Electronic Test Fuze

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ELECTRONIC TEST FUZE - ETF

- What is ETF?
  - Designed to support realistic gun-shock testing of myriad subsystems
  - Digital processor can command and control subsystems under test in flight.
  - ETF is a diagnostic suite of sensors including 3 axis magnetometer and single axis accelerometer
  - ETF is an analog and digital signal multiplexer that encodes data into a single stream used to modulate an RF transmitter
  - ETF is a gun hardened system with self contained power modules

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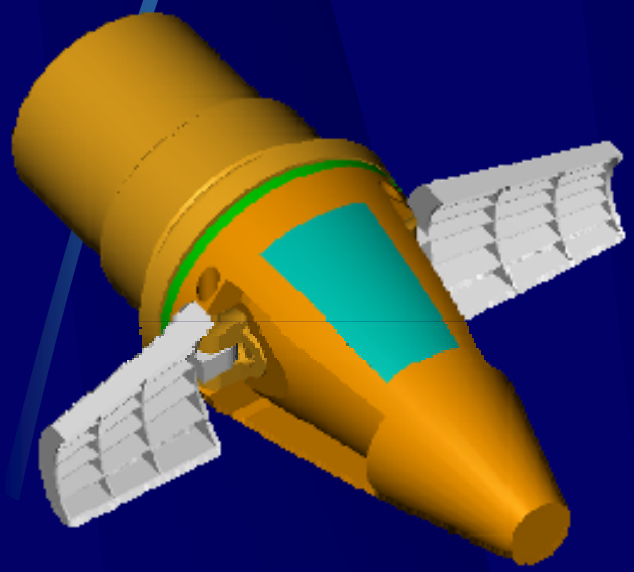
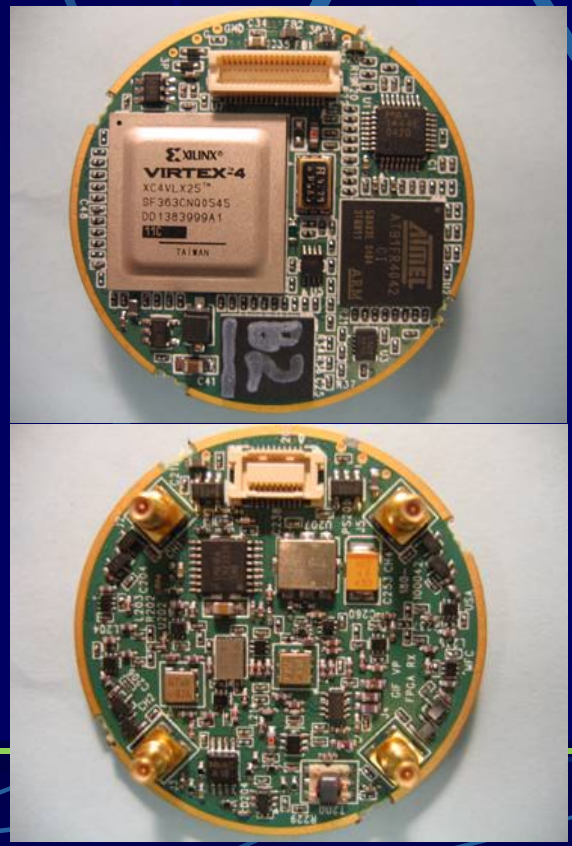
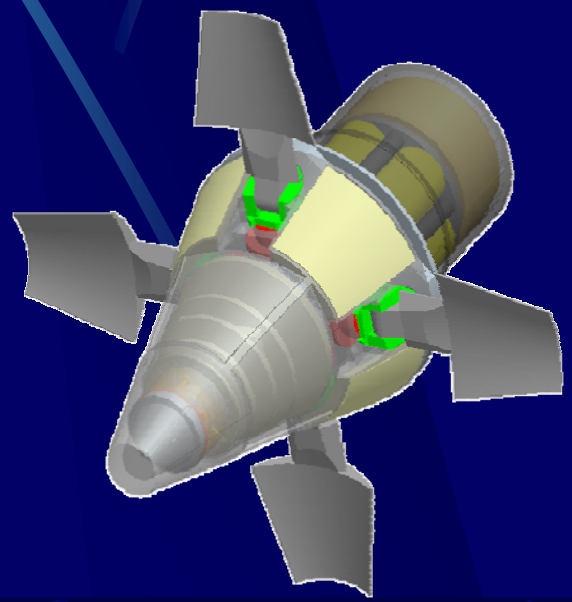
Program Overview

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







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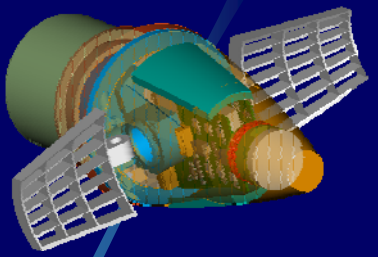
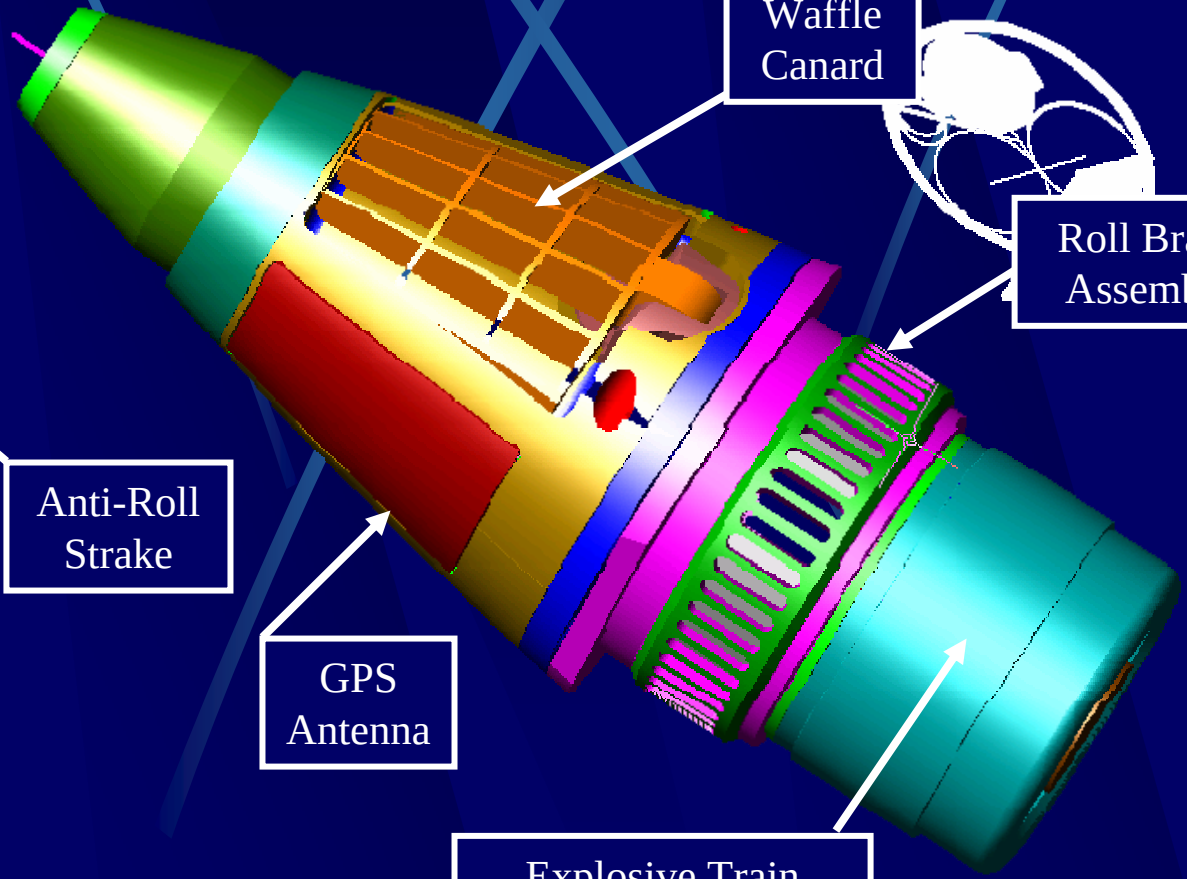
Lift-GIF





Waffle Canard

Roll Brake Assembly

Anti-Roll Strake

GPS Antenna

Explosive Train
OR
TM Support Housing

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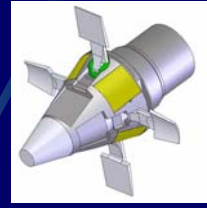
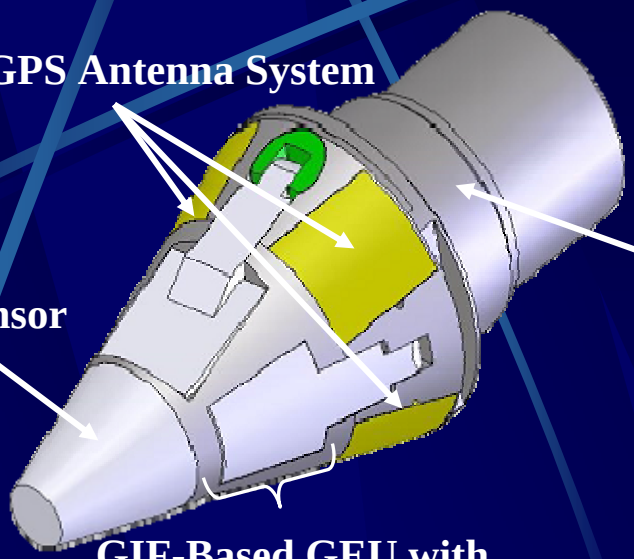
VariPitch



4-Patch GPS Antenna System

HOB Sensor

COTS Battery Module

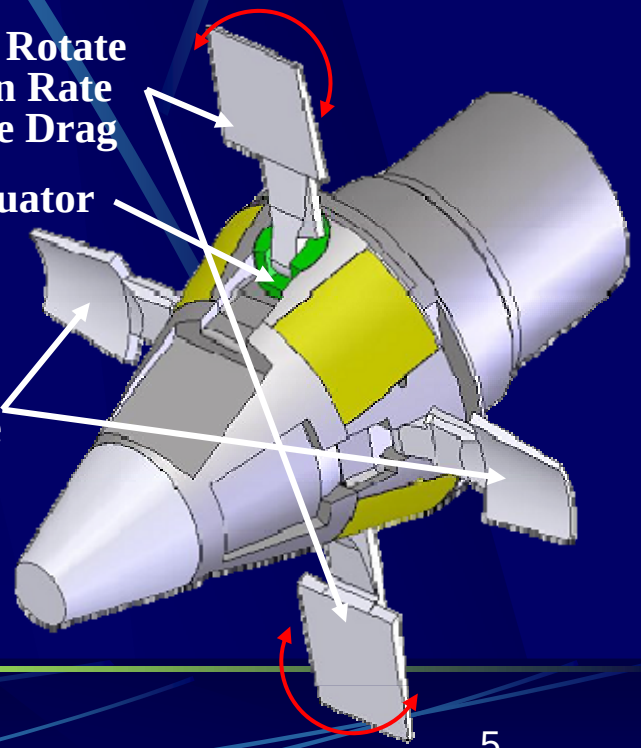


GIF-Based GEU with Advanced Anti-Jam and Backup "Command Mode" using PTS if GPS is Denied

Control Panels that Rotate Controlling the Spin Rate and "throttling" the Drag

GIF COTS Actuator

Drag Panels Don't Rotate



GIF/VP Advantages:

- Simpler than Navy "Lift-GIF" yet more robust in terms of Jamming and Reliability.
- ~$1K Less Expensive in Production
- Capable of a 15m to 20m CEP.
- Applicable to All Ammo Types.
- Meets or Exceeds PGK Inc 1/2/3 Requirements.
- Leverages All Previous Navy-GIF Developments except the Roll Brake and Bearing Assemblies.

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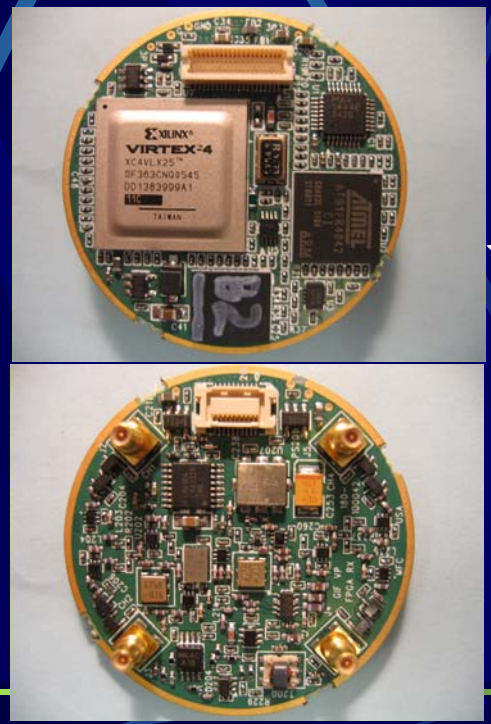
Miniaturized GPS SAASM Receiver Technology

- 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 in^2)
- 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)

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Overview - ETF

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

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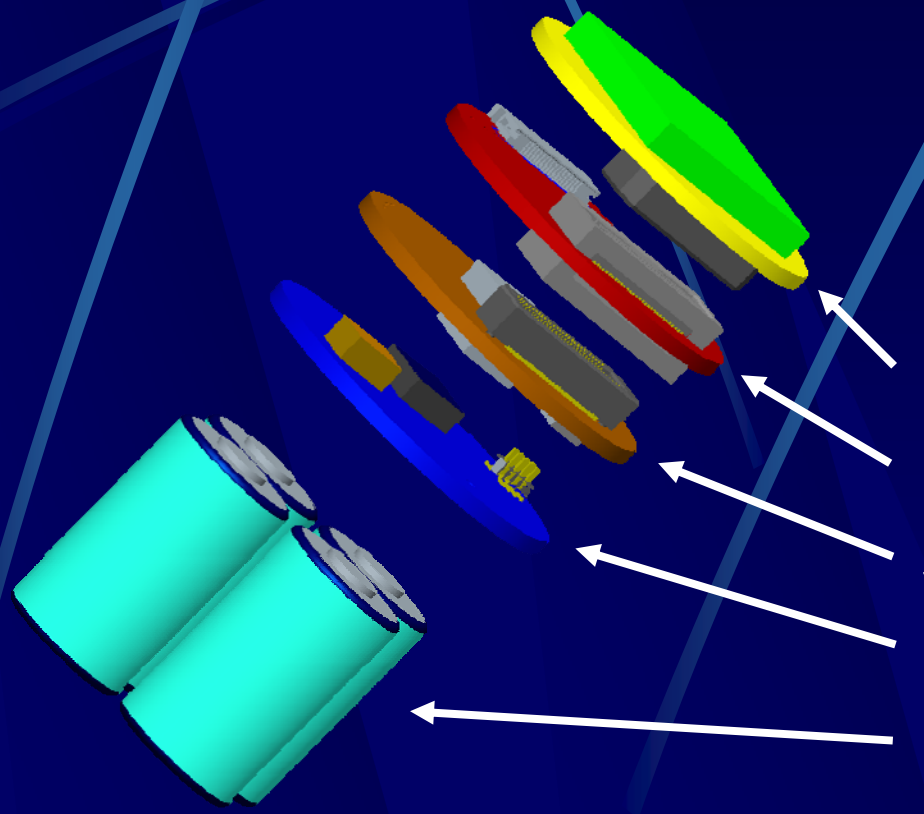
Board Stack - General



FPGA Board

FPGA I/O Support Board

Sensor Board

Power Board

Batteries

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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

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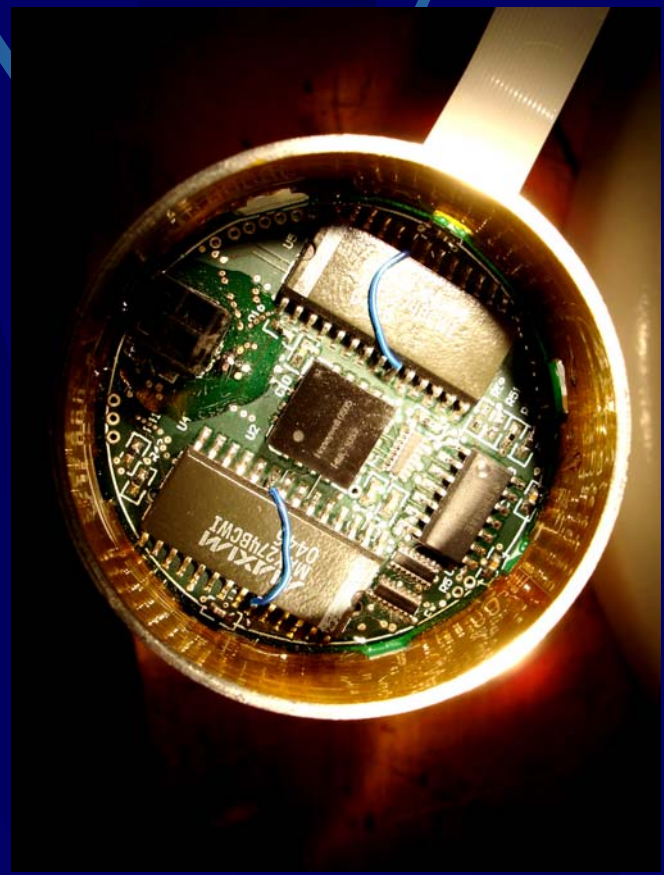
Sensor Board

- 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 ksps



Vias available for additional external sensors

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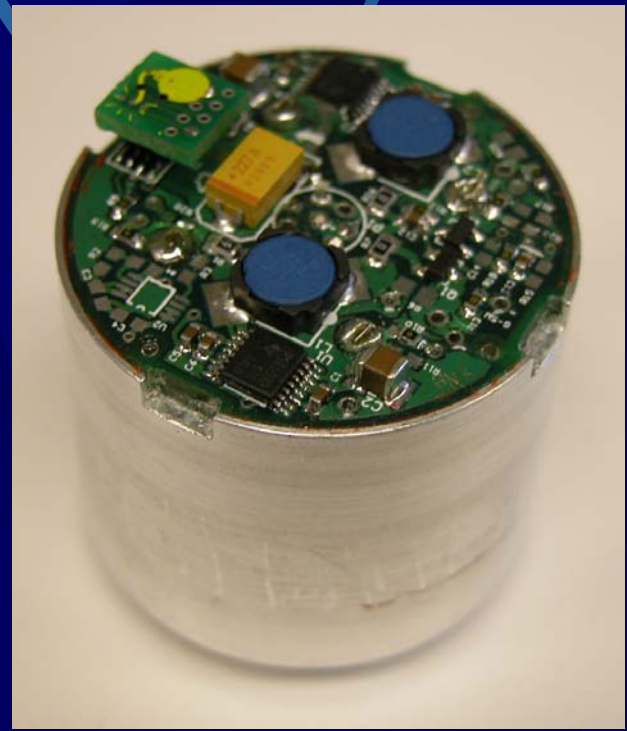
Battery Puck & Power Board

- 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



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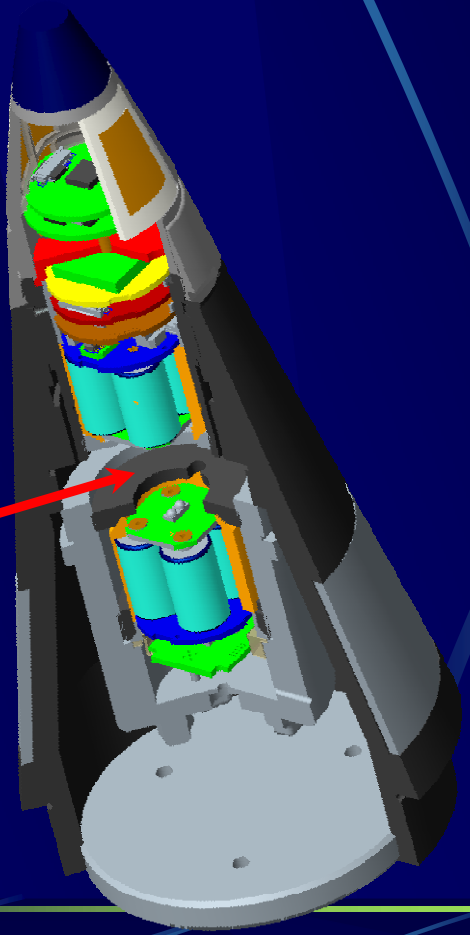
Projectile-Embedded Telemetry



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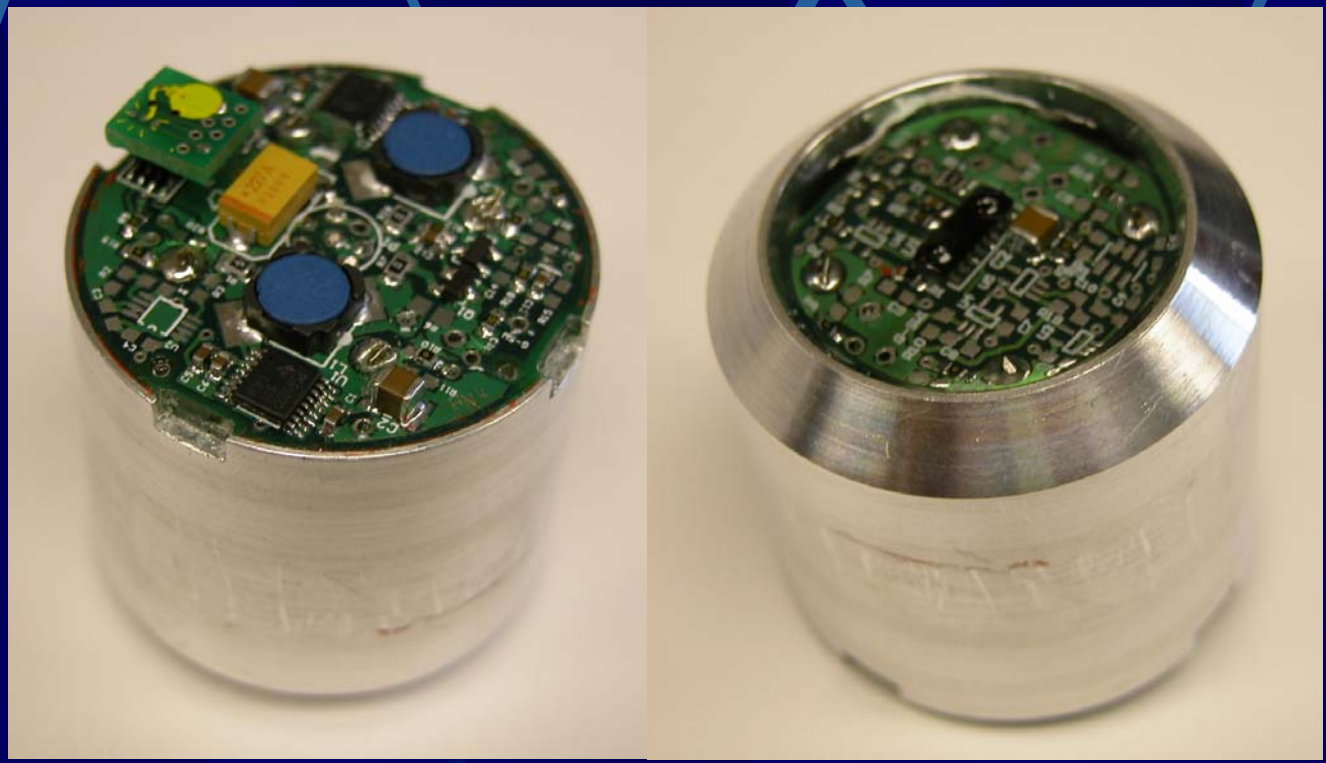
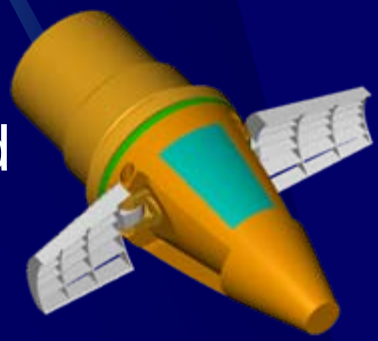
IR Battery Puck



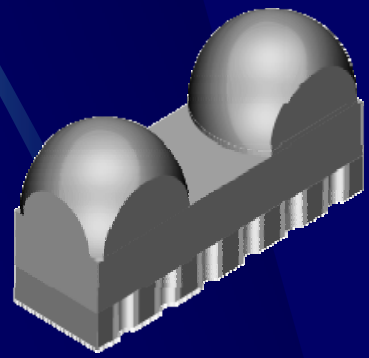
TM Transmitter & Antenna

- 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



IR Transceivers

- Vishay TFBS6614 IrDA used for IR Battery Puck for TM link
- Vishay TFBS4711 IrDA to be used for cover release verification
  - Determine if canard covers have been successfully deployed
  - 2 transceivers/cover



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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 checksum

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%**

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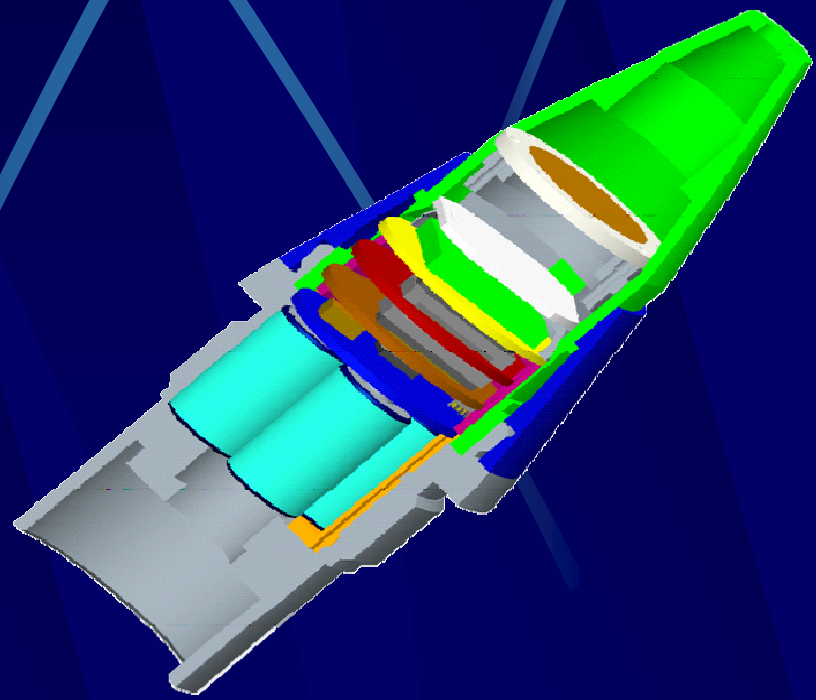
Flight Test 1 August 2006

- Core ETF stack shot at 7R out of 155mm Howitzer on Dahlgren 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



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Flight Accel. Data

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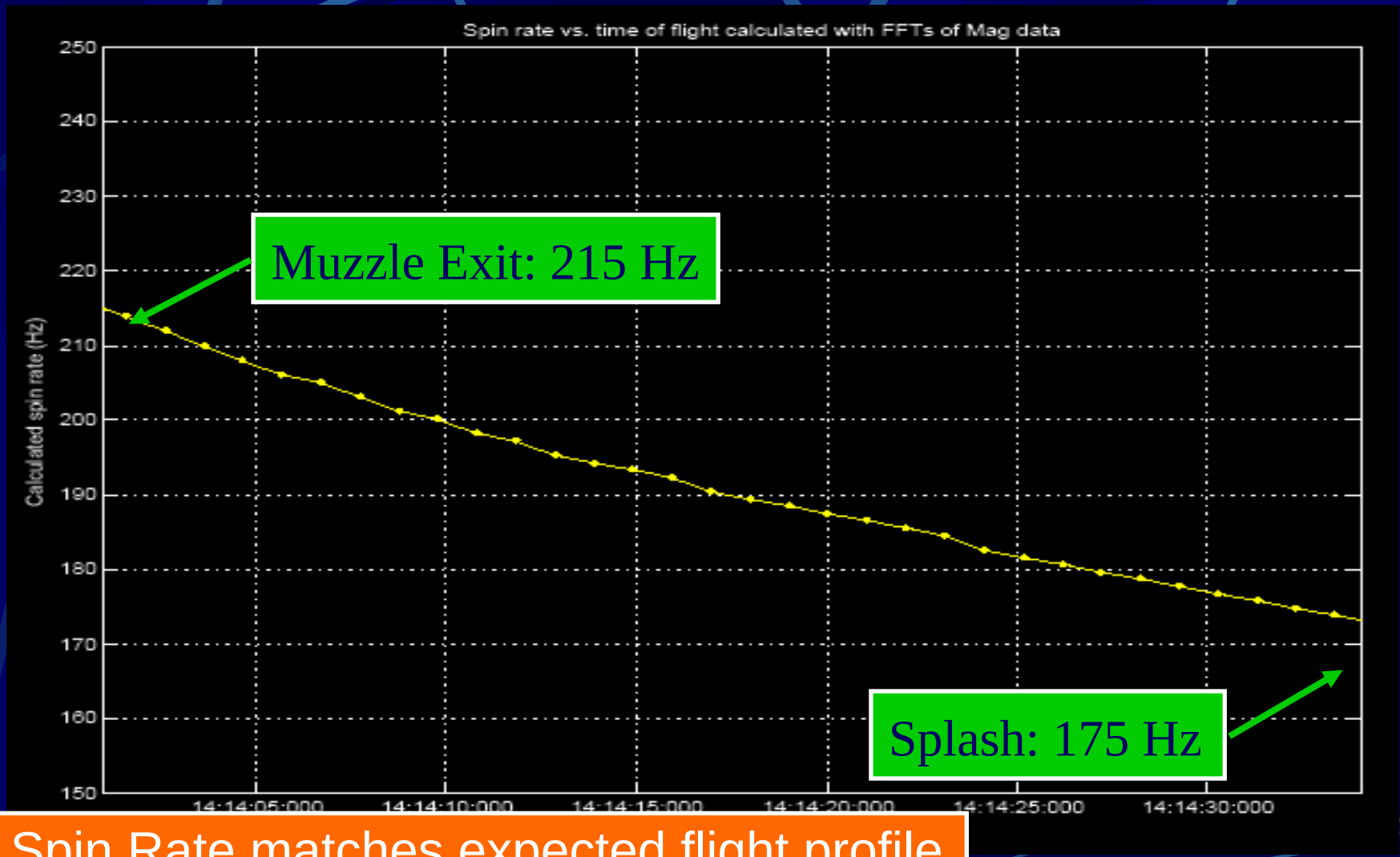
Flight Mag. Data



Spin Rate matches expected flight profile

Flight Test 2 November 2006

- ETF with IR Link shot at 7R out of 155mm Howitzer on Dahlgren 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 Dahlgren AA Fuze Range
- Primary objective of receiver survival met

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Flight Test 4 August 2007

- ETF with Mayflower GPS receiver shot at 7W on Dahlgren AA Fuze Range
- 99% of telemetry data recovered with receivers stationed at fuze range
- Primary sensors survived and functioned
- Valid GPS Receiver data collected the duration of the flight

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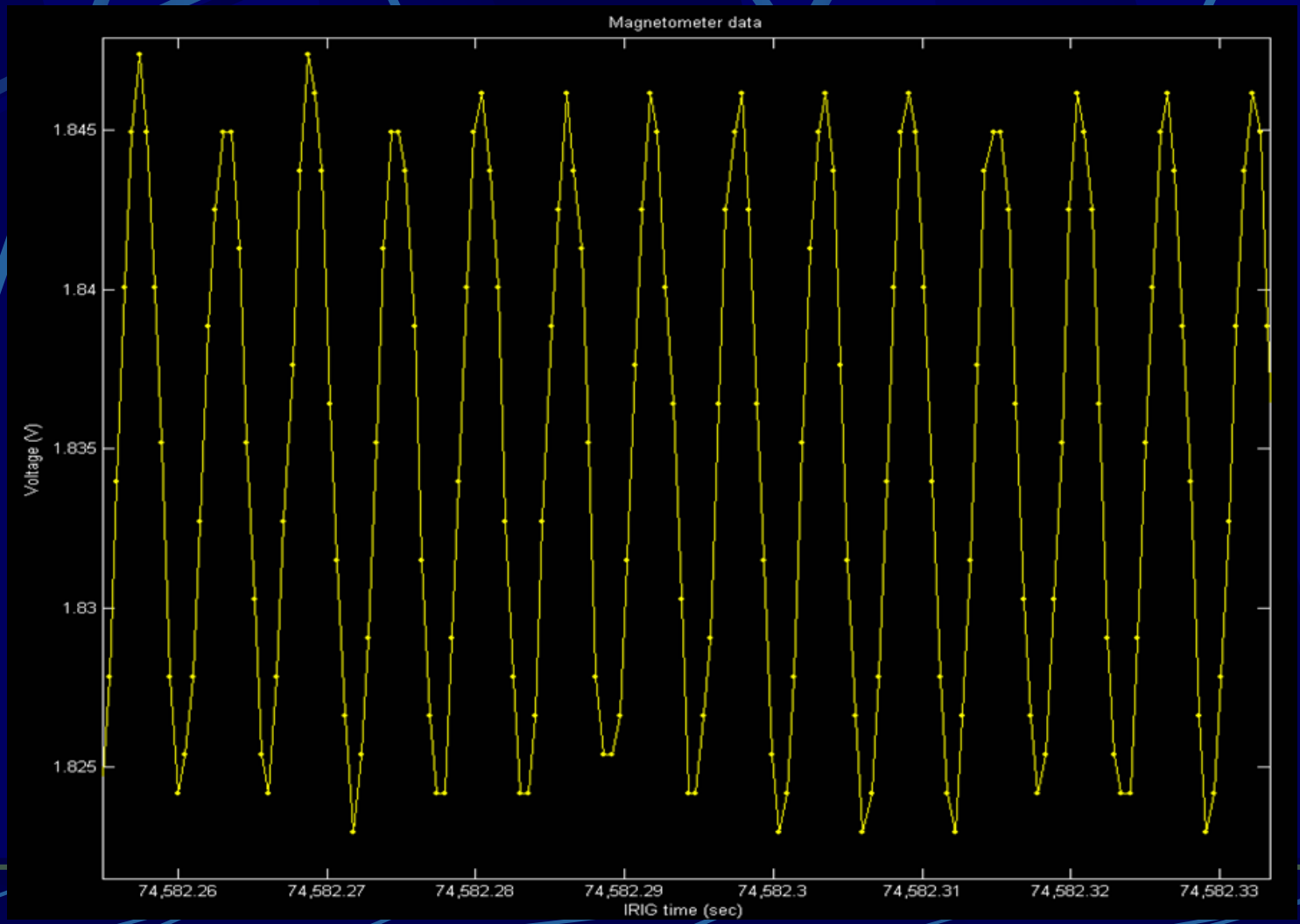
Mag. Data



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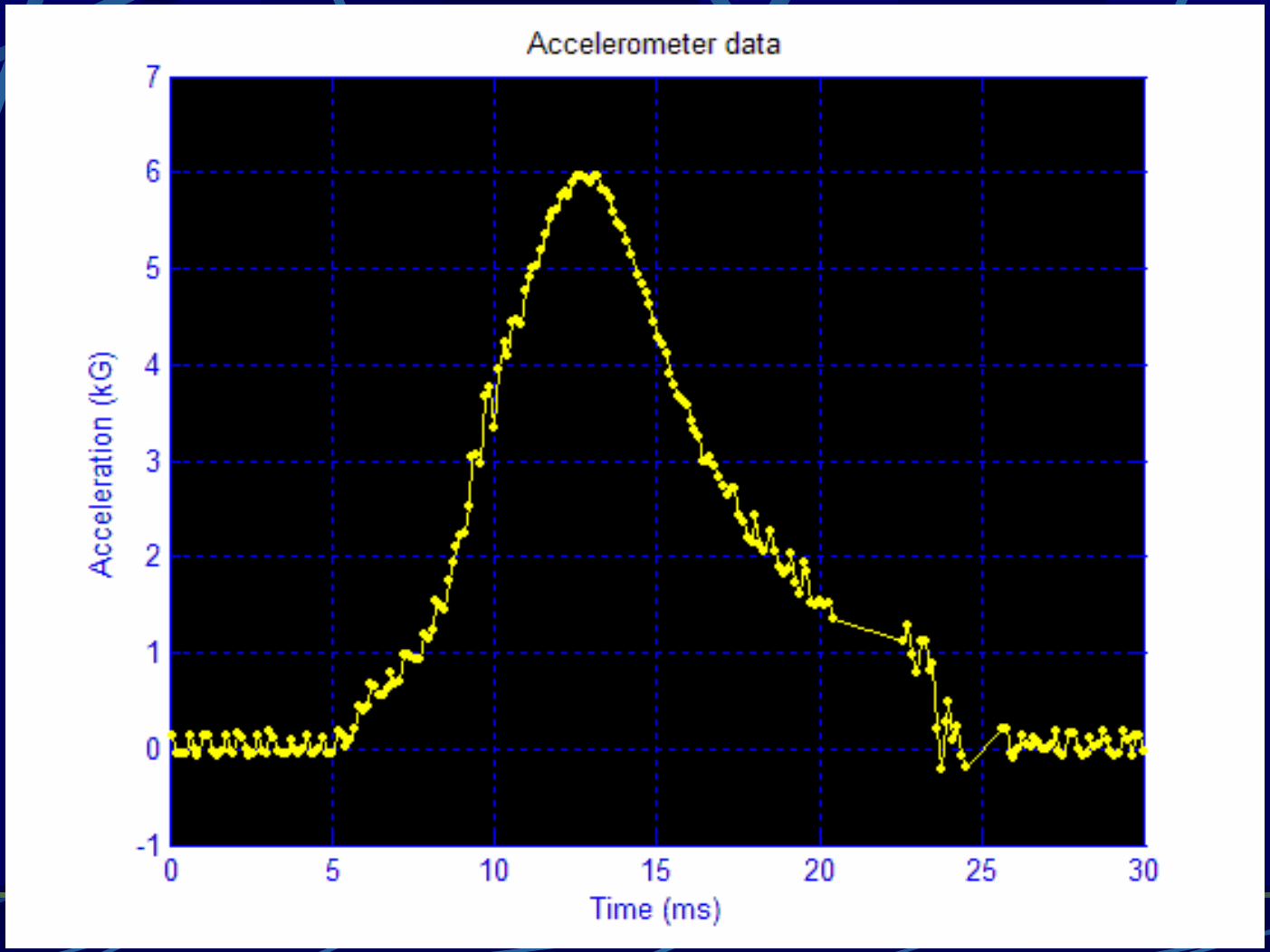
In-Bore Accel. Data



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Future ETF Uses

- May 2008 – Follow-up C/A GPS Receiver Test Shot
- Used on other gun programs to record gun fire dynamics - Ongoing
- December 2008 – Mayflower P(Y) GPS Receiver Test Shot
- This bullet reserved for YOUR subsystem!

2+ cubic inches available to test other subsystems

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Basic Cost

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

Total: $10K / unit

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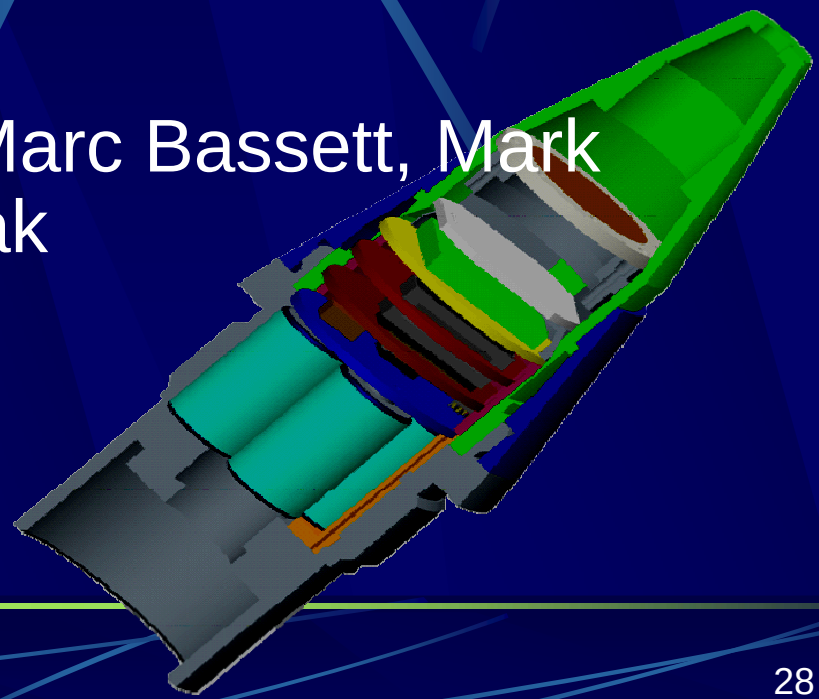
Acknowledgements

- Electrical Team – Mike Irwin, Travis James, Hamish Malin, Wayne Worrell
- Mechanical Team – Marc Bassett, Mark Engel, Nathan Joswiak



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QUESTIONS ?

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Backup Slides