46th Annual Targets, UAVs, and Range Operations Symposium

Telemetry Solutions for Targets and Unmanned Aerial Vehicles (UAVs)

John Watson
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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

Reduced SWaP
Reliable and Flexible
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

The Evolution of Dynetics’ MIS Program

Medium- and Long-Range Missile Telemetry Systems

2003 Development of Miniaturized System

MANPADS Testing Occurs

Data Logger Developed

Encryption Module Developed

Ground Support Station

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

DHS Orders 40+ Telemetry Systems

Army ASE ~40 Telemetry/GPS

Control Test Vehicle (CTV) Developed

Backup Telemetry Collection Role

1990
Modular Telemetry System

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

Integrated IMU Module
Radar Instrumentation With Fiber Optic Input/Output
Integrated GPS Module

Missile Telemetry With Integrated Antennas

Battery
Control and Data Input
USB 2.0 Port
Status Indicator
Record Button

MIS 1216 Data Logger

Ring Laser Gyroscope Module

2.5 in. Dia.

MIS Electronics

Rocketball Data Logger

Modular Telemetry System

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Enhanced IMU Module
Basic and Enhanced Encoder Module
Multipurpose Serial Input/Output Module
High-Dynamic GPS Module
Encryption Module
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
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
Target System Testing on Gulf Coast
Target System Testing on Gulf Coast (Concluded)
GPS Position Results

Towed Test May 2008 Comparison Results
3D Position
Towed Test May 2008 Comparison Results
HAE
Relative to Reference Antenna
GPS Base Time: 314125.5441 s

MOSES Results
GrafNav Results
RF ALT Results
Towed Test May 2008 Comparison Results
HAE
Relative to Reference Antenna
GPS Base Time: 314125.5441 s
PRECISION GPS DATA

GPS Summary

Heading

Altitude

Velocity

GPS Time

Satellite Constellation

Satellite Signal to Noise

Dynetics
The Power of Solutions

LAUNCH SITE
Eglin May 2007 Comparison Results
3D Position

Cross Range (m) vs. Height (m) vs. Down Range (m)

- Red dotted line: GrafNav Results
- Black dashed line: Laser Tracker Results
Eglin May 2007 Comparison Results
Down Range/Cross Range
Relative to Launcher Location

Note Initial Offset
• 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
Eglin May 2007 Comparison Results
Height Versus Down Range
Relative to Launcher Location
• For the Entire Data Set:
  - Down-Range Difference: Mean = -0.92 m
  - Height Difference: Mean = -1.0947 m
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
• 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 Signal Conditioning (Red)

Encryption Card Continuous Ground Plane

Transmitter

Black Compartment

Key Load Connector Port
MIS With Encryption
Telemetry Fabrication, Calibration, and Test
Post-Test Data Viewer


• Matlab-Based Rapid Data Display
• Multiple Channels
• Optional TENA Compliant Real-Time Networked Data Display
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UAV Instrumentation: 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
Smart Sensor Node Family of Products

Nodes

- Standard Node (-10)
- Air Pressure Node (-50)
- Thermocouple Node (-60)

Sensors

<table>
<thead>
<tr>
<th>Measurement Type</th>
<th>Examples</th>
<th>Sensor Type</th>
<th>Typical Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Pressure</td>
<td>Air Speed, Altitude</td>
<td>Pressure Transducers (Absolute and Differential)</td>
<td>20</td>
</tr>
<tr>
<td>Temperature</td>
<td>Ambient Temperature, OAT</td>
<td>Thermister</td>
<td>5</td>
</tr>
<tr>
<td>Temperature</td>
<td>Engine Exhaust, Engine Block</td>
<td>Thermocouple</td>
<td>5</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>Fuel Flow</td>
<td>Flow Meter</td>
<td>20</td>
</tr>
<tr>
<td>Position</td>
<td>Throttle Position, Control Surface Deflection</td>
<td>String-Potentiometer</td>
<td>100</td>
</tr>
<tr>
<td>Acceleration</td>
<td>Vibration</td>
<td>Accelerometer</td>
<td>1000</td>
</tr>
<tr>
<td>Pulse Frequency</td>
<td>RPM Pickup From Spark Plug</td>
<td>(Built-in)</td>
<td>10</td>
</tr>
</tbody>
</table>
OATIS: Ground Station Software

Control Panel

Configuration Editor
OATIS: Situational Awareness

Real-Time Strip Charts

Real-Time Moving Map Display (FalconView)
Complete OATIS System Installed
OATIS Installed
## Comparison of MIS and OATIS Systems

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