

A photograph of a missile launch. A large, dark, billowing plume of smoke and vapor rises from the base of the missile. The missile itself is visible in the center, with a smaller, more defined plume of smoke trailing behind it as it moves forward. The background is a clear, light blue sky.

Electronic Test Fuze

Hamish Malin

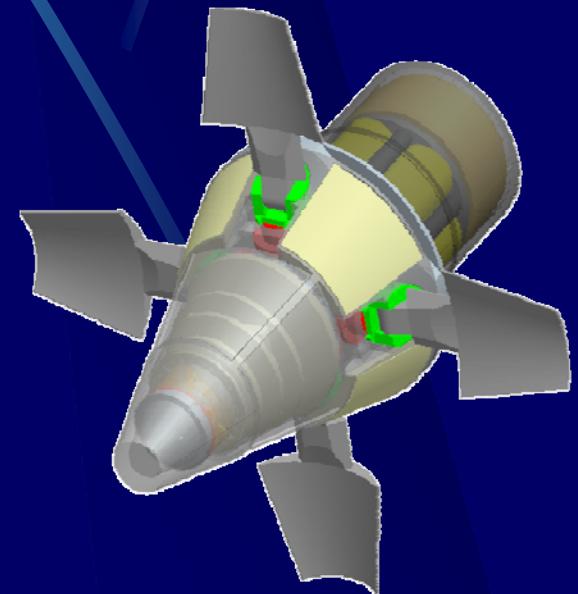
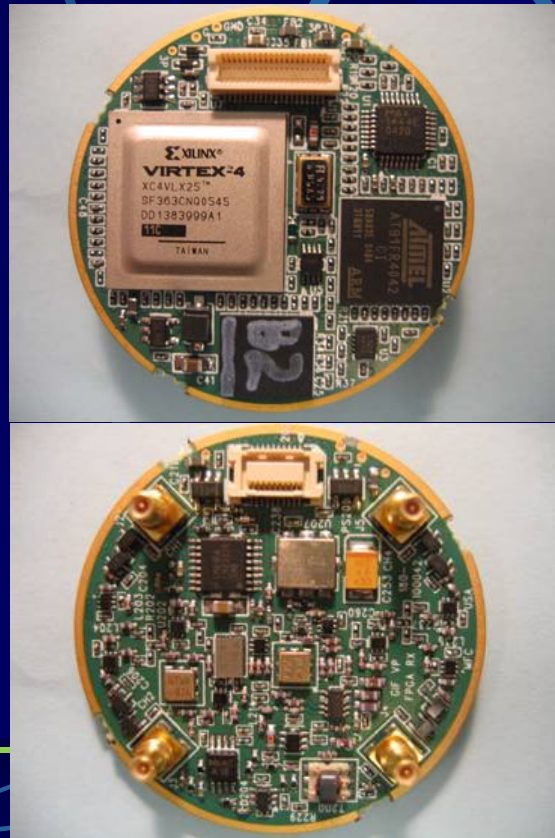
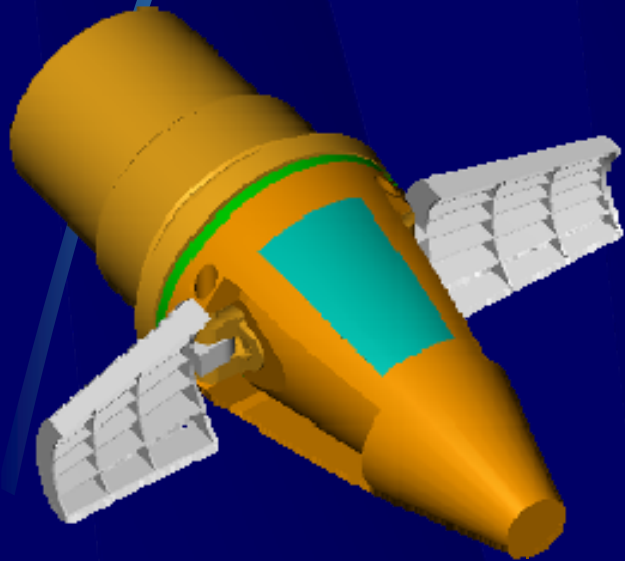
NSWCDD G33

Precision and Advanced

Systems Branch

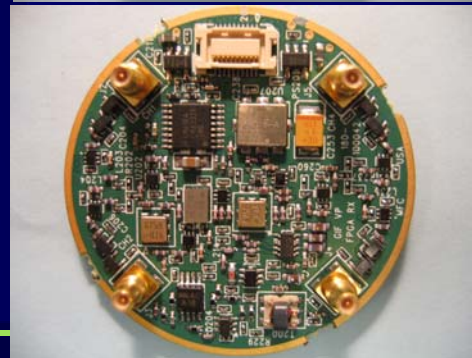
Program Overview

- Electronic Test Fuze (ETF) designed to support Guidance Integrated Fuze (GIF) program



GPS SAASM Receiver Development

- No Existing Product Could Meet GIF Requirements
- Awarded Contract to Mayflower Communications for Development of GPS Receiver
 - Low Cost (< \$500)
 - Low Power (< 1W)
 - Small Size (< 2 in²)
- Phased approach:
 - C/A Version w/ FPGA Available Now!!
 - P(Y) SAASM Receiver (TRL 6) Available Fall 2008
- Not GIF-Centric
 - One Product, Many Applications

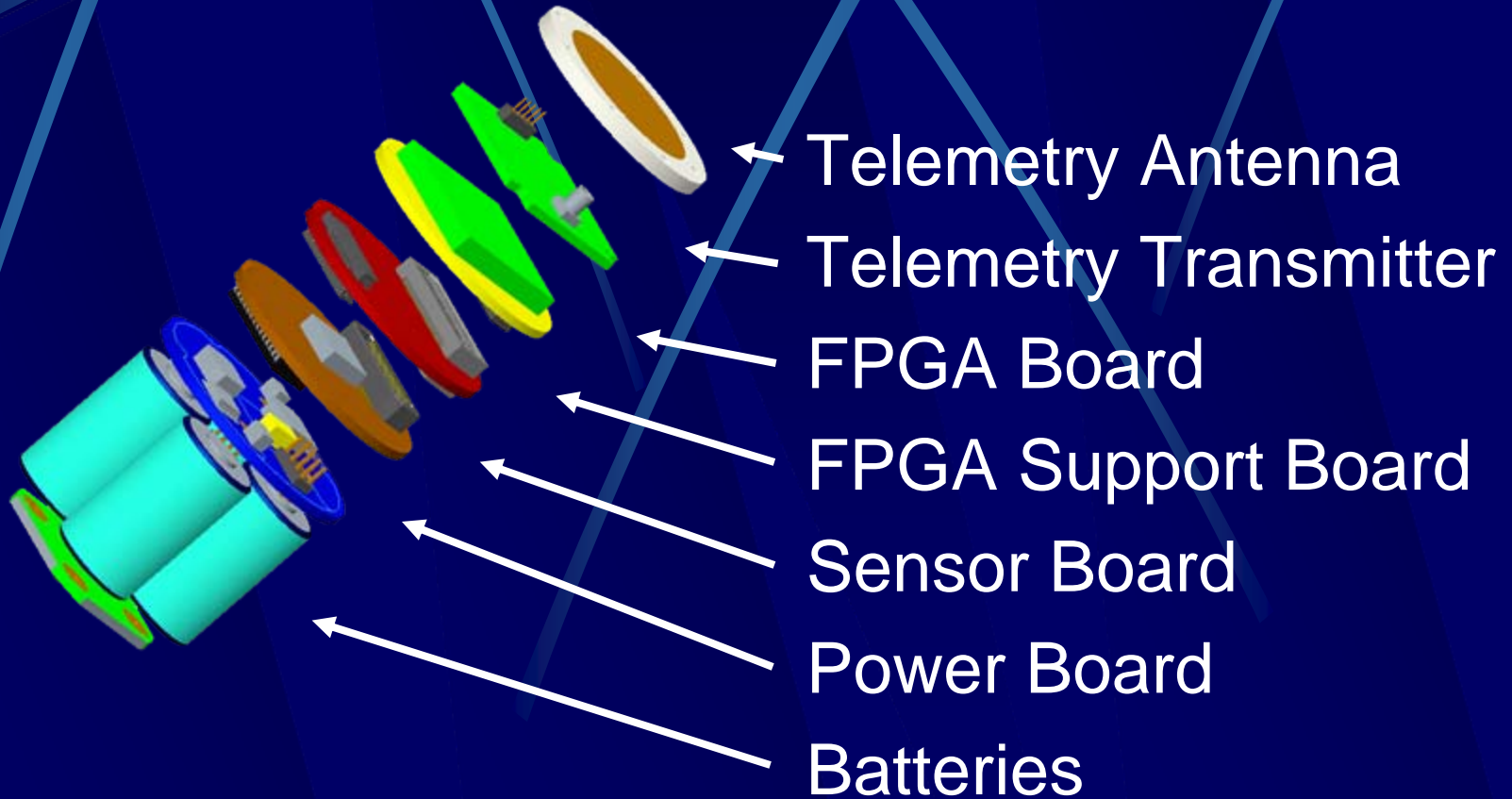


40mm diameter
(VP Form Factor)

Overview - ETF

- Fully designed in-house at NSWCDD
- Initially designed to support in-flight testing of ElectReleaseTM for Lift-GIF
- Designed to support realistic gun-shock testing of myriad subsystems
- Six successful flight tests to date

ETF - General Layout



FPGA Board

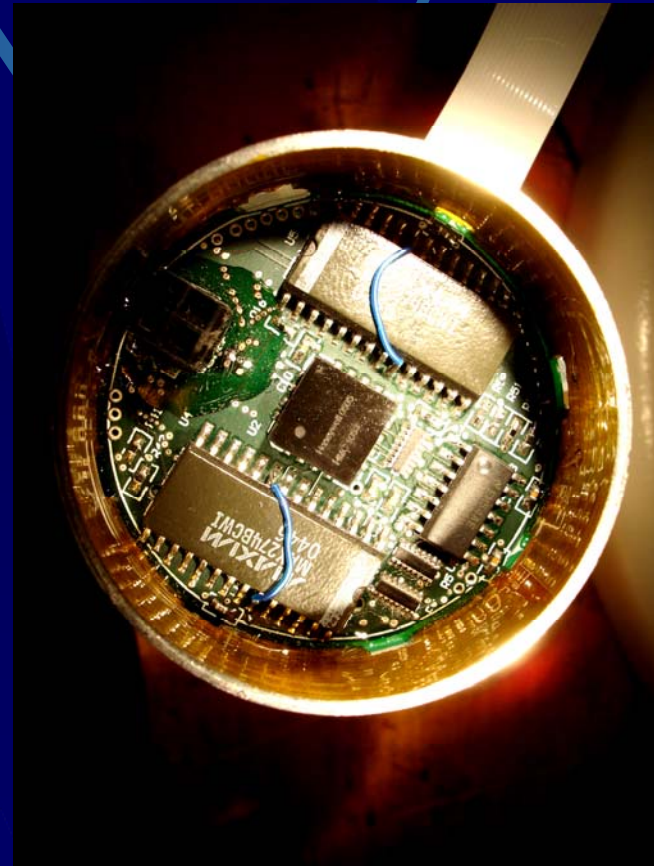
- Interfaces with ADCs and sensors
- Controls & monitors various subsystems under test
 - HOB sensor,
 - ElectRelease actuator,
 - IR transceivers,
 - GPS Rx
- Measures (time = 0) from forward-looking accelerometer
- Encodes test data into telemetry stream



FPGA architecture makes ETF adaptable for future tests

Sensor Board

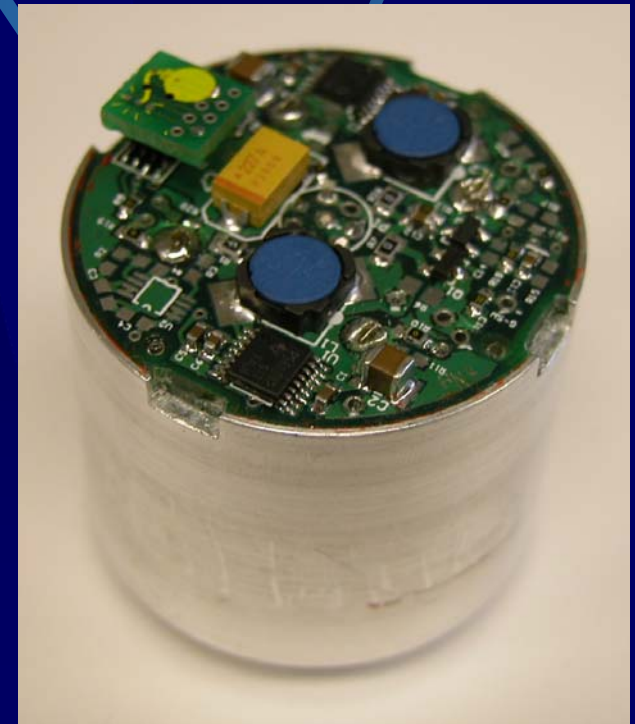
- Silicon Designs 20k-g 1-axis accelerometer
- Honeywell HMC 1053 3-axis magnetometer
- 2 Maxim MAX274 8th-Order Active Filters provide 2nd-Order Chebyshev LPF for each channel
- 2 12-bit, 8-channel TI ADS7852 ADCs sample at up to 32 ksp/s



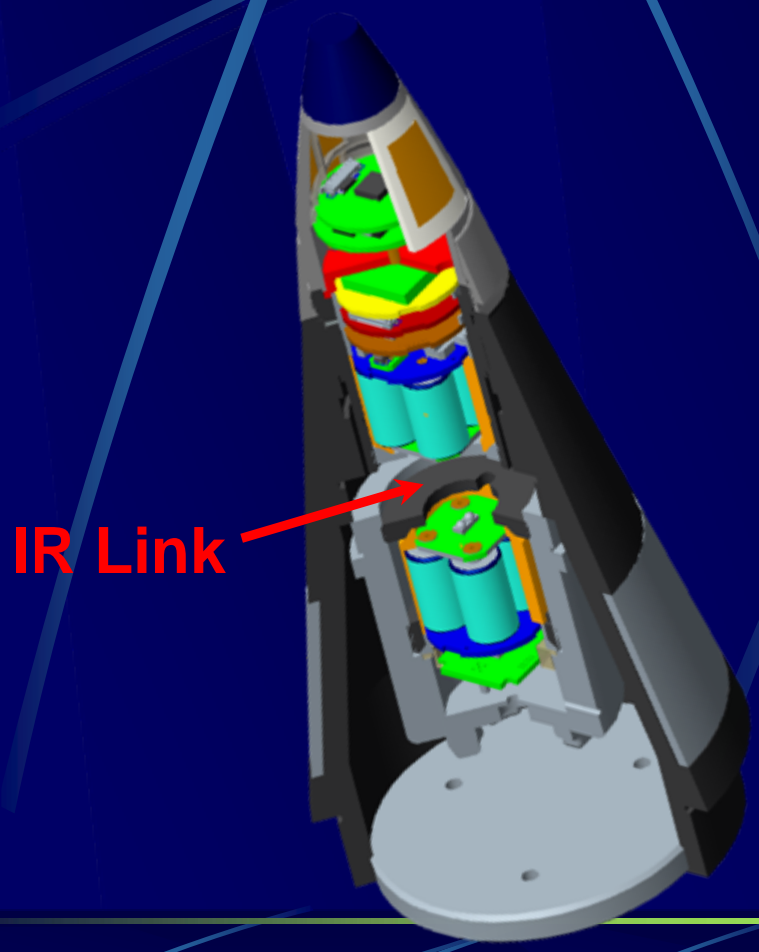
Vias available for additional external sensors

Battery Puck & Power Board

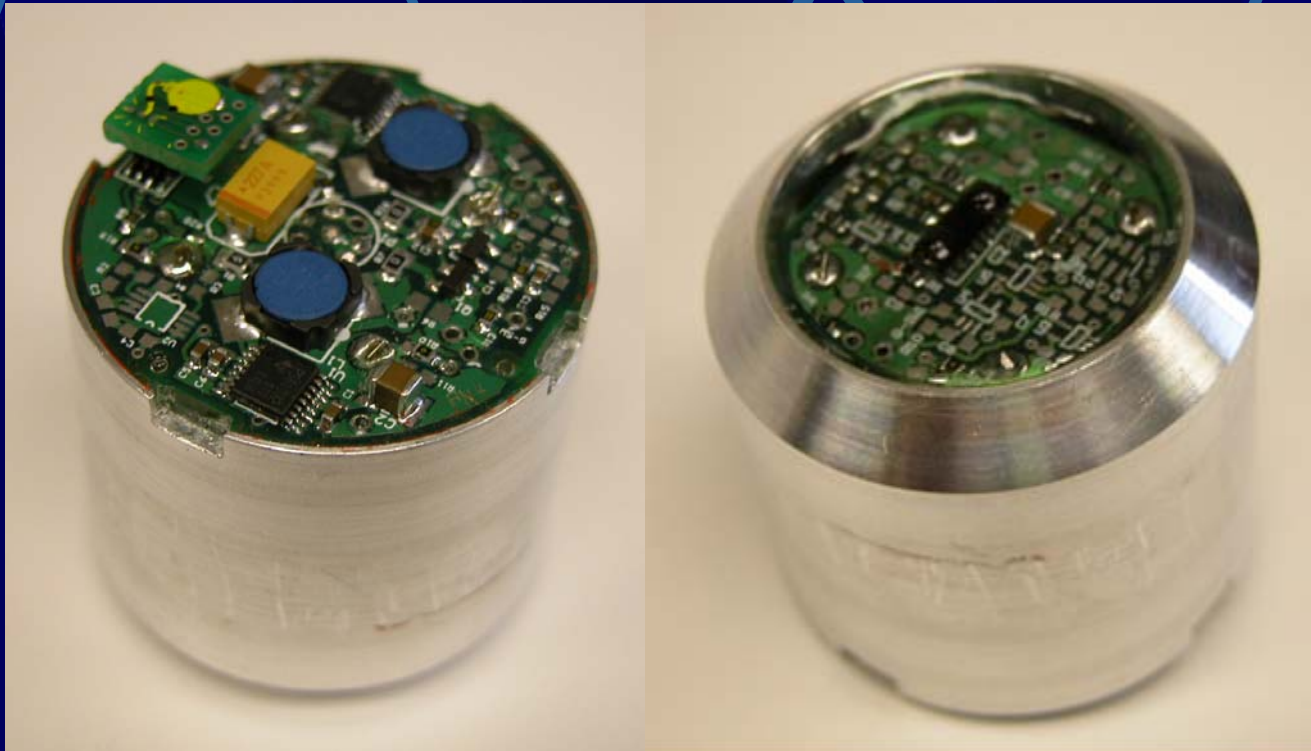
- Current configuration utilizes 4 CR2s
- Puck is designed to be removable such that fresh batteries can be used for flight
- Supplies 5V, 2A; 4V, 500mA
- Other voltages possible
- Current puck can power full ETF stack for > 2hrs



Projectile-Embedded Telemetry

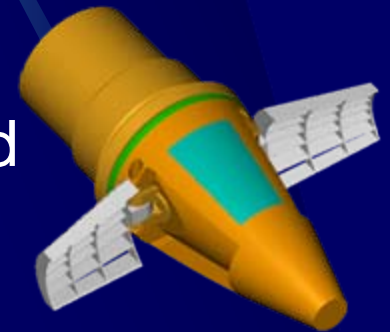


IR Battery Puck



TM Transmitter & Antenna

- M/A-COM MA06836 ½-Watt S-Band HSTSS Telemetry Transmitter
- Three Antenna Versions
 - Round D-Fuze TM Antenna for ‘simple’ ETF
 - IR link integrated between the fuze & the projectile to expand fuze test volume
 - GIF GPS Antennas also re-tuned to S-Band for future test applications



TM Data format

- Manchester encoded
- 1 Mbps data rate
- 1024 bits/frame (1.024 ms frame), including:
 - 32 bit frame sync
 - 24 bit frame counter
 - 32 bit CRC

ETF Telemetry Frame - 18 April 2007 Test Shot

updated on 16 April 2007

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------|-------------------------|---|---|---|---|---|---|-------|-----|---|----|----|-----|----|----|----|---------------|----|----|----|----|----|-------|----|-------|----|-------|----|----|----|----|----|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 16-bit word | 0 | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | | 13 | | 14 | | 15 | |
| 32-bit word | 0 | | | | 1 | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | | | 6 | | | | 7 | | | |
| Data | Frame Sync (0xFAF32019) | | | | A | | F | Power | GPS | | | | GPS | | | | Frame Counter | | | | A | | M1(i) | | M1(j) | | M1(k) | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------|-----|----|----|----|----|----|-----|----|-----|----|----|----|-----|----|----|----|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Byte | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
| 16-bit word | 16 | | 17 | | 18 | | 19 | | 20 | | 21 | | 22 | | 23 | | 24 | | 25 | | 26 | | 27 | | 28 | | 29 | | 30 | | 31 | |
| 32-bit word | 8 | | | | 9 | | | | 10 | | | | 11 | | | | 12 | | | | 13 | | | | 14 | | | | 15 | | | |
| Data | GPS | | | | A | | GPS | | GPS | | | | GPS | | | | GPS | | | | A | | | | | | | | | | | |

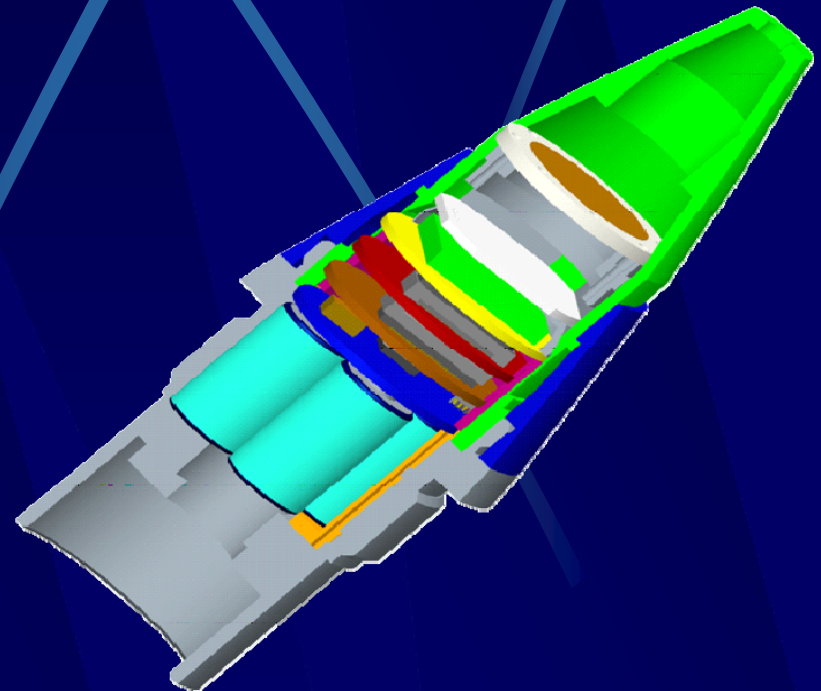
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-------|----|-------|----|-------|----|----|----|----|----|----|----|
| Byte | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 |
| 16-bit word | 32 | | 33 | | 34 | | 35 | | 36 | | 37 | | 38 | | 39 | | 40 | | 41 | | 42 | | 43 | | 44 | | 45 | | 46 | | 47 | |
| 32-bit word | 16 | | | | 17 | | | | 18 | | | | 19 | | | | 20 | | | | 21 | | | | 22 | | | | 23 | | | |
| Data | | | | | A | | | | | | | | | | | | | | A | | M1(i) | | M1(j) | | M1(k) | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------------|-----|-----|-----|-----|-----|
| Byte | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 125 | 126 | 127 |
| 16-bit word | 48 | | 49 | | 50 | | 51 | | 52 | | 53 | | 54 | | 55 | | 56 | | 57 | | 58 | | 59 | | 60 | | 61 | | 62 | | 63 | |
| 32-bit word | 24 | | | | 25 | | | | 26 | | | | 27 | | | | 28 | | | | 29 | | | | 30 | | | | 31 | | | |
| Data | | | | | A | | | | | | | | | | | | | | A | | | | | | TOF | | CRC Checksum | | | | | |

| Label | Signal | Resolution (bits) | # of Channels | Samples / Frame | Sample Rate (kHz) | Bandwidth (kHz) |
|------------------|---|-------------------|---------------|-----------------|-------------------|-----------------|
| A | High-G Accelerometer | 12 | 1 | 8 | 7.81 | 93.75 |
| * M(i) M(j) M(k) | 3-axis Mags (1 = South, 2 = North) | 12 | 3 | 2 | 1.95 | 70.31 |
| TOF | Time of Flight (ms) | 20 | 1 | 1 | 0.98 | 19.53 |
| * F | Flags: In flight; Actuator Power; HOB Power; HOB CO | 1 | 1 | 1 | 0.98 | 0.98 |
| GPS | GPS Data, see additional sheet for more info | 168 | 1 | 1 | 0.98 | 164.06 |
| Frame Sync | Frame Sync (0xFAF32019) | 32 | 1 | 1 | 0.98 | 31.25 |
| Frame Counter | 24-bit counter (~4.8 hours of unique numbers) | 24 | 1 | 1 | 0.98 | 23.44 |
| CRC Checksum | 32-bit Cyclic Redundancy Check | 32 | 1 | 1 | 0.98 | 31.25 |
| Total: | | | | | | 43.46% |

Flight Test 1 August 2006

- Core ETF stack shot at 7R out of 155mm Howitzer on AA Fuze Range
- Primary objective of survival met
- 99.96% of telemetry data recovered with receivers stationed at fuze range
- Primary sensors survived and functioned



Flight Test 2 November 2006

- ETF with IR Link shot at 7R out of 155mm Howitzer on AA Fuze Range
- Primary objective of survival met, both for fuze and aft TM section
- Primary sensors survived and functioned

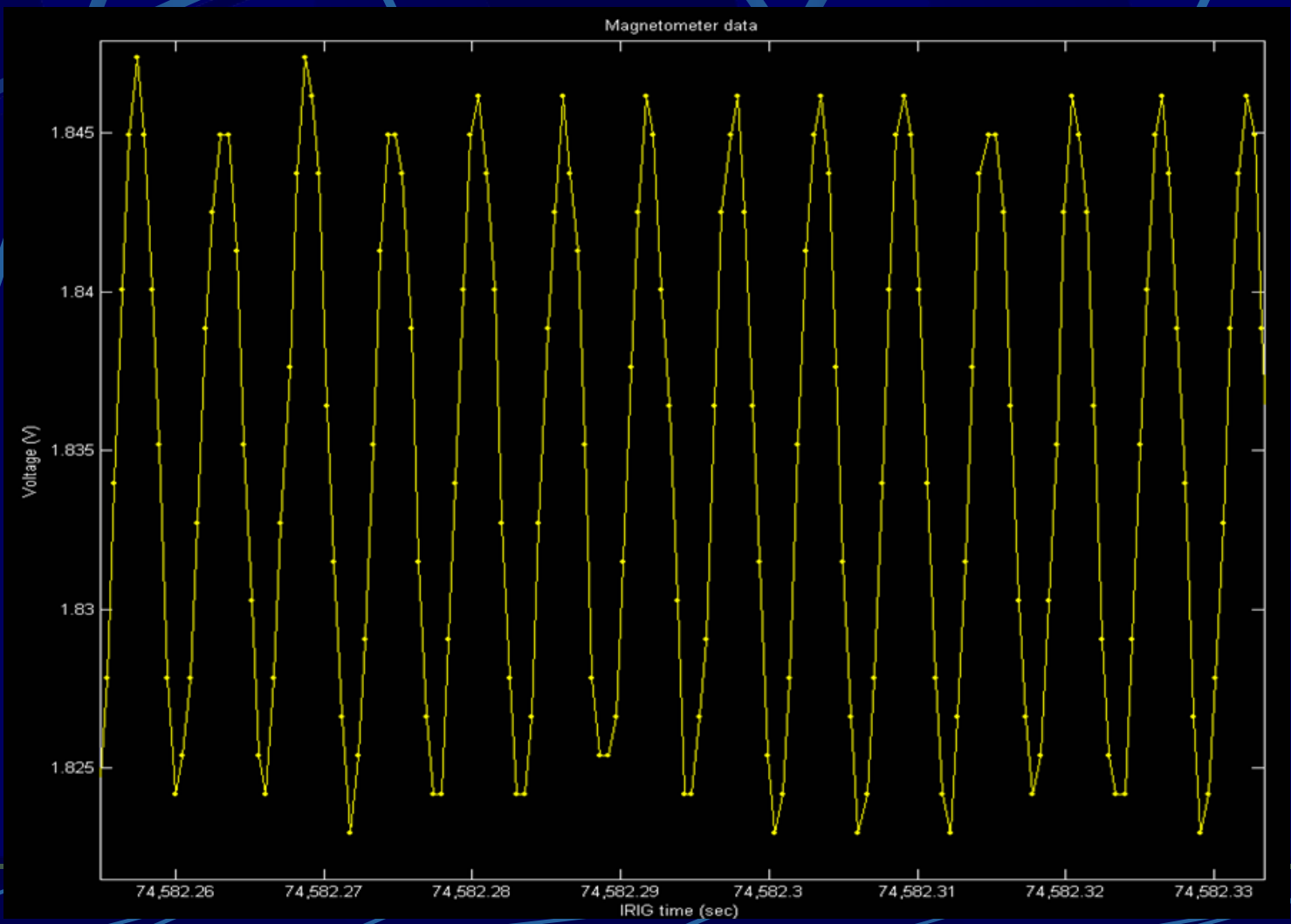


Flight Test 3 April 2007

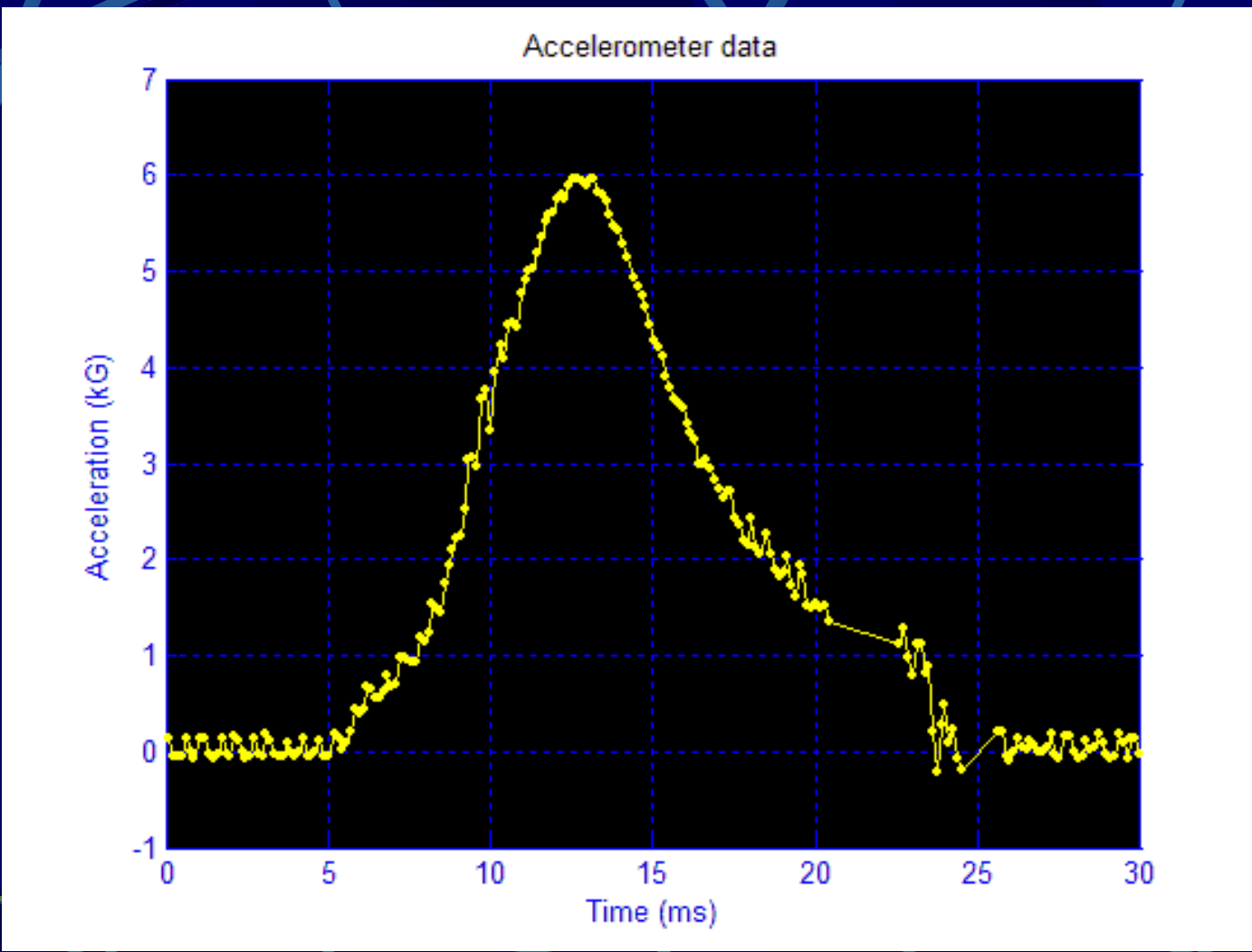
- ETF with Mayflower GPS receiver shot at 7W out of 155mm Howitzer on AA Fuze Range
- Primary objective of receiver survival met



Mag. Data



In-Bore Accel. Data

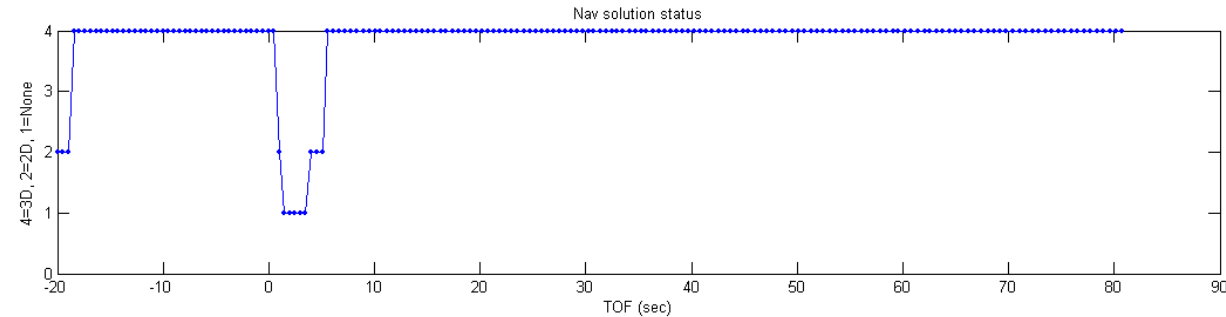
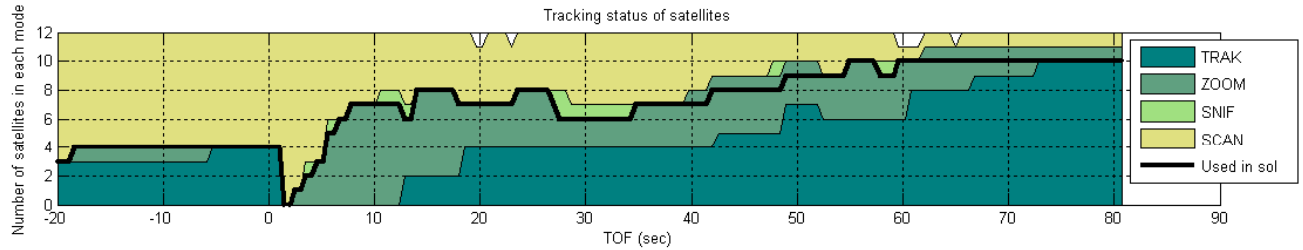
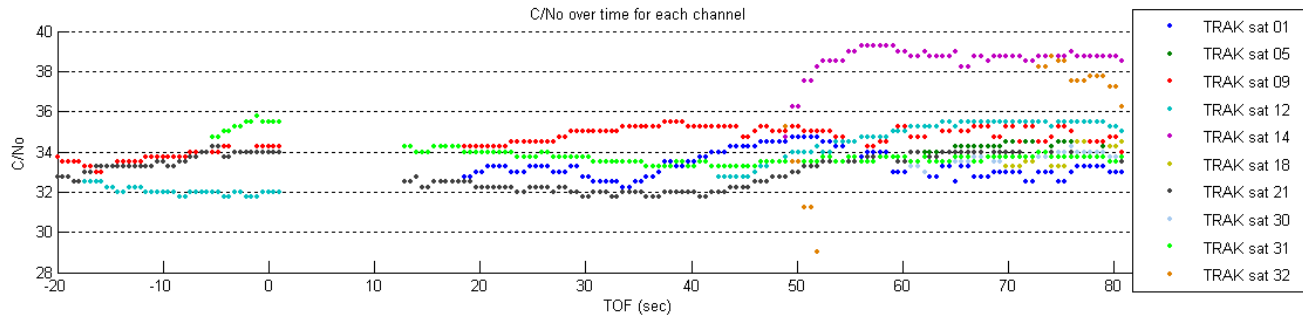


Flight Test 4 August 2007

- ETF with C/A Mayflower GPS receiver shot at 7W out of 155mm Howitzer on AA Fuze Range
- 99% of telemetry data recovered with receivers stationed at fuze range
- Primary objective of receiver survival met

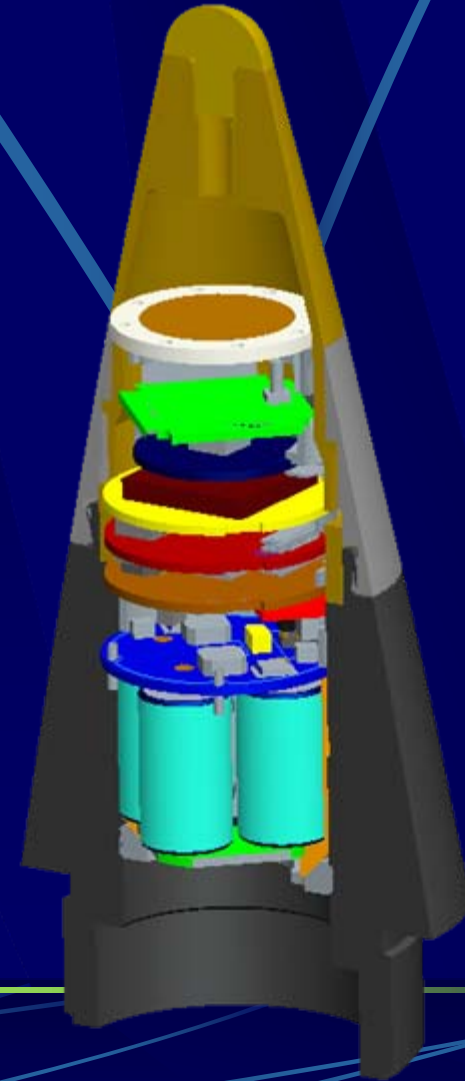


GPS Rx Test Data

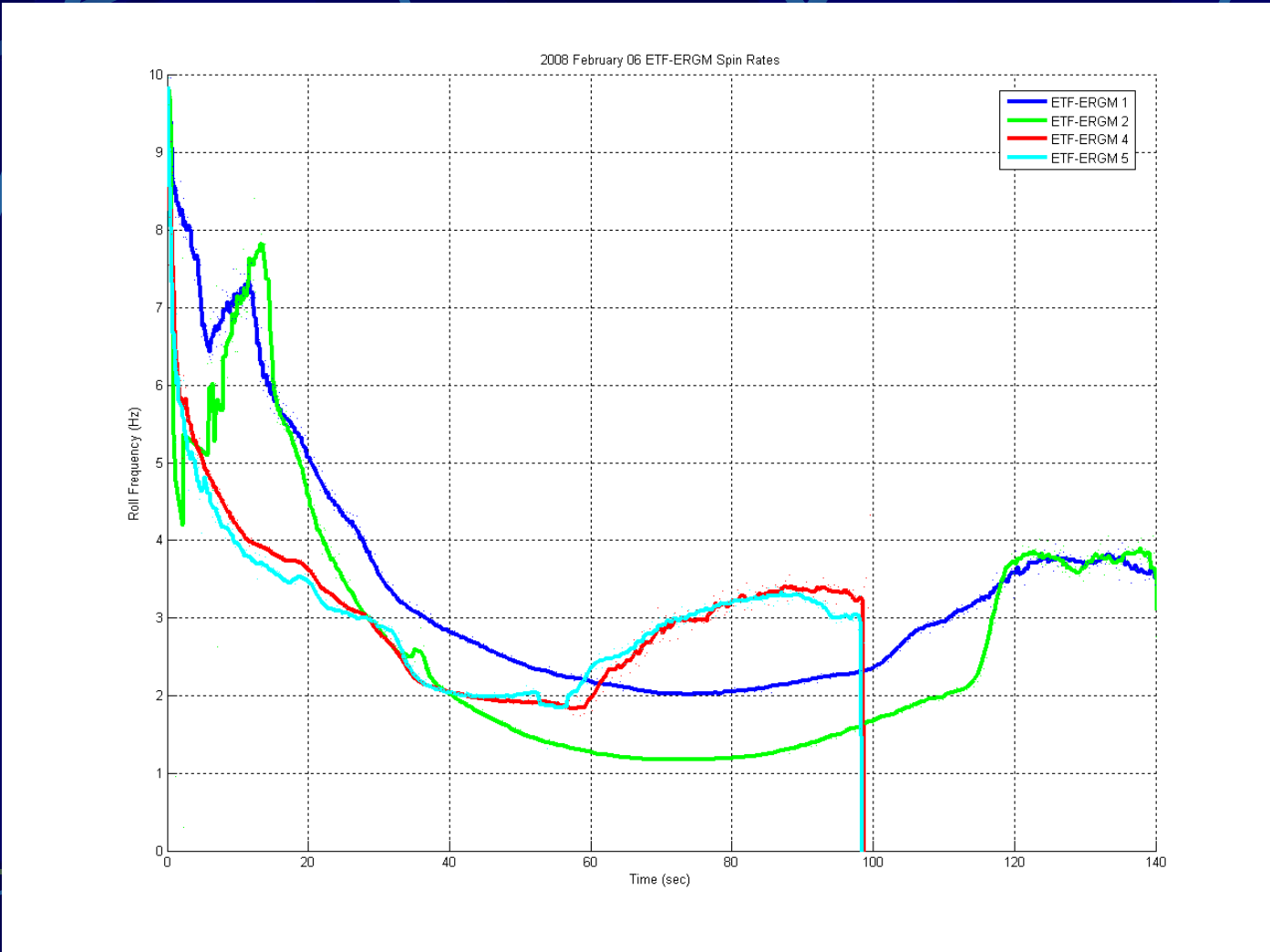


ERGM Flight Tests

- (5) Core ETFs shot at WSMR to support ERGM T&E
- (3) on ERGM rocket motor rounds; (2) on baseline rounds
- Primary objective of characterizing projectile roll-rates met



ERGM Flight Data



ETF-WPML

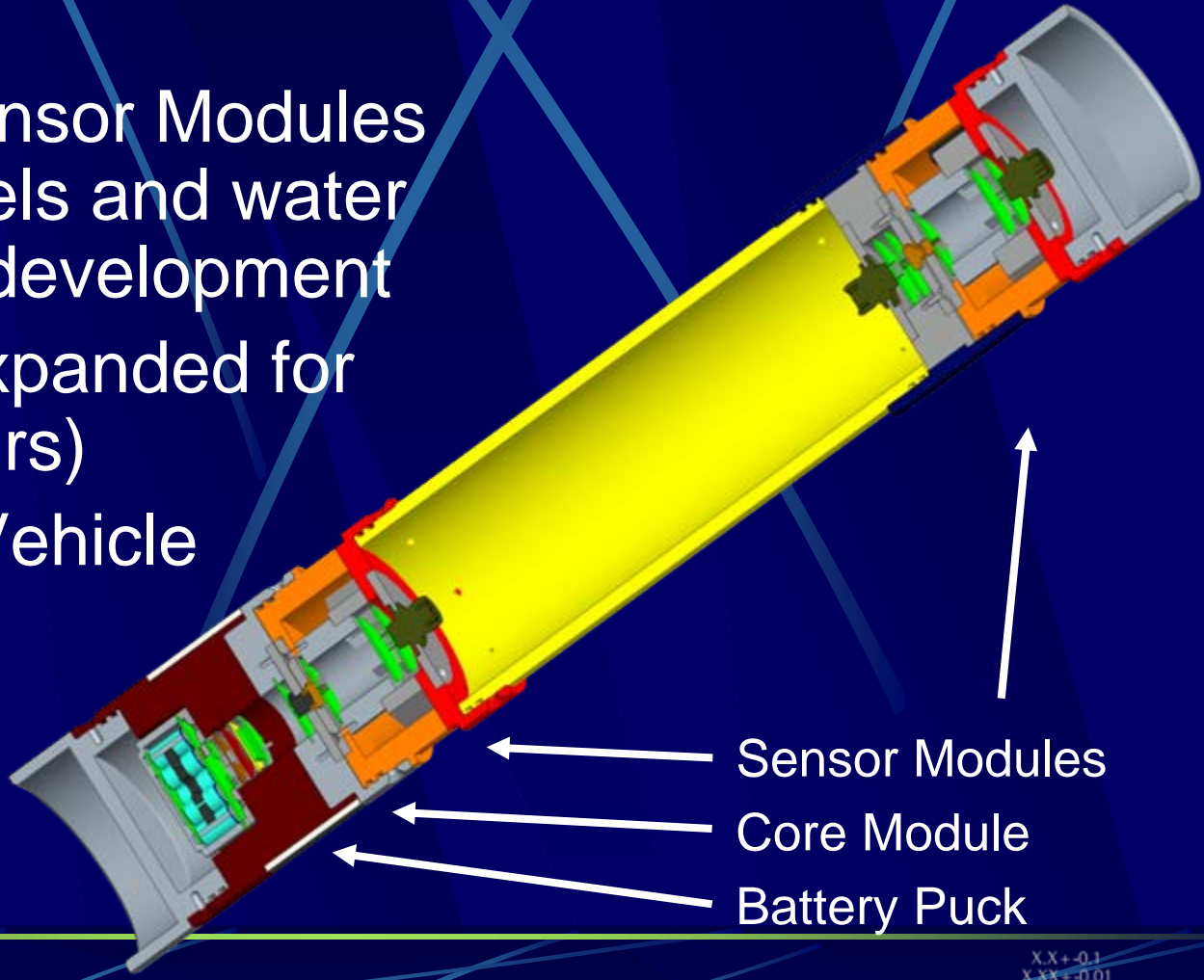
- ETF currently being integrated into Water Piercing Missile Launcher (WPML) test package
- Primary objectives are to measure shock environment and sense possible contact with water during firing
- June flight test on JATO rocket motor scheduled; future testing on other rocket platforms dependent on results





ETF-WPML

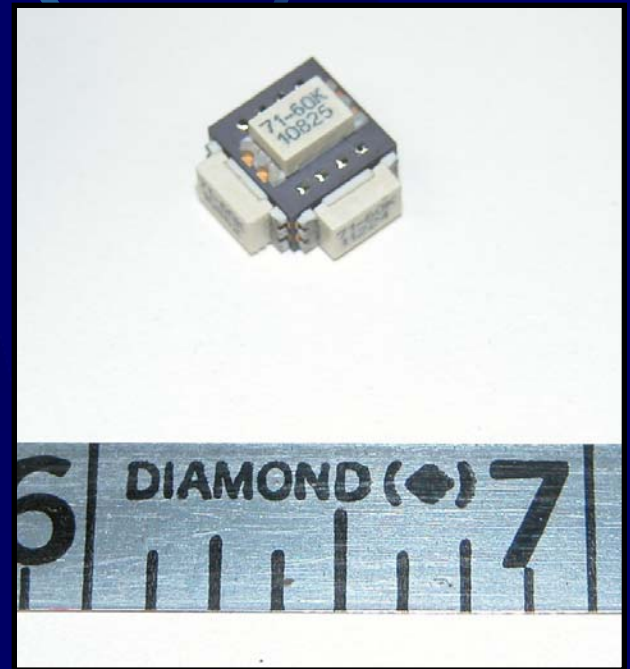
- (2) Auxiliary Sensor Modules with 3-axis accels and water sensors are in development
- Battery Puck expanded for longer life (10 hrs)
- 6" O.D. Flight Vehicle



Sensor Modules
Core Module
Battery Puck

Additional ETF Developments

- Currently designing board to interface Endevco 60k-g tri-axial accelerometer with ETF
- Funded to shock-harden core system to 50+ k-g's



Future ETF Uses

- May 2008 – (2) additional C/A GPS Receiver Test Shots
- June 2008 – ETF-WPML Testing of JATO Rocket Motor
- 2nd quarter 2009 – Mayflower P(Y) GPS Receiver Test Shots
- This bullet reserved for YOUR subsystem!

2+ cubic inches available to test other subsystems

Basic Cost

- Core Electronics: \$3500
- Mechanical Hardware: \$3000
- EE Hardware Test: \$2000
- Mechanical Assembly: \$1500

Total: \$10K / unit

Acknowledgements

- Electrical Team – Mike Irwin, Travis James, Ted Kuhn, Hamish Malin, Wayne Worrell
- Mechanical Team – Marc Bassett, Mark Engel, Nathan Joswiak
- Contact: hamish.malin@navy.mil

