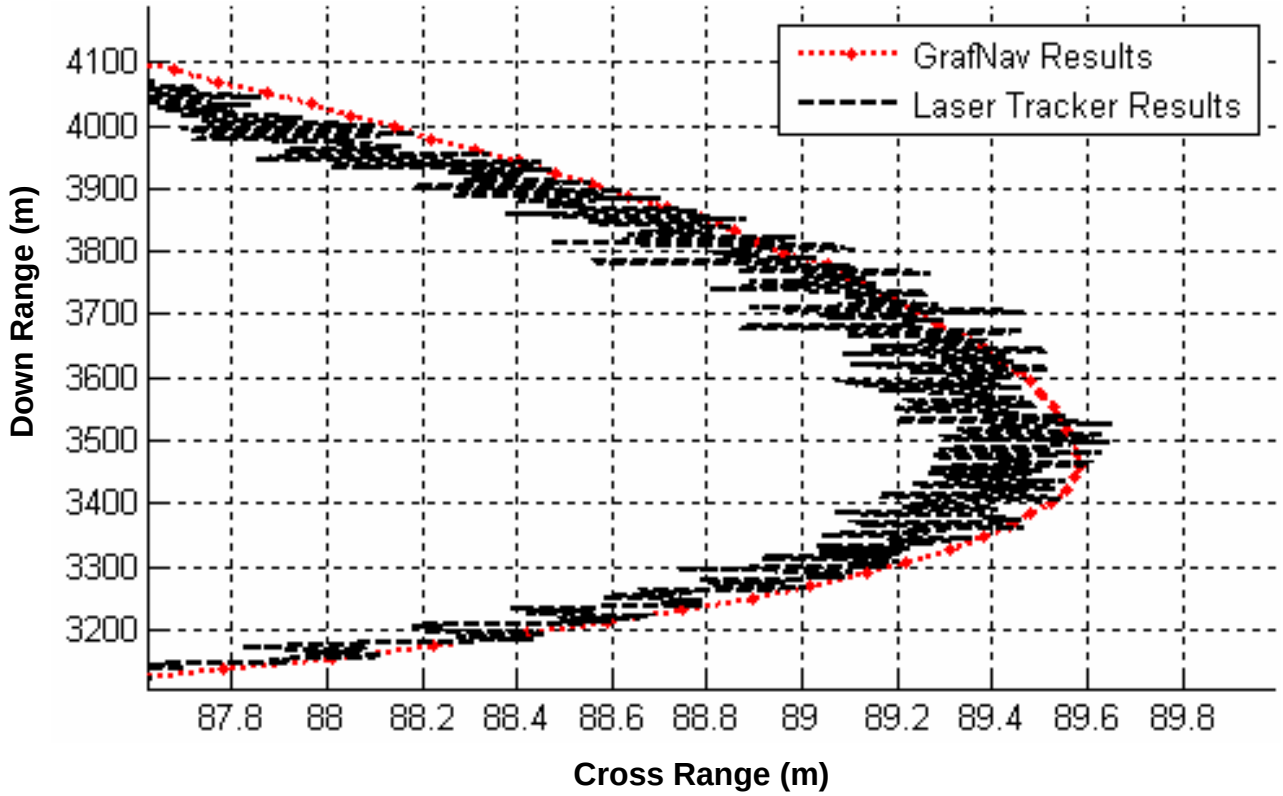
GPS Position Results Versus Laser Tracker Results (Sensor Mode) (Continued)

Eglin May 2007 Comparison Results
Down Range/Cross Range
Relative to Launcher Location



GPS Position Results Versus Laser Tracker Results (Sensor Mode) (Continued)

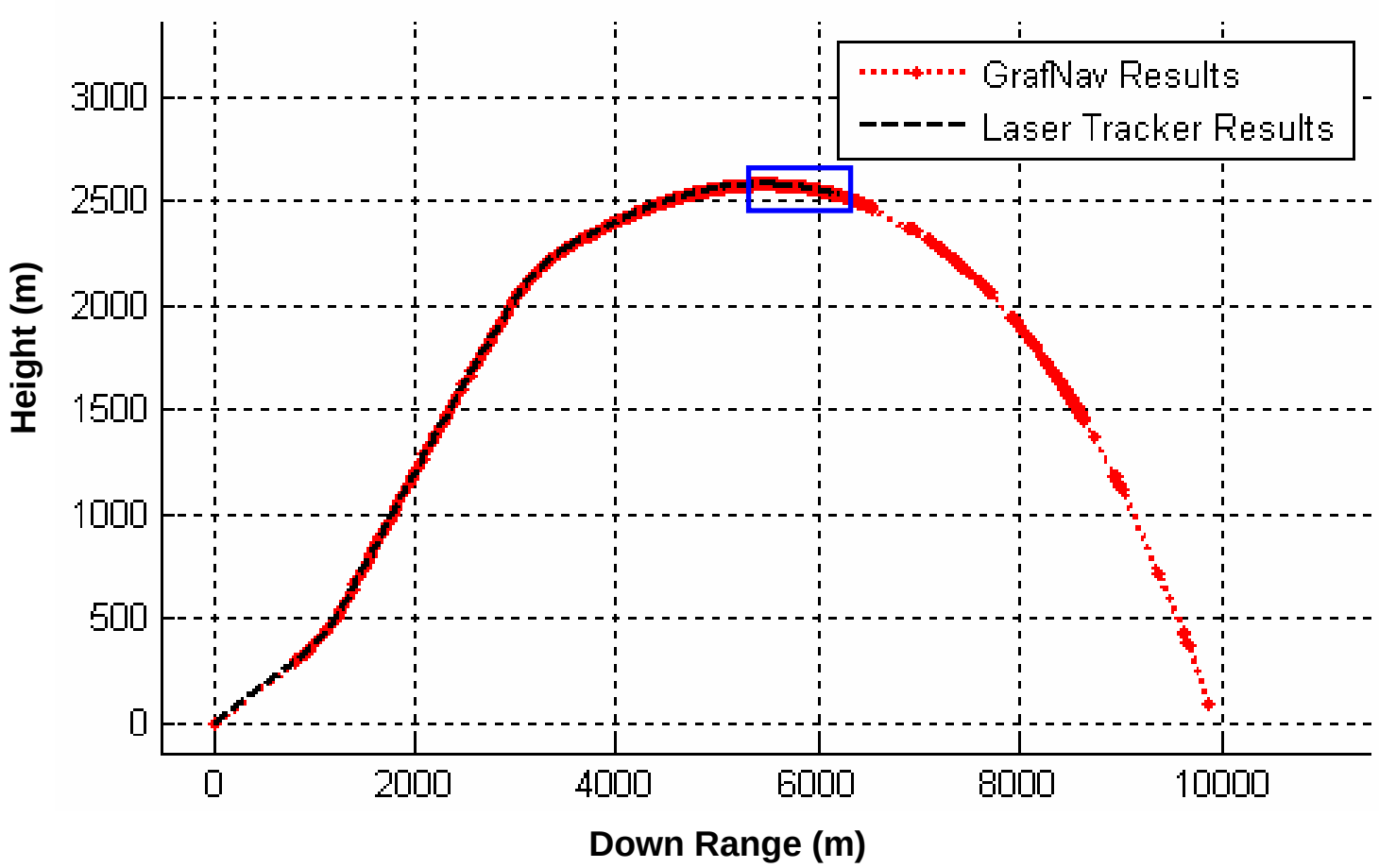
- **For This View:**
  - **Cross-Range Difference > 0.4 m During the Maneuver**
  - **Down-Range Difference = ~1.4 m (Not Easily Seen in This Graph)**



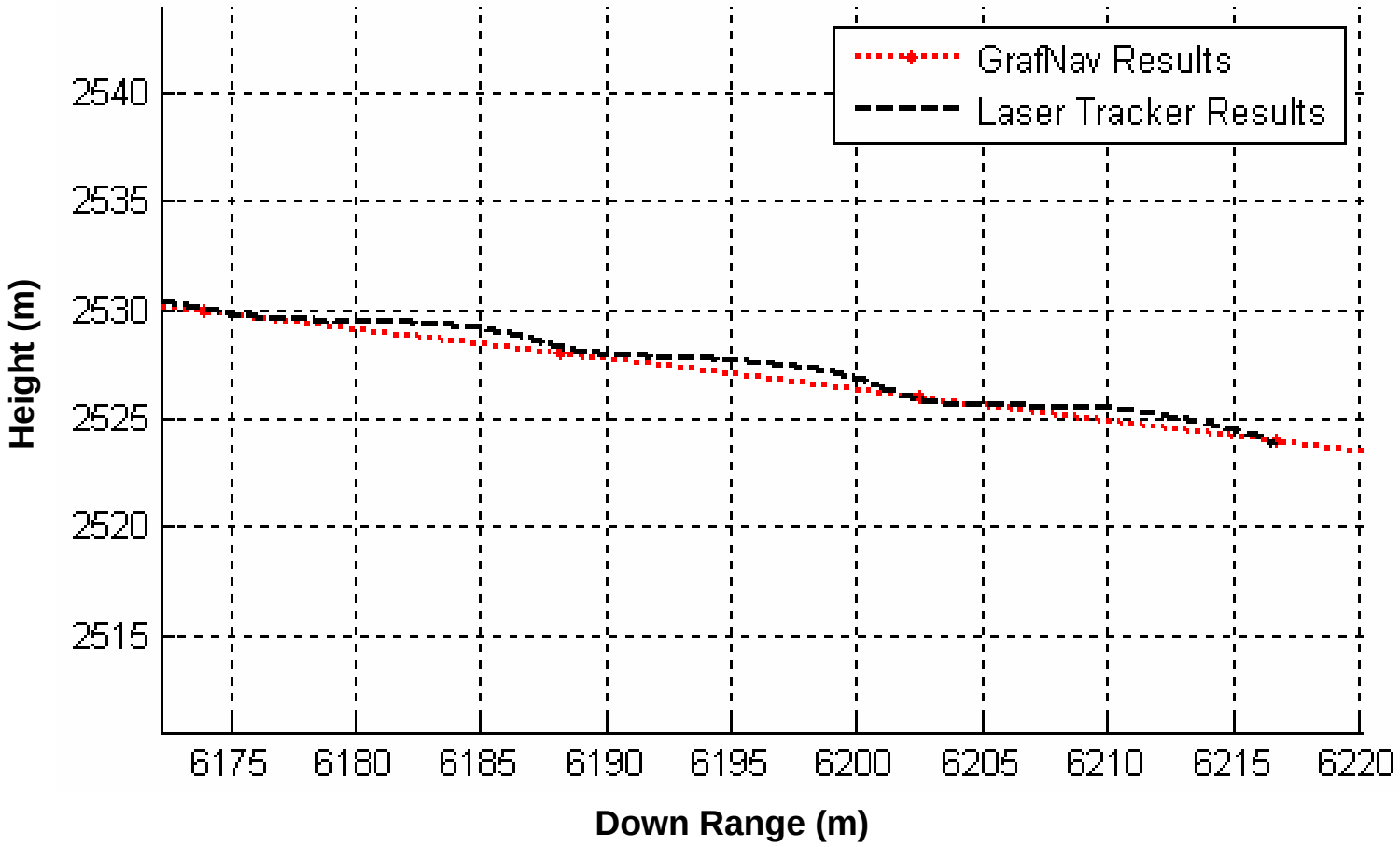
- **For the Entire Data Set:**
  - **Cross-Range Difference: Mean = -0.16 m**
  - **Down-Range Difference: Mean = -0.92 m**

GPS Position Results Versus Laser Tracker Results (Sensor Mode) (Continued)

Eglin May 2007 Comparison Results
Height Versus Down Range
Relative to Launcher Location



GPS Position Results Versus Laser Tracker Results (Sensor Mode) (Concluded)



- **For the Entire Data Set:**
  - **Down-Range Difference: Mean = -0.92 m**
  - **Height Difference: Mean = -1.0947 m**

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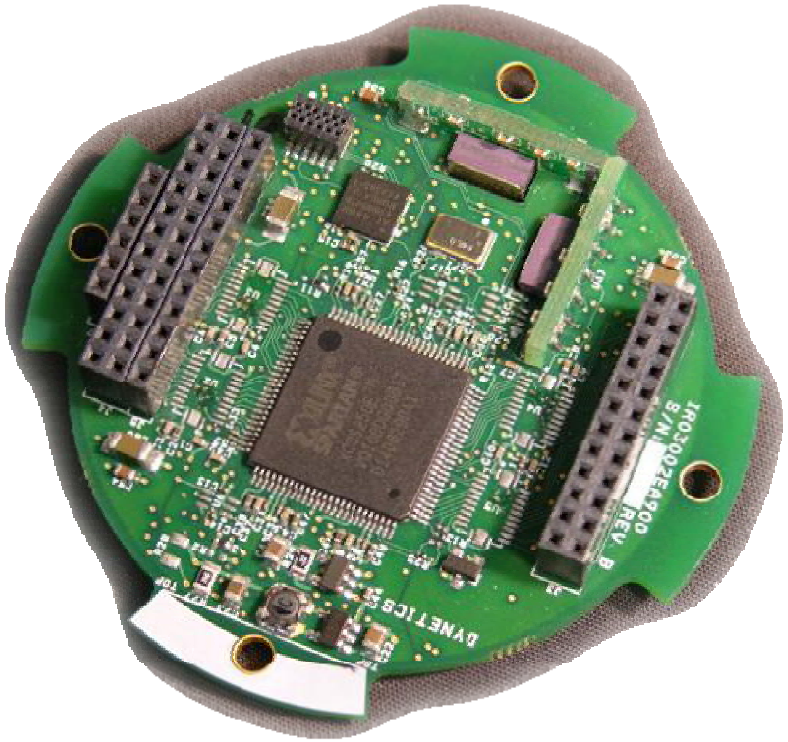
Benefits for Using GPS Over Laser Tracker

- **Operates in Adverse Weather Conditions (e.g., Fog and Rain)**
- **Only Dependent on the Satellite Coverage, Which Is Fairly Reliable**
  - Requires at Least Six Satellites for Carrier-Phase Processing
  - Satellite Coverage Is Predicable; Therefore, Test Scheduling Can Be Determined in Advance
- **Technology Is Capable of Regaining Track After Loss**
  - Has Been Demonstrated in Results
- **Tracking Range Only Limited by RF Link Capabilities of the Telemetry Stream**
- **Relatively Inexpensive Ground Station Equipment**
  - Makes Having Redundant Equipment Possible, Which Allows for More Reliable Data Collection or Support for Multiple Test Locations if Required
- **Minimal Additional Personnel to Support Collection**
  - Telemetry Team and Equipment Already There to Support Test
  - One Person Can Perform GPS Responsibilities for Mission and Post-Mission Tasks

IMU Module



- **Linear Acceleration**
  - 3-Axis
  - Lateral Accelerations (Dual Range)
    - ±35 and ±50 g
  - Axial Accelerations (Dual Range)
    - ±10, ±25, ±50, and ±100 g
- **Roll Rate to 20,000 deg/s**
- **Angular Rate Sensor**
  - 3-Axis
  - ±300-deg/s Range
- **Magneto-Resistive Sensor**
  - 3-Axis
  - ±6 Gauss
- **Signal Processing**
  - CPLD – Address Decoding
  - A/D Converter – 12 Bit

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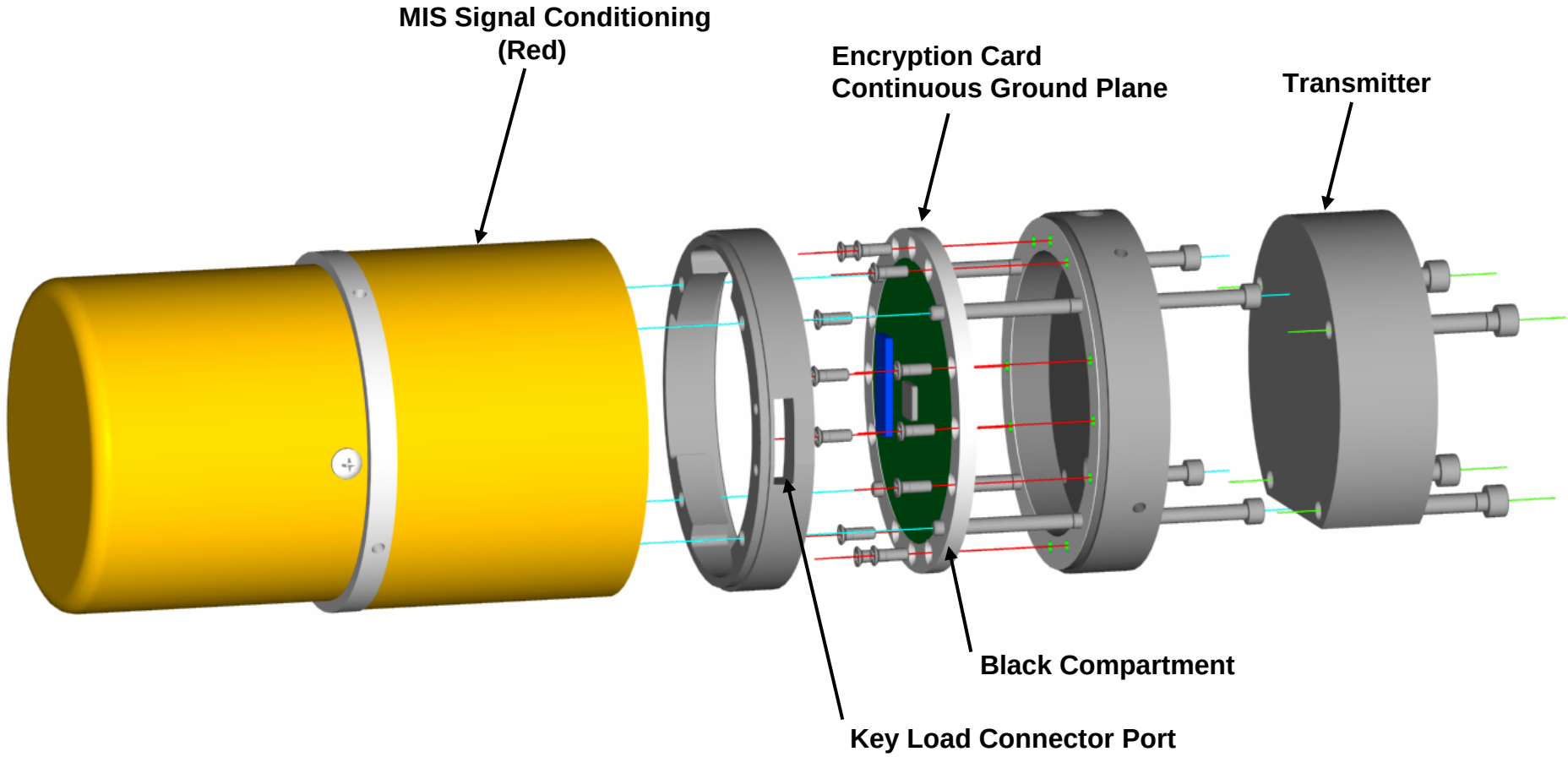
Encryption Capability



MIS With Encryption

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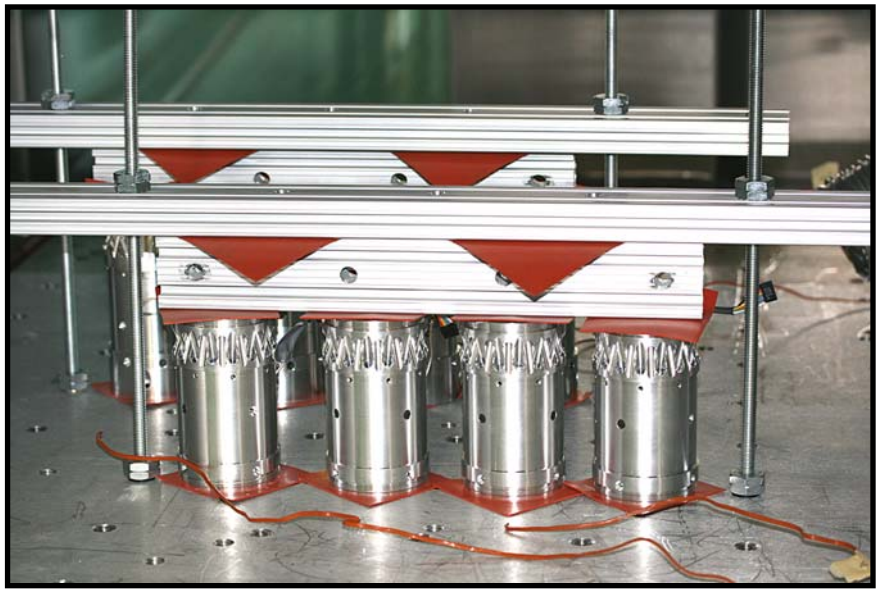
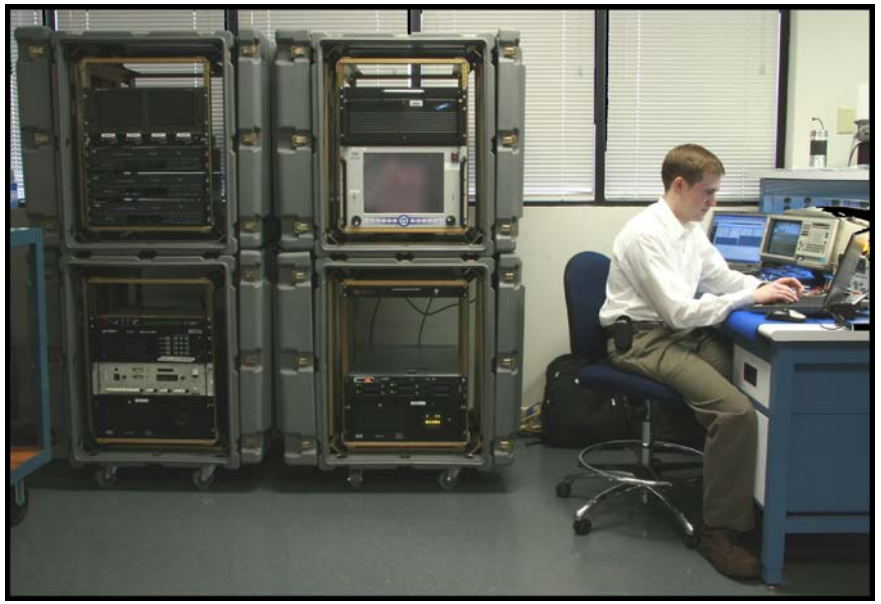
Telemetry Fabrication, Calibration, and Test





Telemetry and Instrumentation Ground Receiver Station (TIGRS) Van

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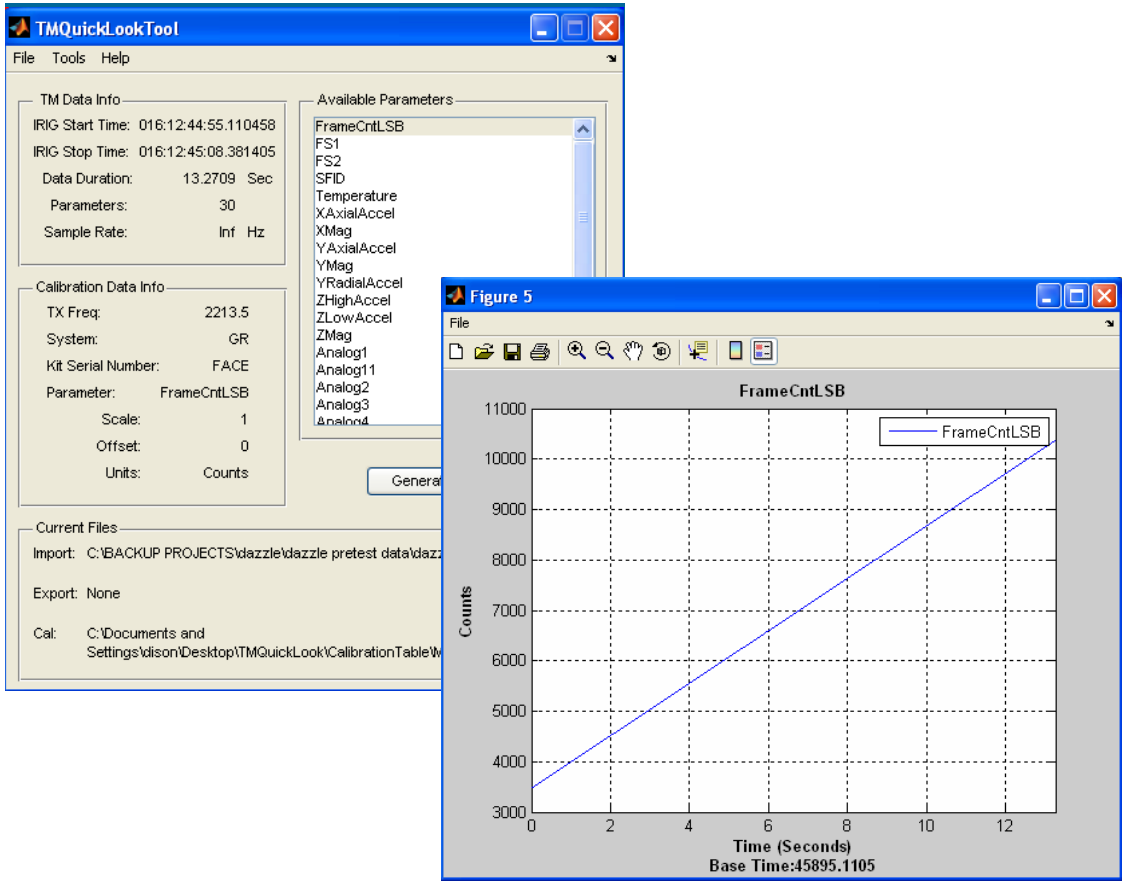
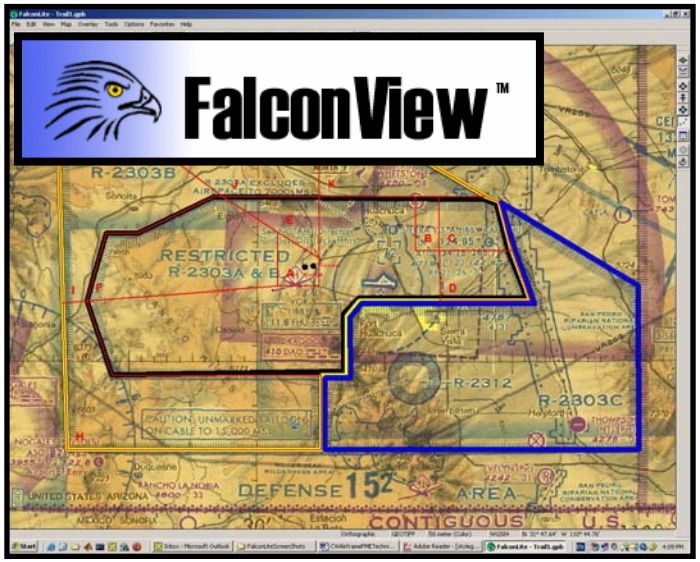
Post-Test Data Viewer

Real-Time and Post-Mission Performance Monitoring Is Critical for System Evaluation

- Matlab-Based Rapid Data Display
- Multiple Channels
- Optional TENA Compliant Real-Time Networked Data Display



UAV Instrumentation: OATIS

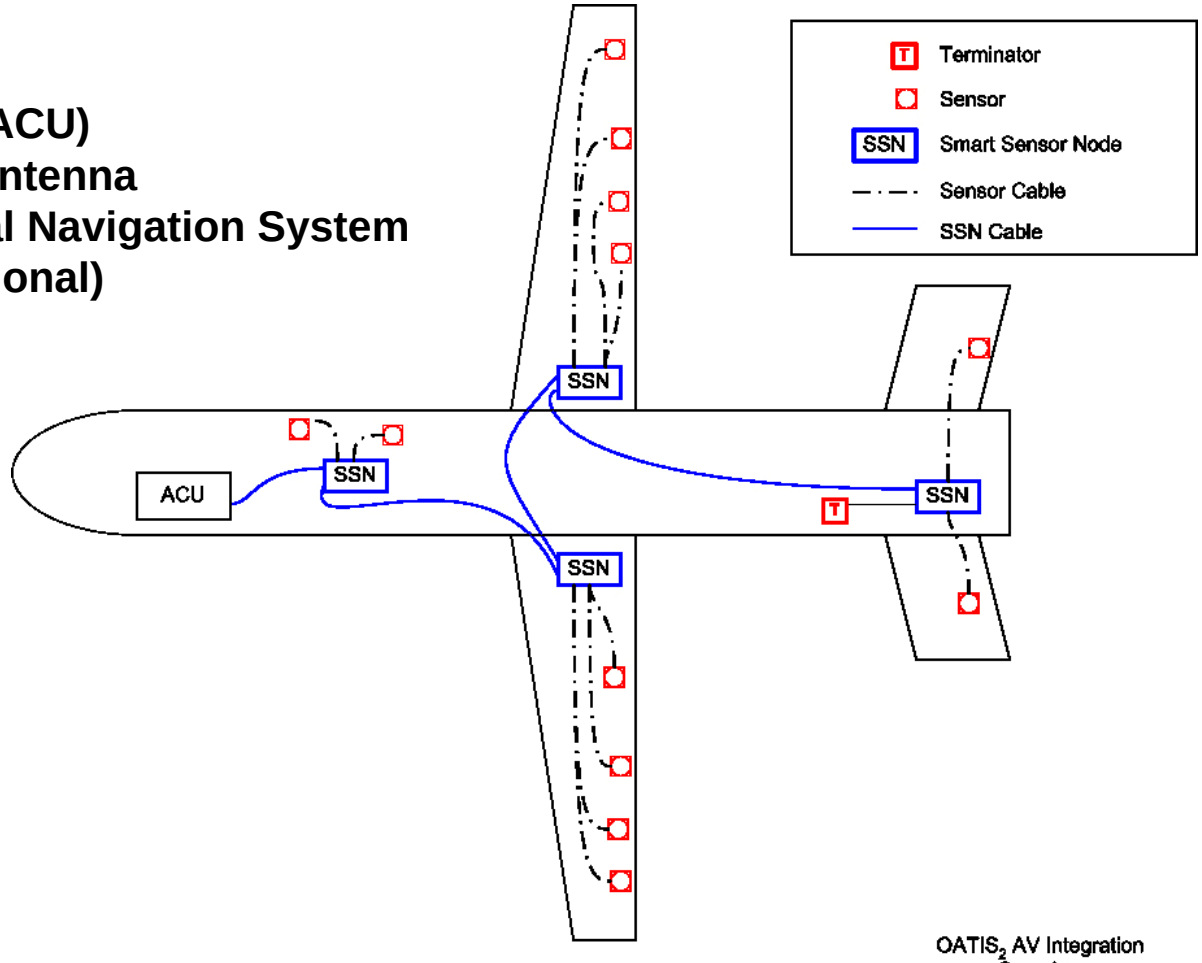


OATIS

- **OATIS Is a Modular System Designed to Make, Log, and Transmit Inertial and Various Other Measurements to a Ground Station**

- **Airborne Payload**
  - Airborne Control Unit (ACU)
  - RF Modem and Blade Antenna
  - C-MIGITS III GPS/Inertial Navigation System (INS) and Antenna (Optional)
  - Smart Sensor Nodes

- **Ground Station**
  - Ground Station Server
  - Control Panel
  - Moving Map Display
  - Strip Charts

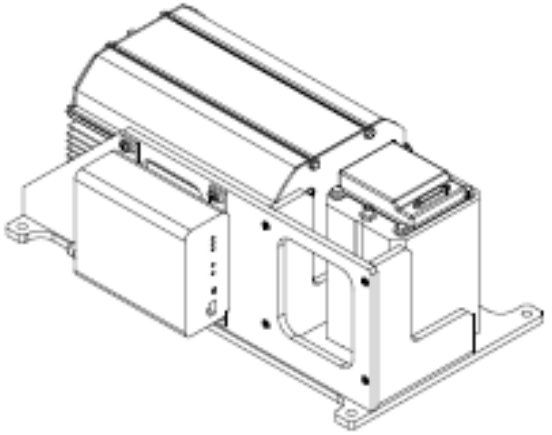


OATIS$_2$ AV Integration
Overview
5jan2005 mpw

OATIS: Airborne Components

C-MIGITS III GPS/INS

ACU



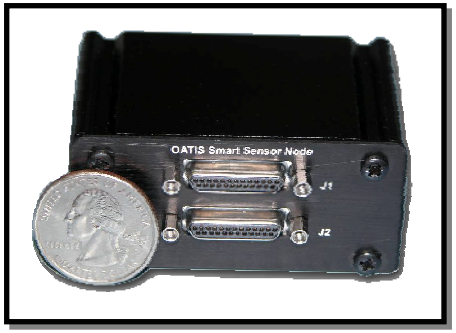
Equipment Tray

Microhard Modem

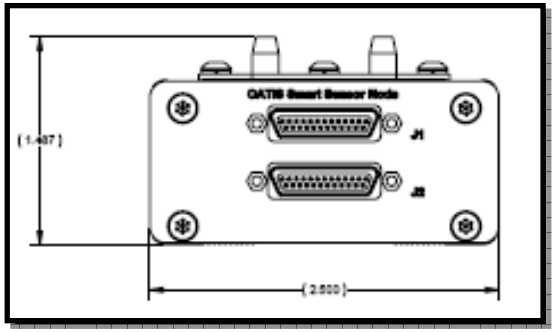
Smart Sensor Nodes

Smart Sensor Node Family of Products

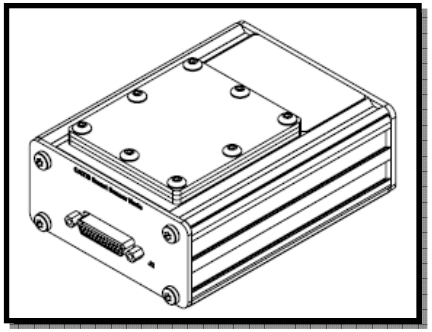
Nodes



Standard Node (-10)



Air Pressure Node (-50)



Thermocouple Node (-60)

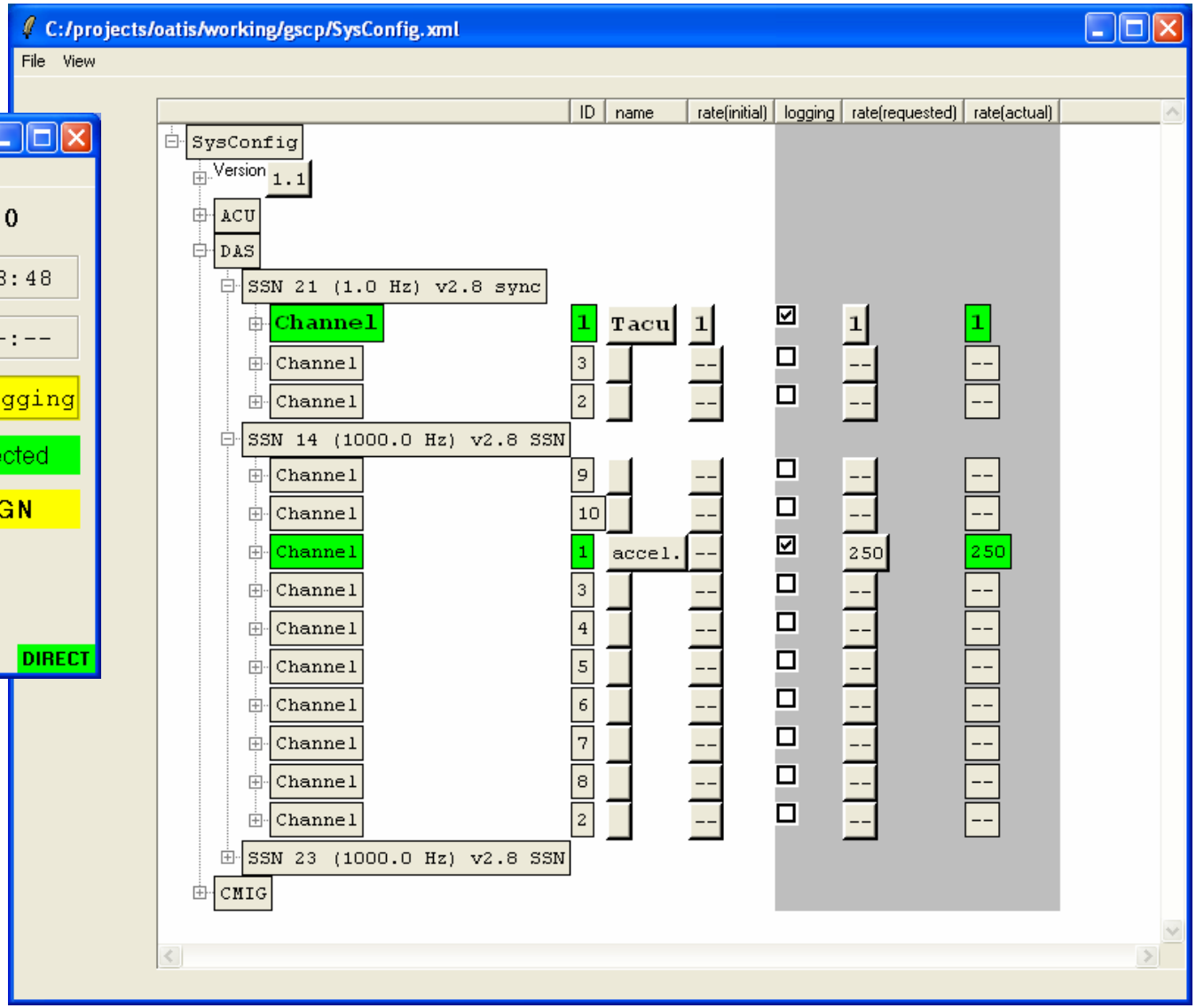
Sensors

Measurement Type	Examples	Sensor Type	Typical Rate (Hz)
Air Pressure	Air Speed, Altitude	Pressure Transducers (Absolute and Differential)	20
Temperature	Ambient Temperature, OAT	Thermister	5
Temperature	Engine Exhaust, Engine Block	Thermocouple	5
Flow Rate	Fuel Flow	Flow Meter	20
Position	Throttle Position, Control Surface Deflection	String-Potentiometer	100
Acceleration	Vibration	Accelerometer	1000
Pulse Frequency	RPM Pickup From Spark Plug	(Built-in)	10

OATIS: Ground Station Software

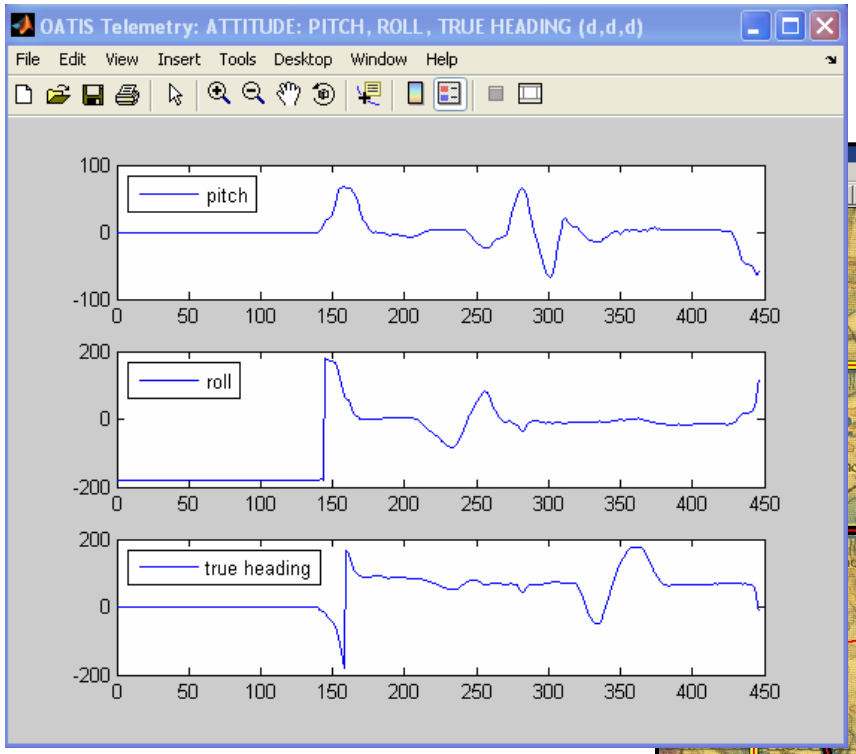
Control Panel

Configuration Editor

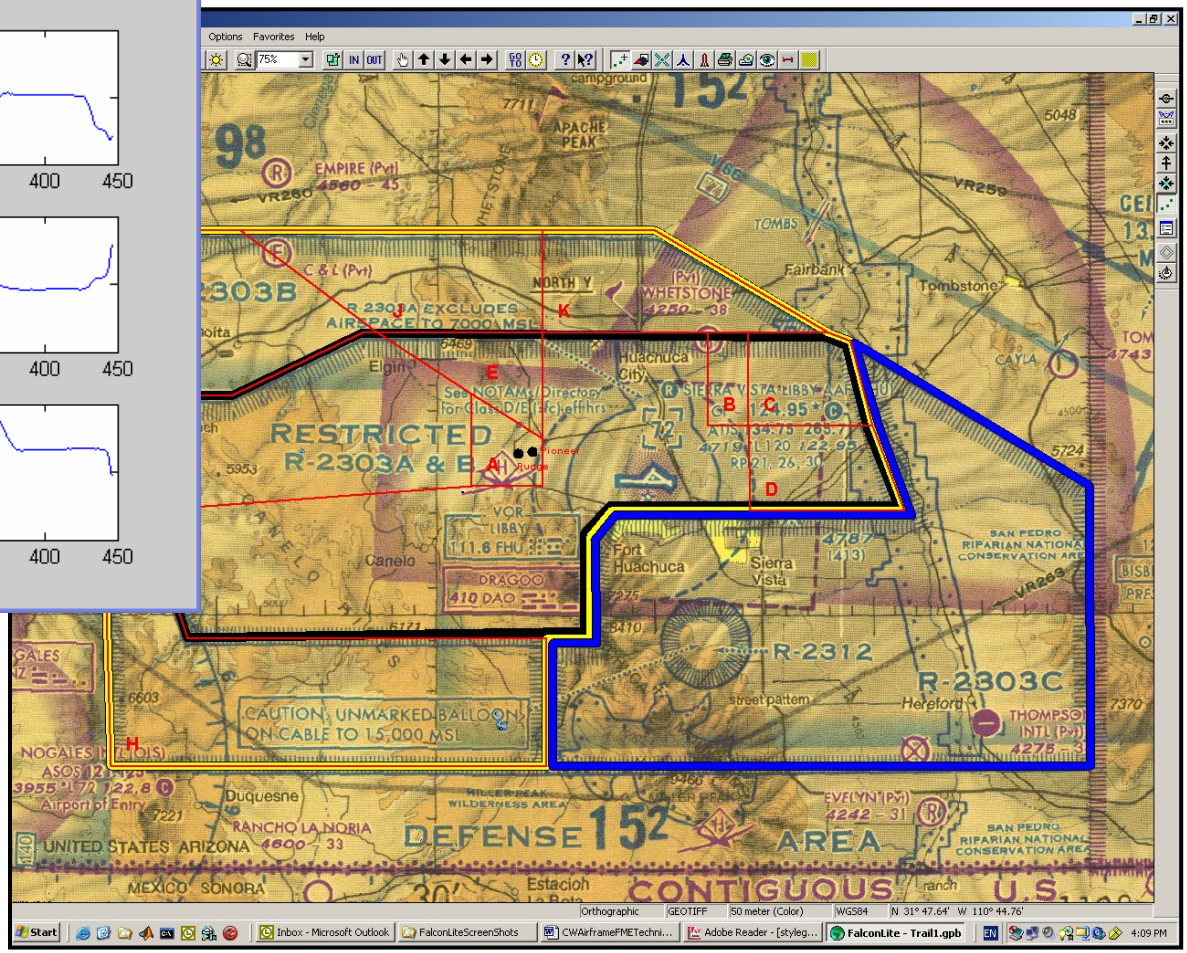


OATIS: Situational Awareness

Real-Time Strip Charts



Real-Time Moving Map Display (FalconView)



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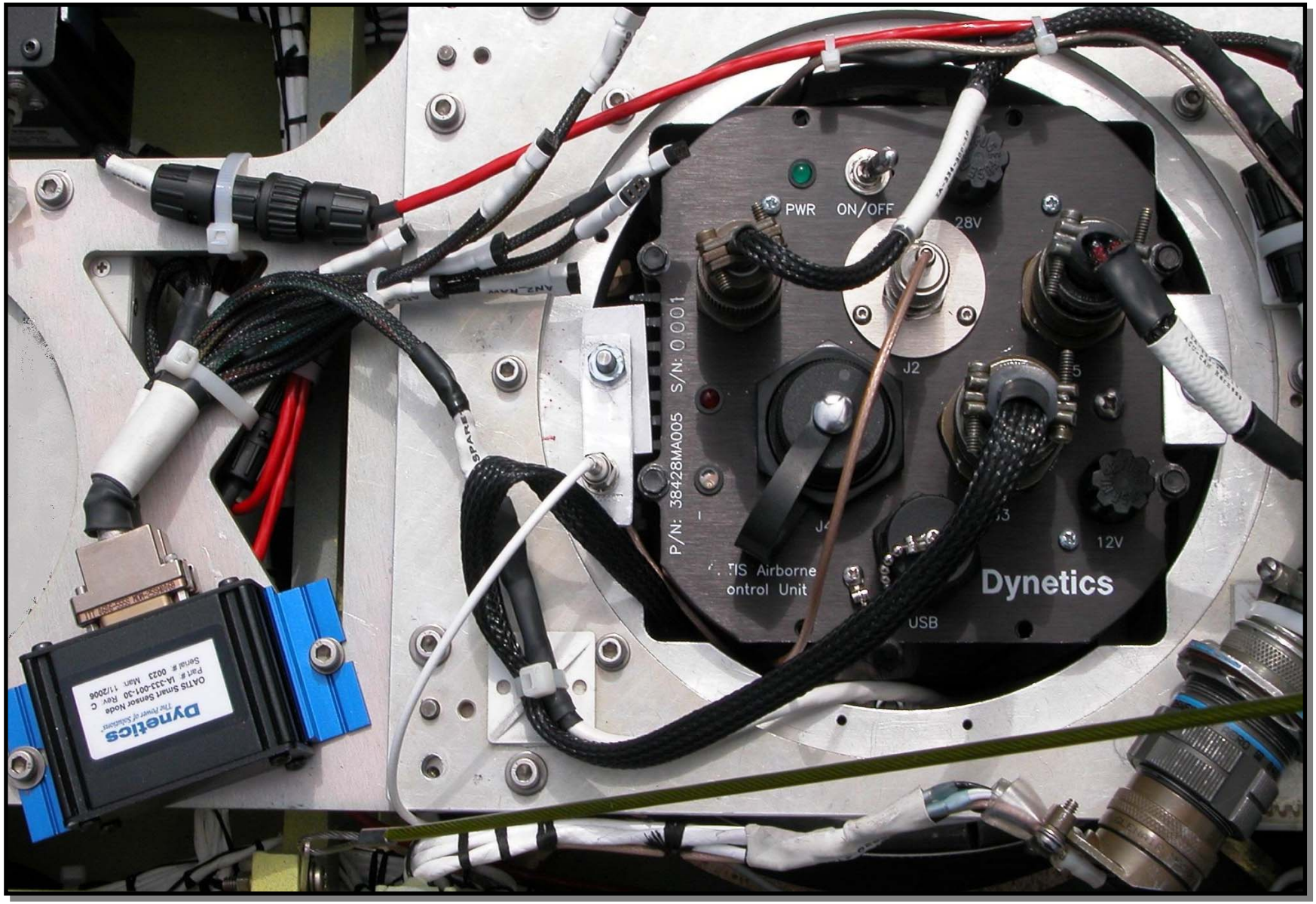
Complete OATIS System Installed

OATIS Installed



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Comparison of MIS and OATIS Systems

Parameter	MIS System	OATIS System
Size	2.5” Diameter x 3” Length	8” Length x 7” Diameter
Weight	< 1lb	5 lbs
Downlink Data Rates	10 Mbits/s	115 kbits/s
Downlink Protocol	IRIG 106, 1-Way	Commercial, 2-Way
Range	2 to 50 km	100 km, Omnidirectional
Encryption Type	Tactical	Commercial
Onboard Memory	8 GB/Board	4 to 32 GB
Operational Environments	High G	Flight Tests
Typical Applications	Missiles, Targets, and Sled Testing	UAVs and Manned Aircraft

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Future System Enhancements

- **MIS System**
  - MIL-STD-1553 Interface Card Development
  - Enhanced Encoder Card Development
  - Graphical User Interface (GUI) Development
  - Qualification Testing of Encryption Module
  - Expanded Analog Conditioning Module
- **OATIS System**
  - Enhanced Signal Conditioning Capability
  - Onboard FFT Capability
  - Reduced System Size and Weight

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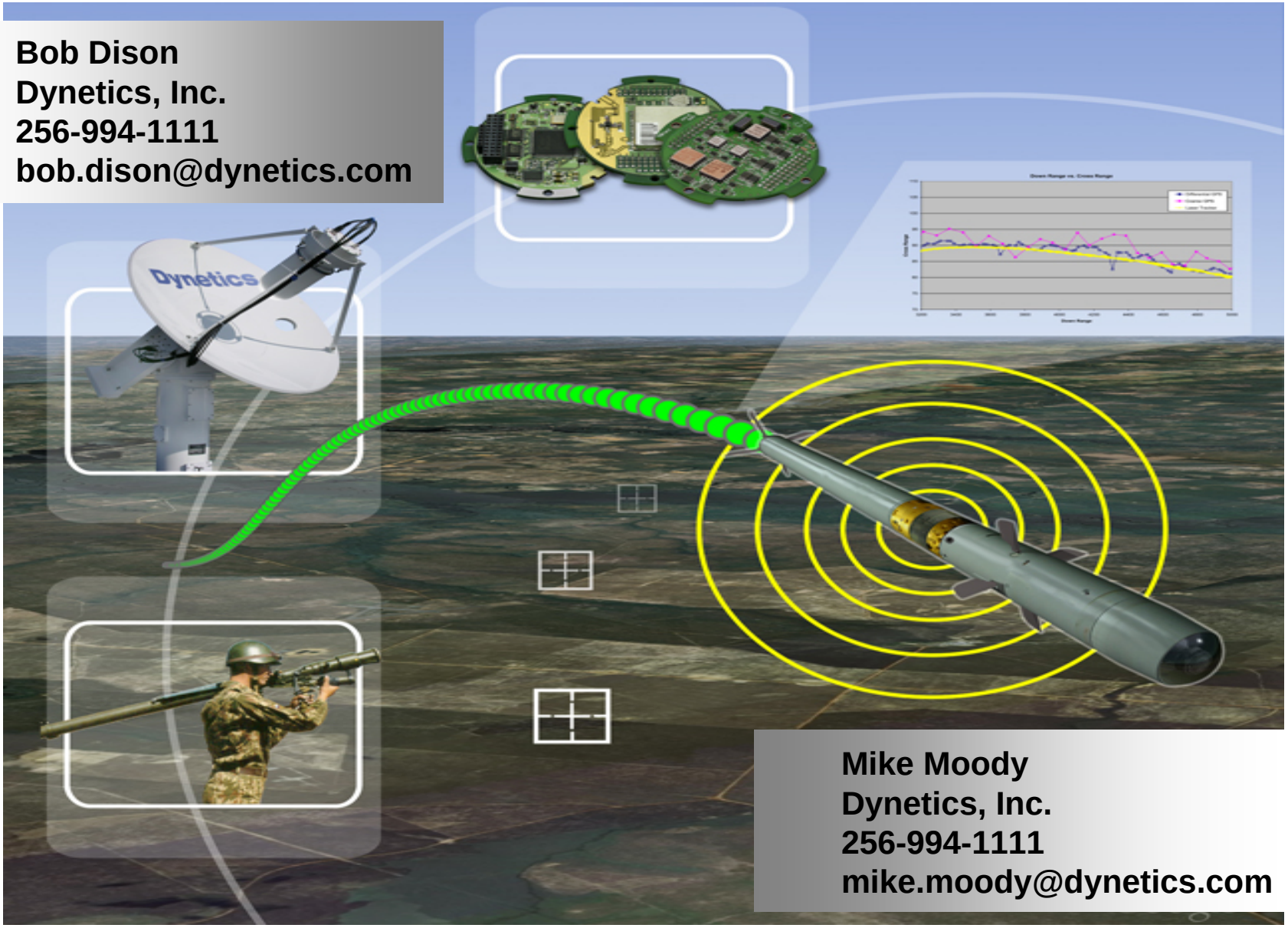
Summary

- **Dynetics Has a Long History of Supporting Flight Tests for Weapons, Targets, and UAVs**
  - Over 50 Missile Shots on 10 Different Platforms With Latest MIS System
  - Over 70 MIS Systems Planned for Delivery During the Next Year
  - Over 450 hrs of Flight Testing on 4 Different Platforms With OATIS
- **From This Experience, We Have Developed Two Distinct Telemetry Systems**
  - OATIS for Applications Where Space and Weight Can Be Traded Off for Flexibility
  - MIS for Applications Where Space, Range Standards, and Data Rates Are the Driving Factors
- **New Applications May Be Addressed by Either OATIS, MIS, or a Hybrid Mix**
- **Dynetics Has Significantly Invested in Redundant Ground Collection Equipment and Offers These Services for Flight Tests**

Points of Contact for MIS



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