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
Program Overview

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

- Waffle Canard
- Roll Brake Assembly
- Anti-Roll Strake
- GPS Antenna
- Explosive Train OR TM Support Housing
Drag Panels

Don’t Rotate

Control Panels that Rotate
Controlling the Spin Rate
and “throttling” the Drag

COTS Battery Module

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

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.
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
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
Board Stack - General

- FPGA Board
- FPGA I/O Support Board
- Sensor Board
- Power Board
- Batteries
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

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 Link
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
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

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<th>Sample Rate (kHz)</th>
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**Total:** 43.46%
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
Flight Accel. Data

Start of muzzle exit as observed by high speed video

Muzzle Exit
Flight Mag. Data

Spin rate vs. time of flight calculated with FFTs of Mag data

- Muzzle Exit: 215 Hz
- Splash: 175 Hz

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
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
Mag. Data
In-Bore Accel. Data
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
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, Hamish Malin, Wayne Worrell

Mechanical Team – Marc Bassett, Mark Engel, Nathan Joswiak
QUESTIONS ?
Backup Slides