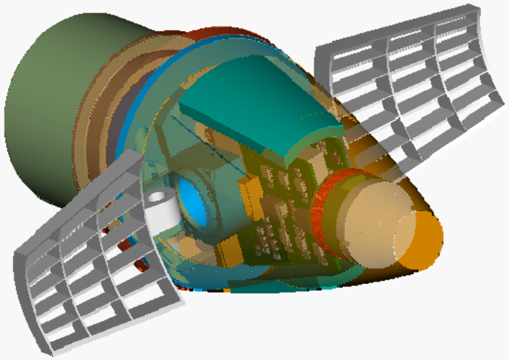

# GUIDANCE INTEGRATED FUZE DEMONSTRATION PROGRAM

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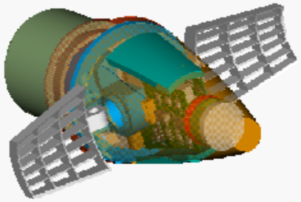
# BACKGROUND

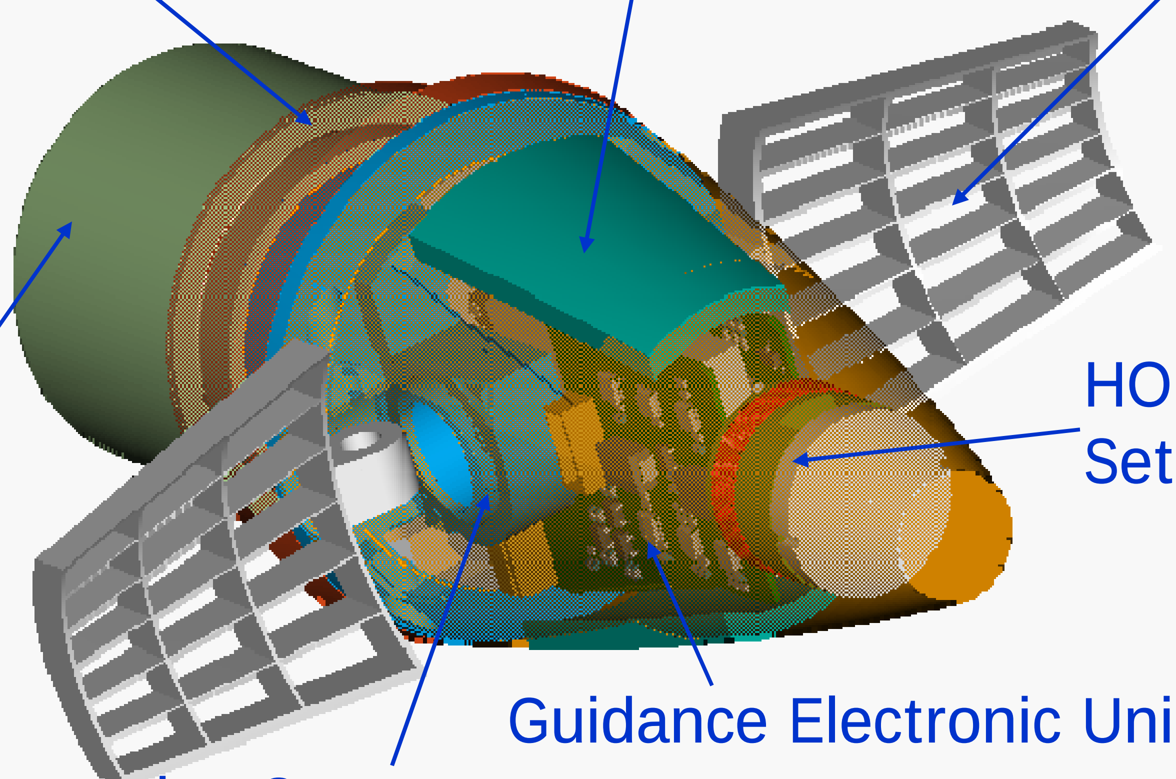


- The Guidance Integrated Fuze "GIF" program is in its last year of Demonstration Development.

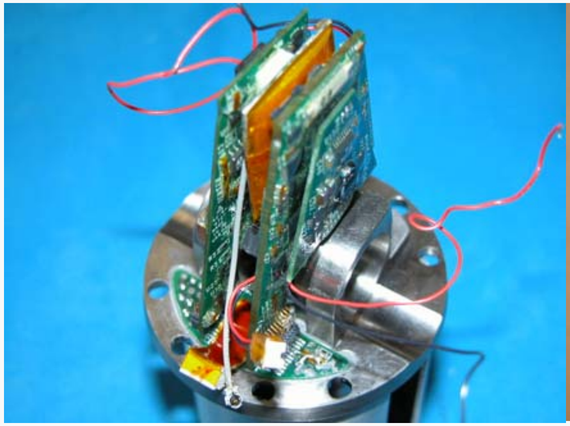
- The Naval Surface Warfare Center was given two tasks:
  - Produce a self contained NATO standard fuze with integrated guidance to increase the accuracy of existing gun projectile inventories.
  - Produce a SAASM P(Y) GPS receiver with reduced cost/power requirements and sized to fit within a NATO standard fuze contour.

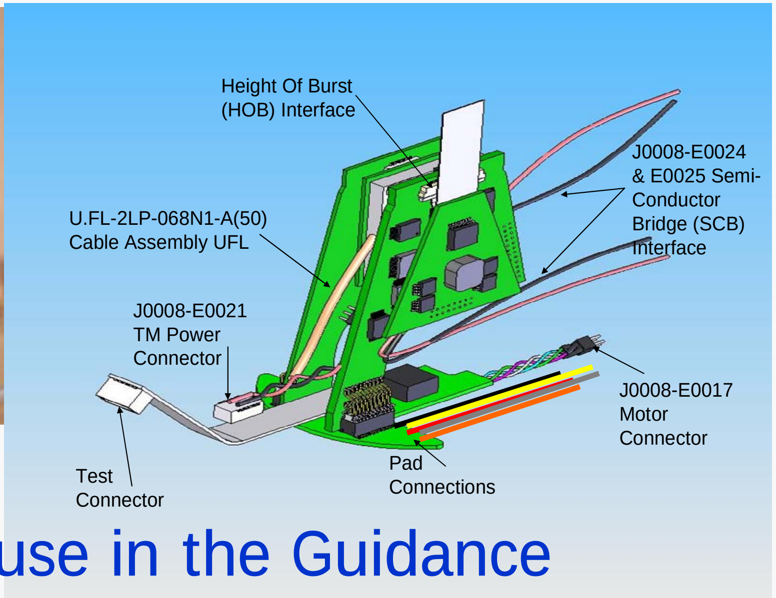
- This presentation will review fuze subsystems developed during the “GIF” program, final system test results, and the development of the 40mm SAASM GPS receiver and “VIPER” fuze.

# GIF - Major Component Development



# Guidance Electronic Unit - GEU

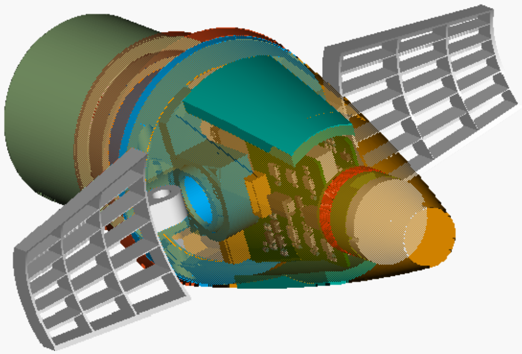


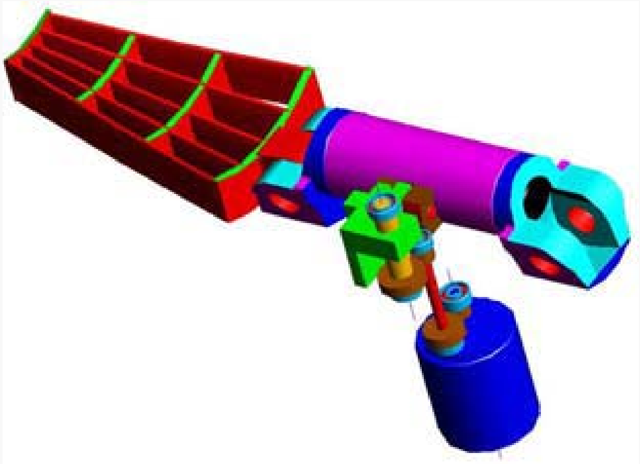



- Developed by Syntronics, Inc. for use in the Guidance Integrated Fuze “GIF”.

- The GEU successfully controlled: gun fire sensing, boot up, GPS receiver function, guidance computations, power regulation, roll brake control, canard deployment and control, HOB sensor control, fire pulse generation, and telemetry modulation data.

# Waffle CANARD





- Waffle canards were modeled, designed, analyzed, and wind tunnel tested by NSWCDD for our GIF fuze.
- Design gives more lift and less stalling than solid control surfaces of similar size.
- Design easily conforms to the fuze contour and required less hinge moments to deflect and hold canards.

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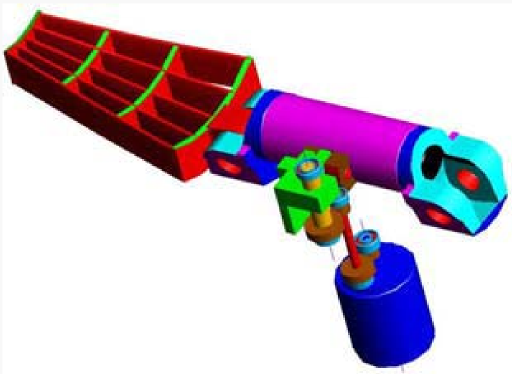
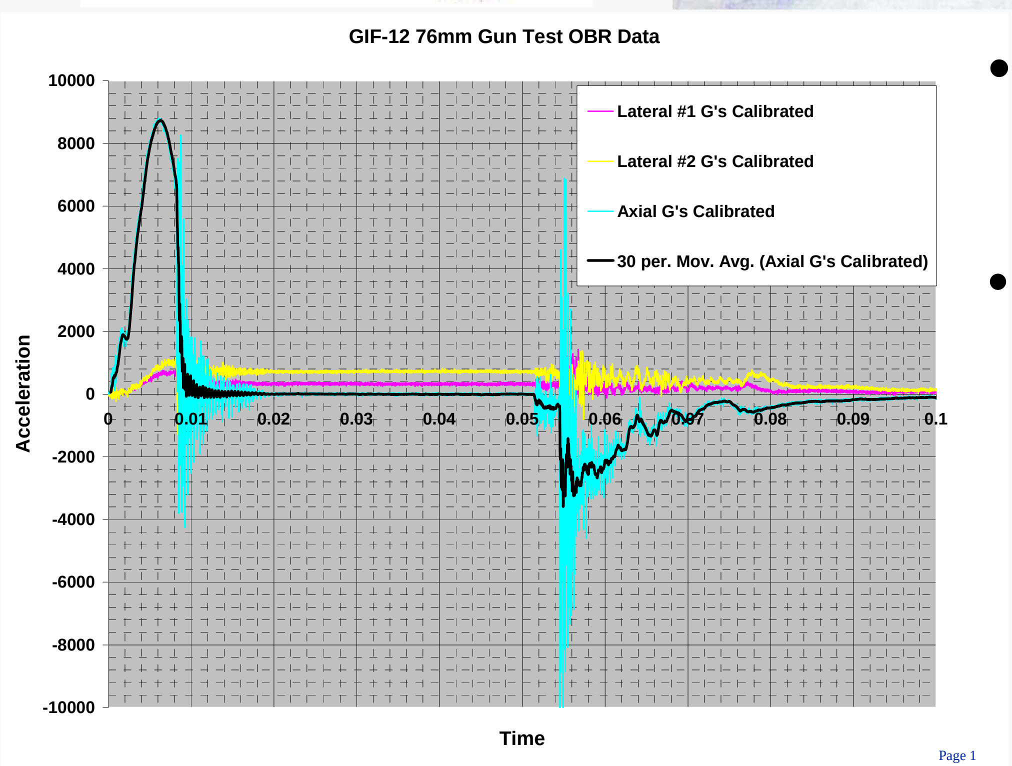
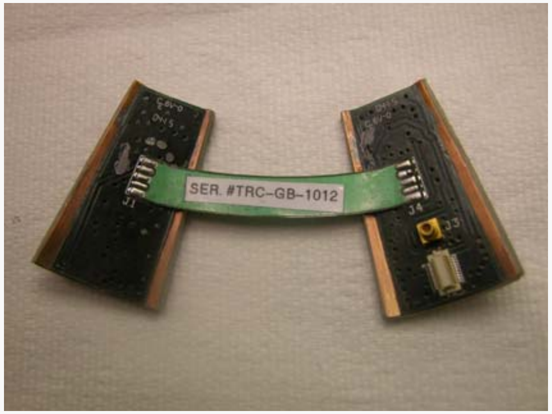
# CANARD ACTUATION SYSTEM

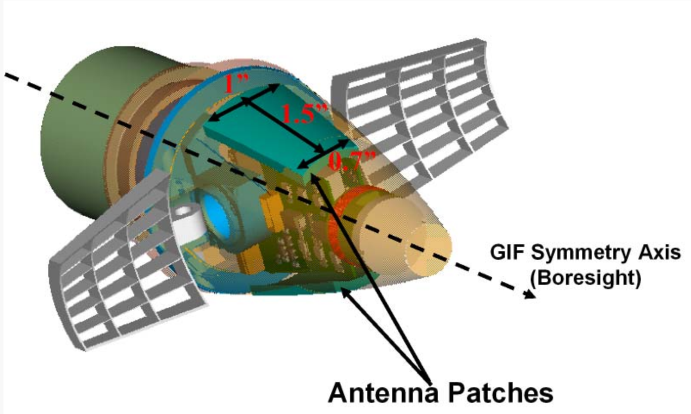





- A motor driven gear train was developed by CAES Corp.
- The CAS performed robustly. One system was tested five times to the gun G levels in the graph to the left and continued to perform without degradation.

# GPS ANTENNAS

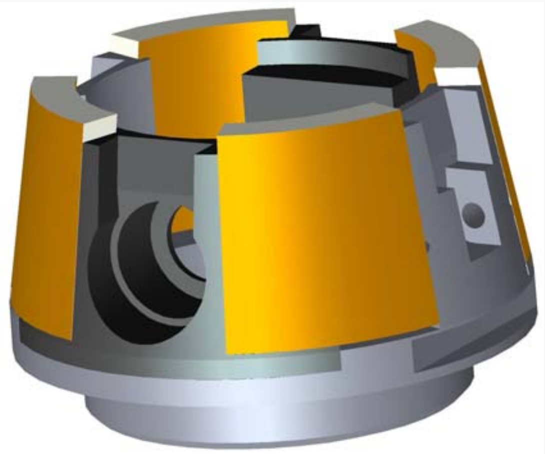


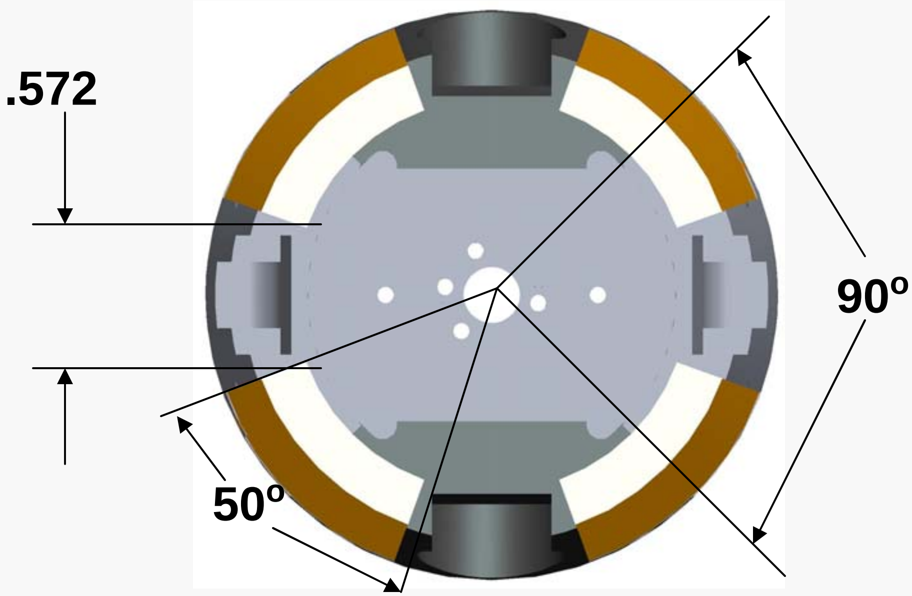



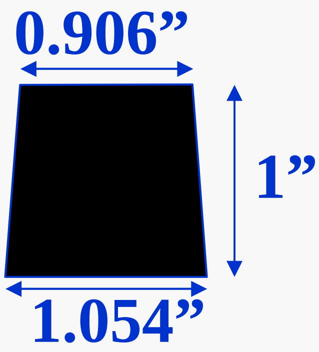

- Small aperture GPS antennas were developed to fit within NATO Standard Fuze dimensions by TOYON Research Corp.
- GIF uses two element active antennas.
- Four element linear and RHCP antennas were also developed.

# TOYON Antenna Design

## Passive Four Element





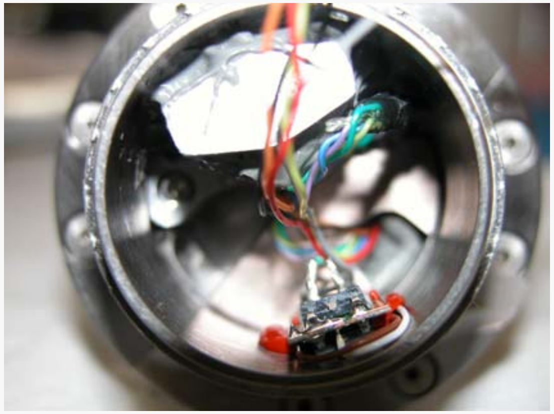



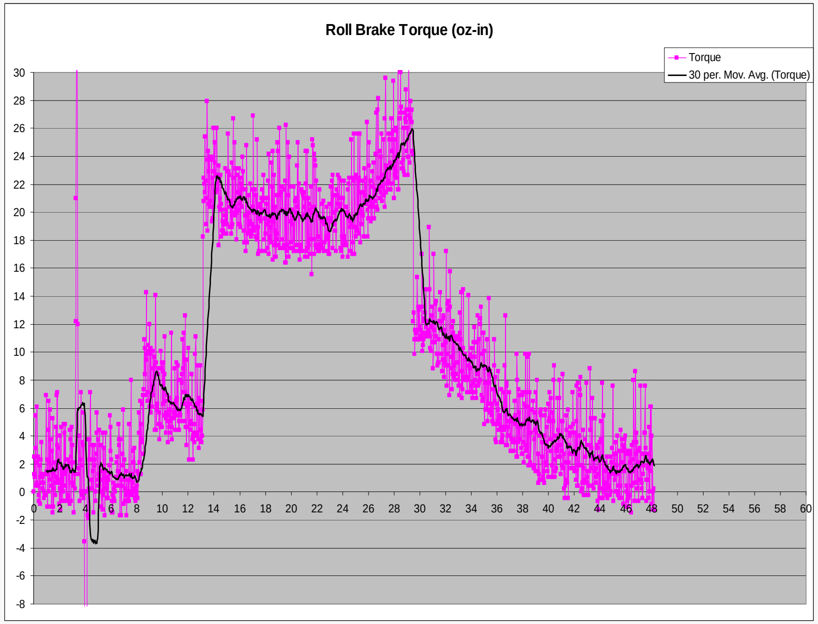

Tapered Profile Formed by:

- Bottom Radius – 1.208”
- Top Radius – 1.039”
- Thickness - .203”
- Axial Height – 1”
- Arc Width – 50$^o$

Base of antenna sits .25” above the fuze shoulder.

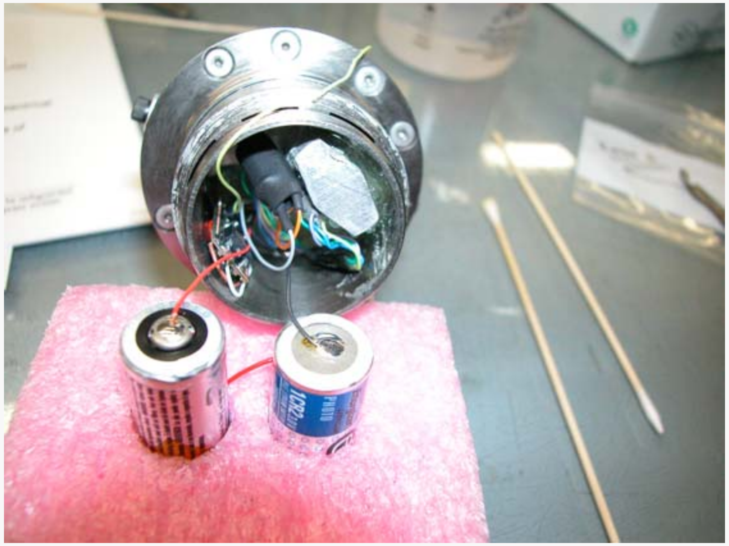
# ROLL BRAKE





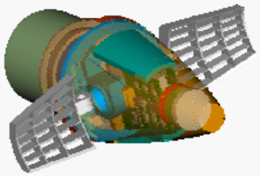

- Designed & produced by CAES Corp.
- The fuze is decoupled from the projectile body and a constant roll is induced in the opposite spin direction of the projectile.
- The roll brake is used to couple the fuze back to the projectile body by modulating the brake to hold the nose steady.

# CR2 BATTERY POWER

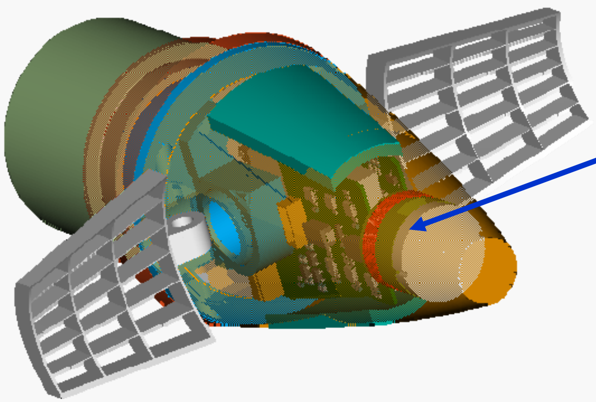


- Used commercial off the shelf batteries.
- G switch activated and used to power all fuze functions.
- The batteries survive gun shock.
- Artificial aging tests predicted a minimum shelf life of 7 years.

# Height of Burst & Inductive Set Repackaging



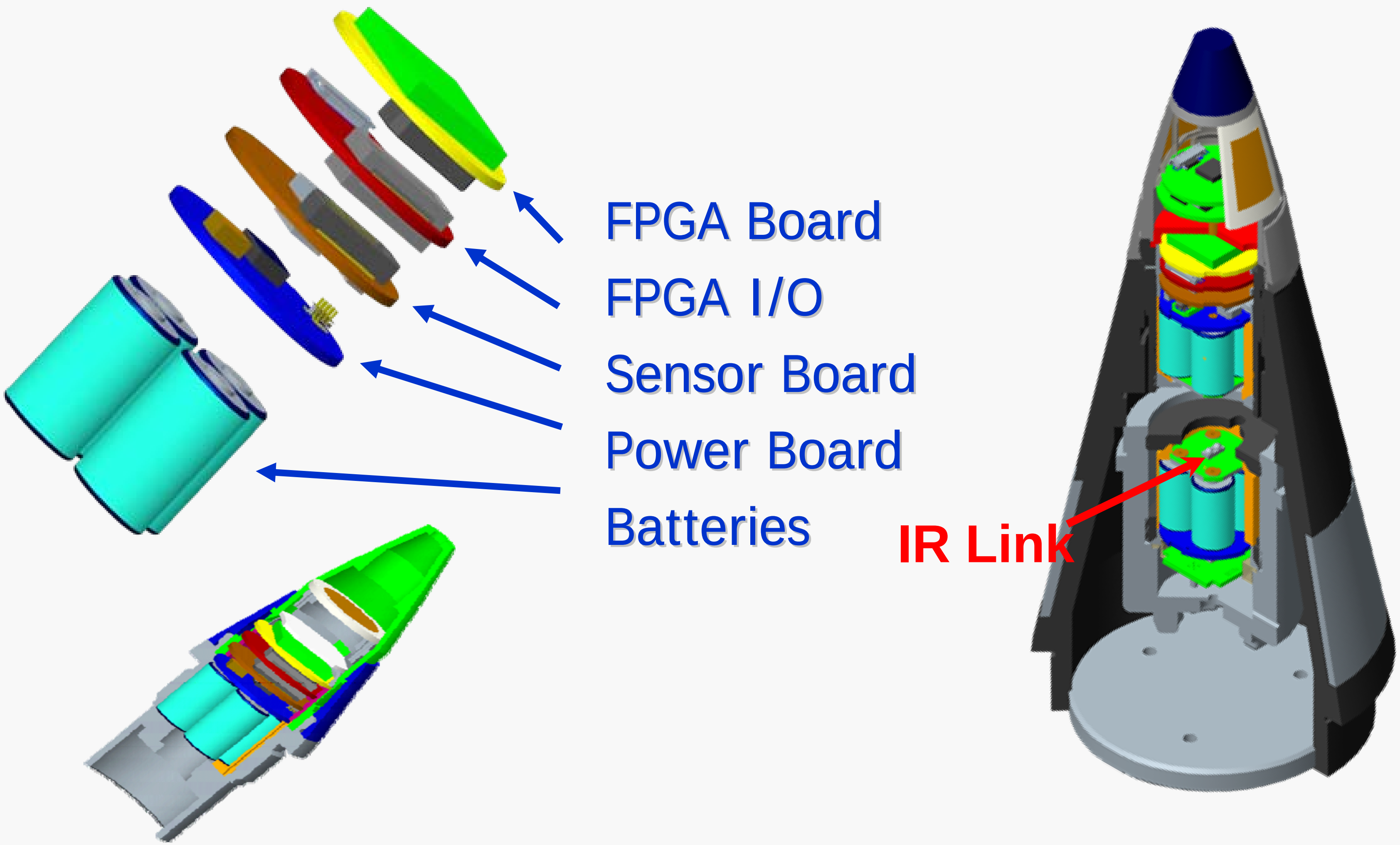
- Repackaged the MOFA signal processor into a single 1.075” diameter board solution.
- Coil form was shortened and coil modified to work with the EPIAFS setter.
- The standard MOFA antenna and MMIC was used.



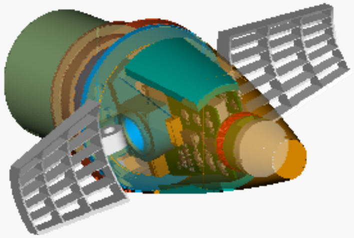
**HOB Sensor & Inductive Set**

Distribution Statement “A”

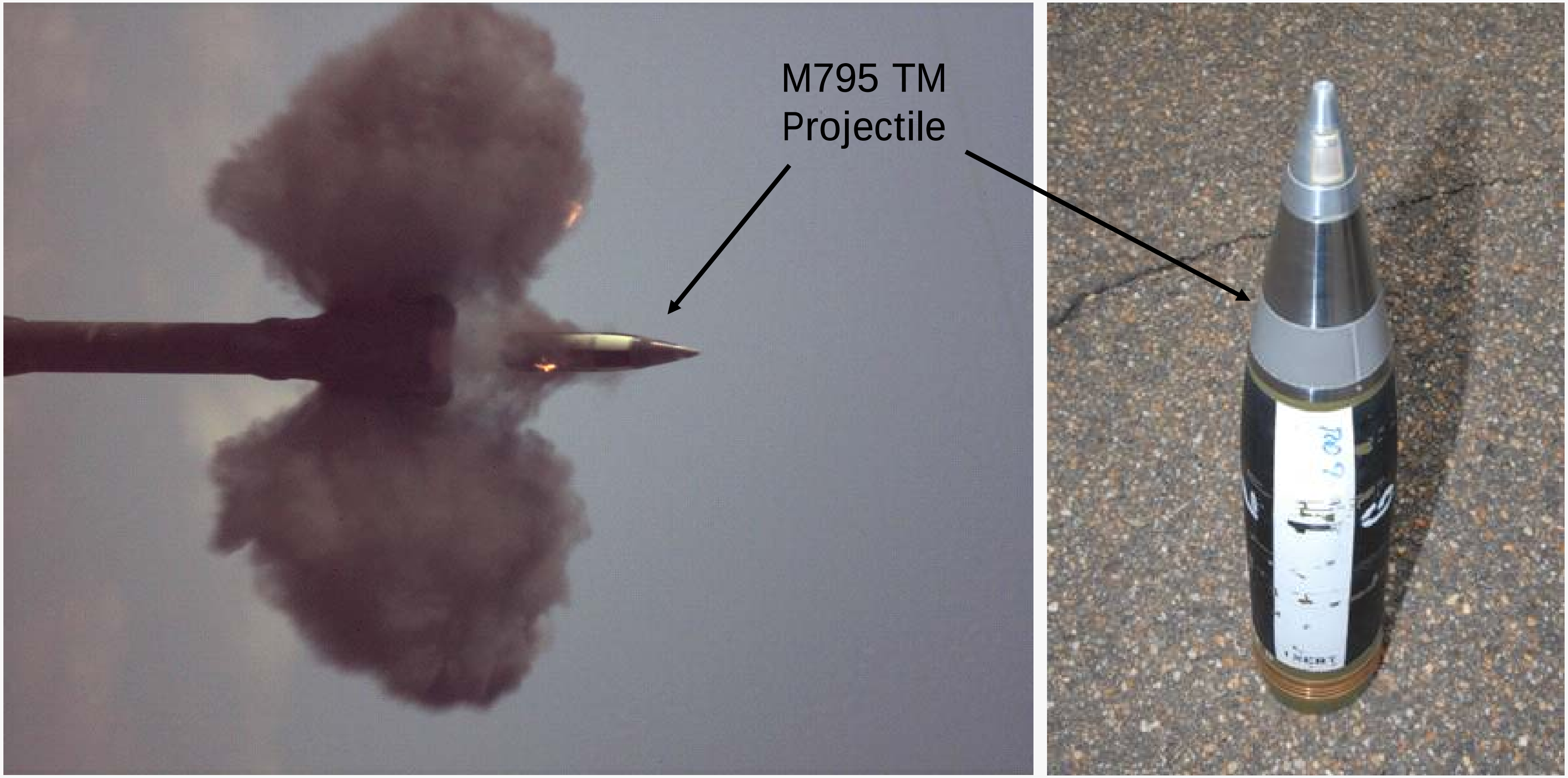
# Electronic Test Fuze (ETF)



# Telemetry Projectiles

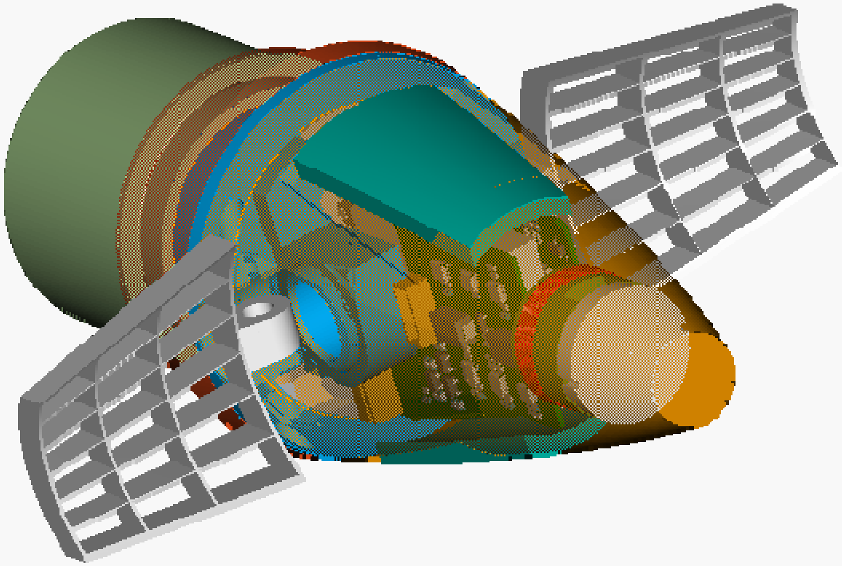


- M795
- M483
- M549 RAP



# GIF

# FLIGHT PERFORMANCE



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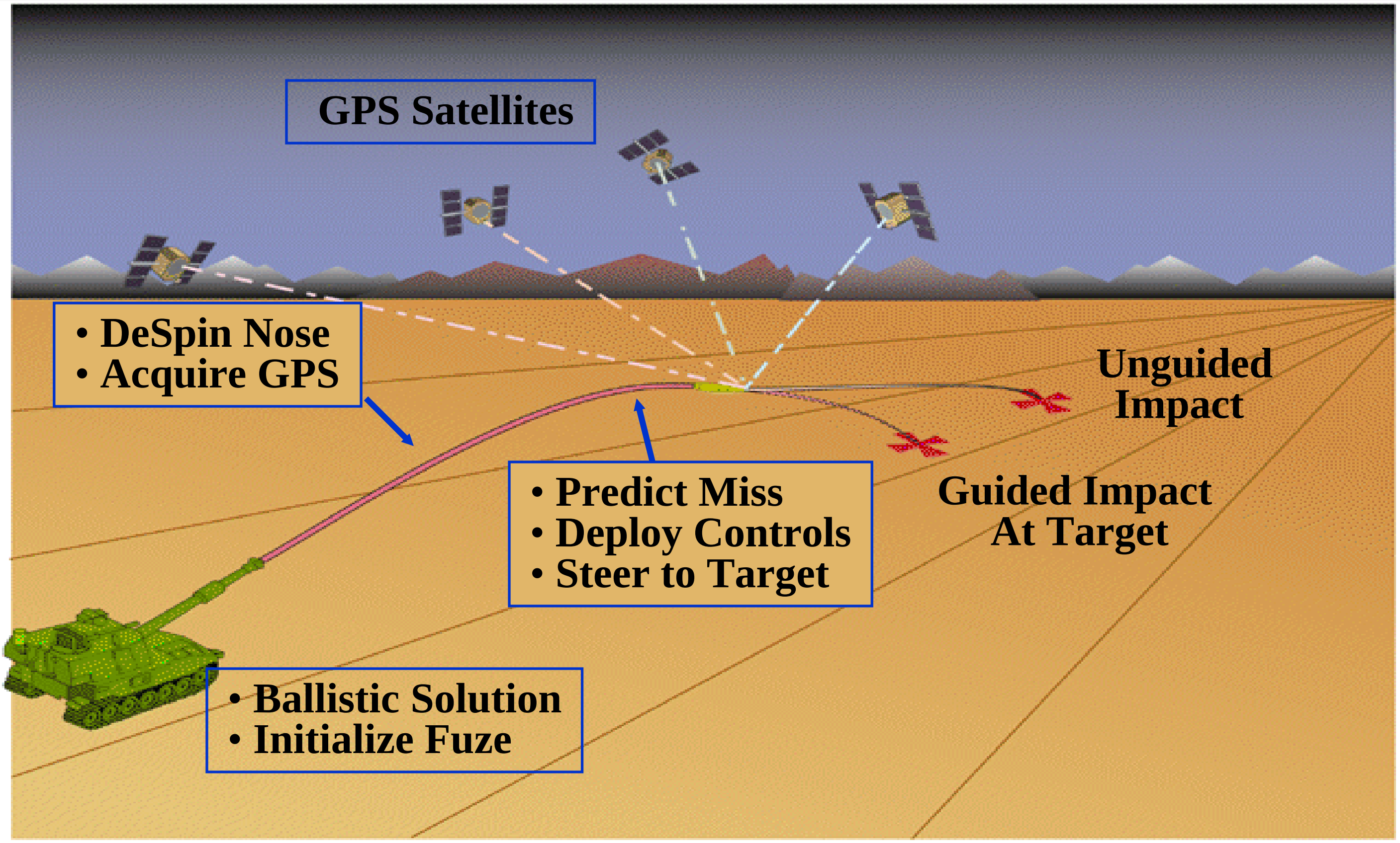
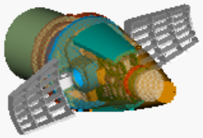
# GIF FLIGHT SEQUENCE



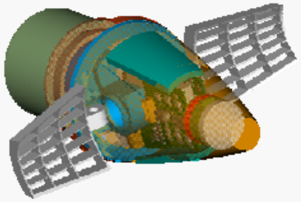

# Final GIF 10 & 11 Test



## May 2008-Dahlgren Potomac River Test Range

- Two GIF fuzes were gun fired on 155mm, M483 telemetry projectiles.
- Objective: fuze survival, GPS navigation solution, and guidance performance of the control surfaces.
- Fired 14,000 yards, with a total flight time of 64 seconds. Telemetry data was received for full flight.
- GIF 10 and 11 survived shock, controlled nose position, acquired GPS solution, and expelled canard covers.
- GIF 11 appeared to not deploy canards and the projectile became unstable and fell short of the target.
- GIF 10 did deploy canards and achieved closed-loop navigation.

# GIF10 Test Summary

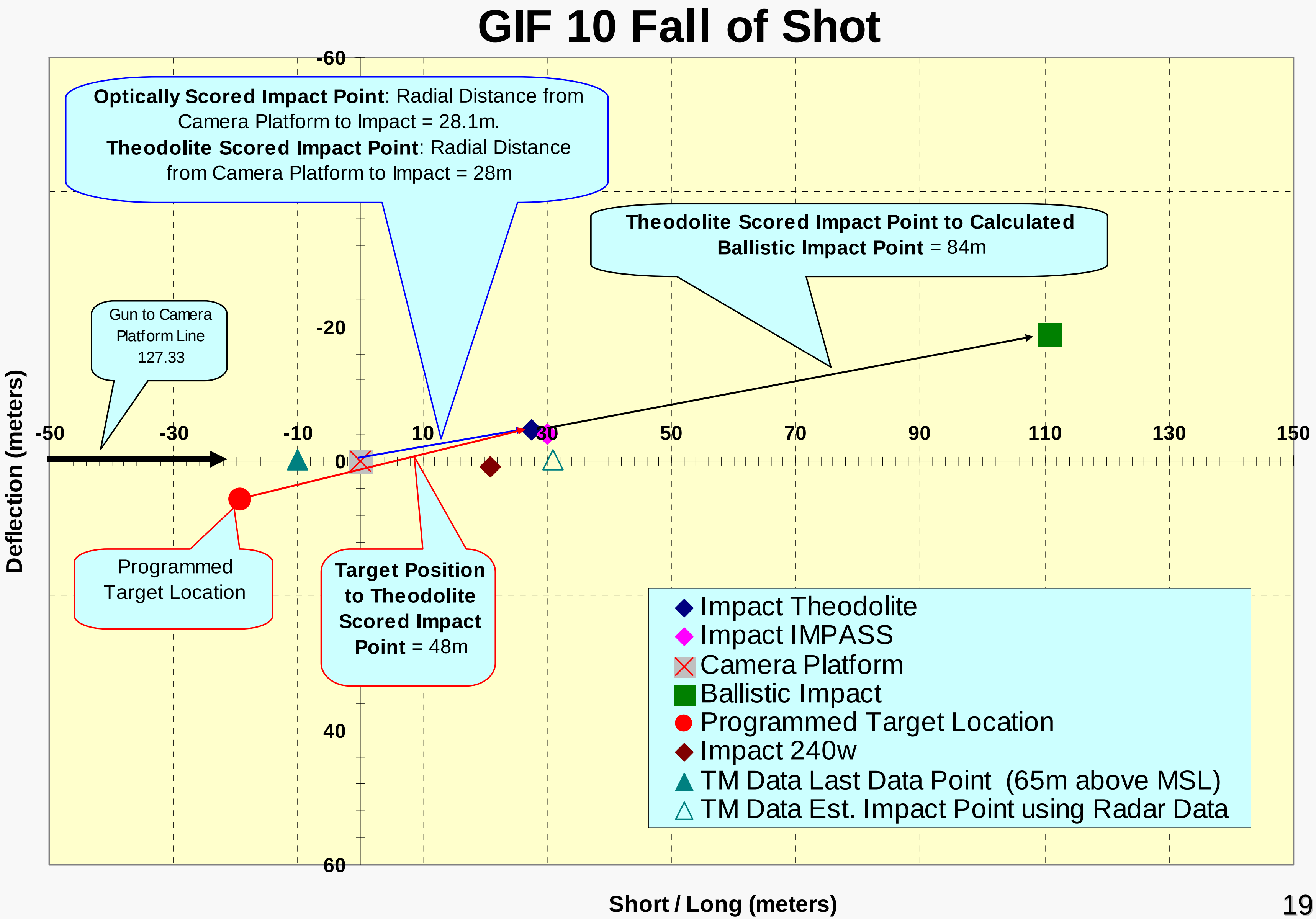


- GIF10 achieved closed-loop Navigation of a NATO-Standard Fuze eliminating ~84m of miss and splashing ~48m from the programmed target coordinates.
- Launch Conditions should have resulted in an unguided miss in excess of 132m so the GIF fuze steered out about 64% of the error.
- Loss of nose roll control and (apparently) limited control surface deflections (<7 deg) adversely impacted the final accuracy.
- The guidance algorithm was properly estimating the final miss distance to within 2 m when nose control was lost.

# Photo of GIF 10 Splash
## (48 M from target coordinate)

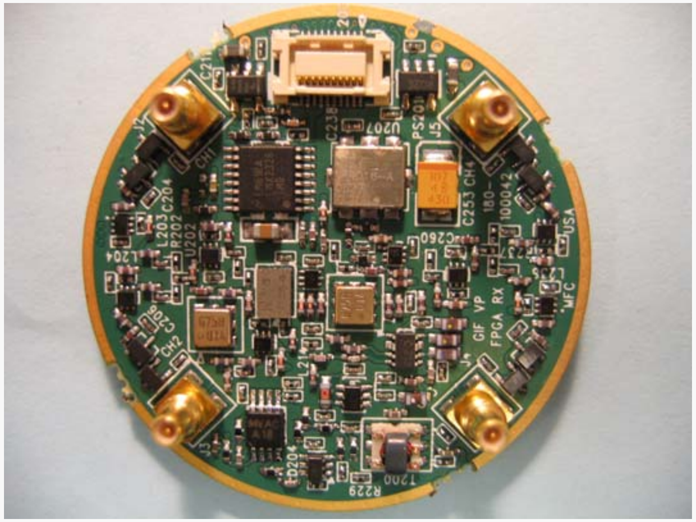

**48 meter Miss Distance Confirmed by Theodolites, IMPASS, Optical Cameras, and GIF Navigation System.**

# GIF 10 Scoring Performance



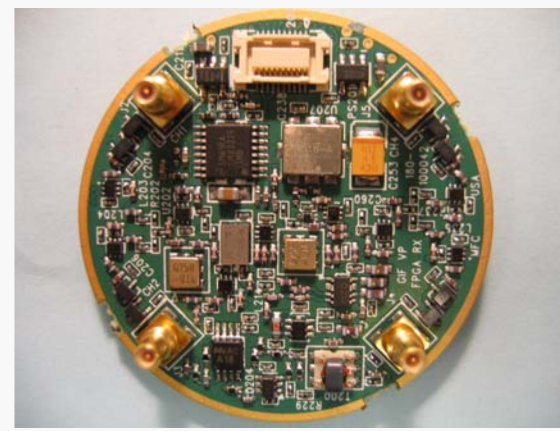
# GPS SAASM Receiver Development

– Produce a SAASM P(Y) GPS receiver with reduced cost/ power requirements and sized to fit within a NATO standard fuze contour.



# GPS SAASM Receiver

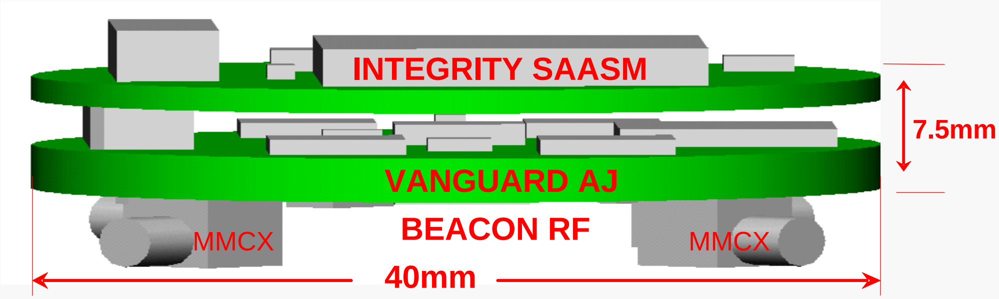
- No Existing Product Could Meet GIF Requirements
- Awarded Contract to Mayflower Communications Company, Inc. to Develop a SAASM GPS Receiver
  - Low Cost (< $500)
  - Low Power (< 1W)
  - Small Size (< 2 $in^2$)

**C/A Version**
**40mm dia.**

# GPS SAASM Receiver
## Cont'd

- Phased approach:
  - C/A Version w/ FPGA available now!
  - ASICs developed:
    - MAGIC C/A
    - VANGUARD AJ
    - BEACON RF
    - INTEGRITY SAASM
      - KDP-III-B
  - P(Y) SAASM Receiver Available Mar. 2010




**P(Y) SAASM Version**

# Up-Find & Anti-Jam Work

- Under our existing Navy contract, Mayflower Communications is tasked to:
  - Enhance the SAASM GPS receiver with an up determination capability using Satellite phasing alone (no sensors needed).
  - Complete the Anti-Jam module developed under a previous Navy contract.
  - The Army has funded these two tasks.

- Mayflower and NSWCDD are working toward:
  - Proof of Up-Finding in a jammed environment, up to three jammers, during 0 to 300Hz spin rates.
  - This testing will be done at Holloman AFB in mid May 09.

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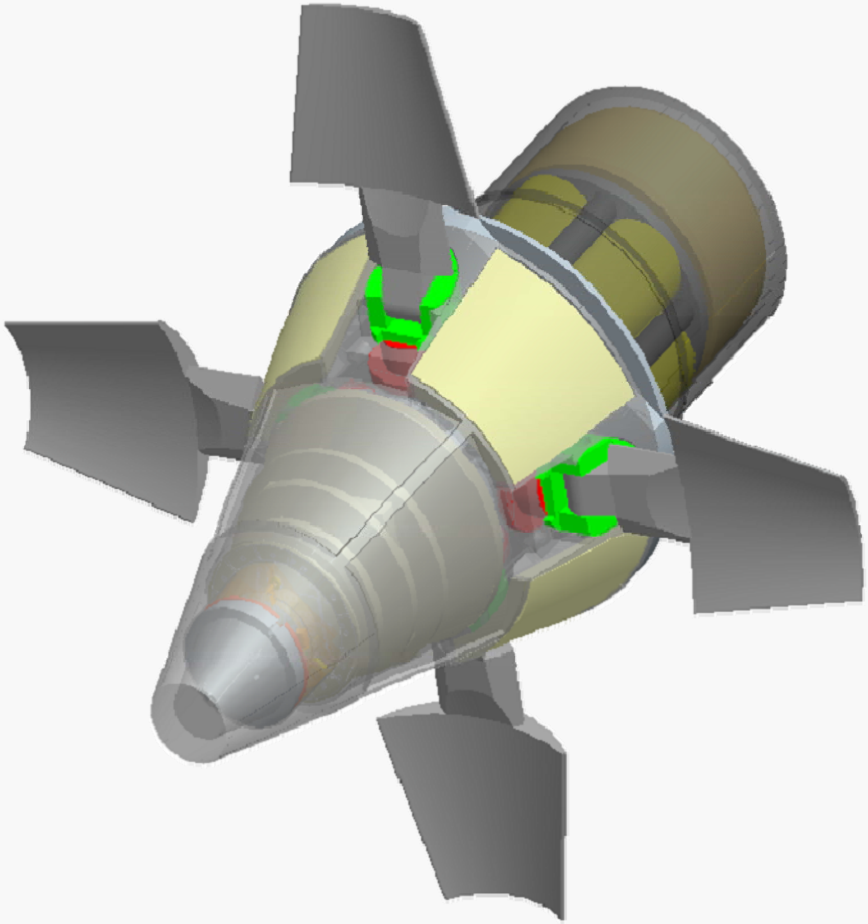
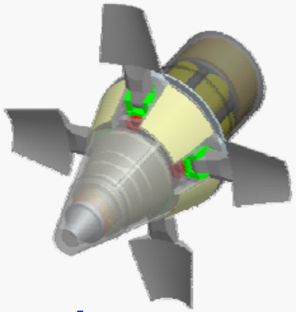
# VIPER FUZE DESIGN



# VIPER DESIGN, WHY?

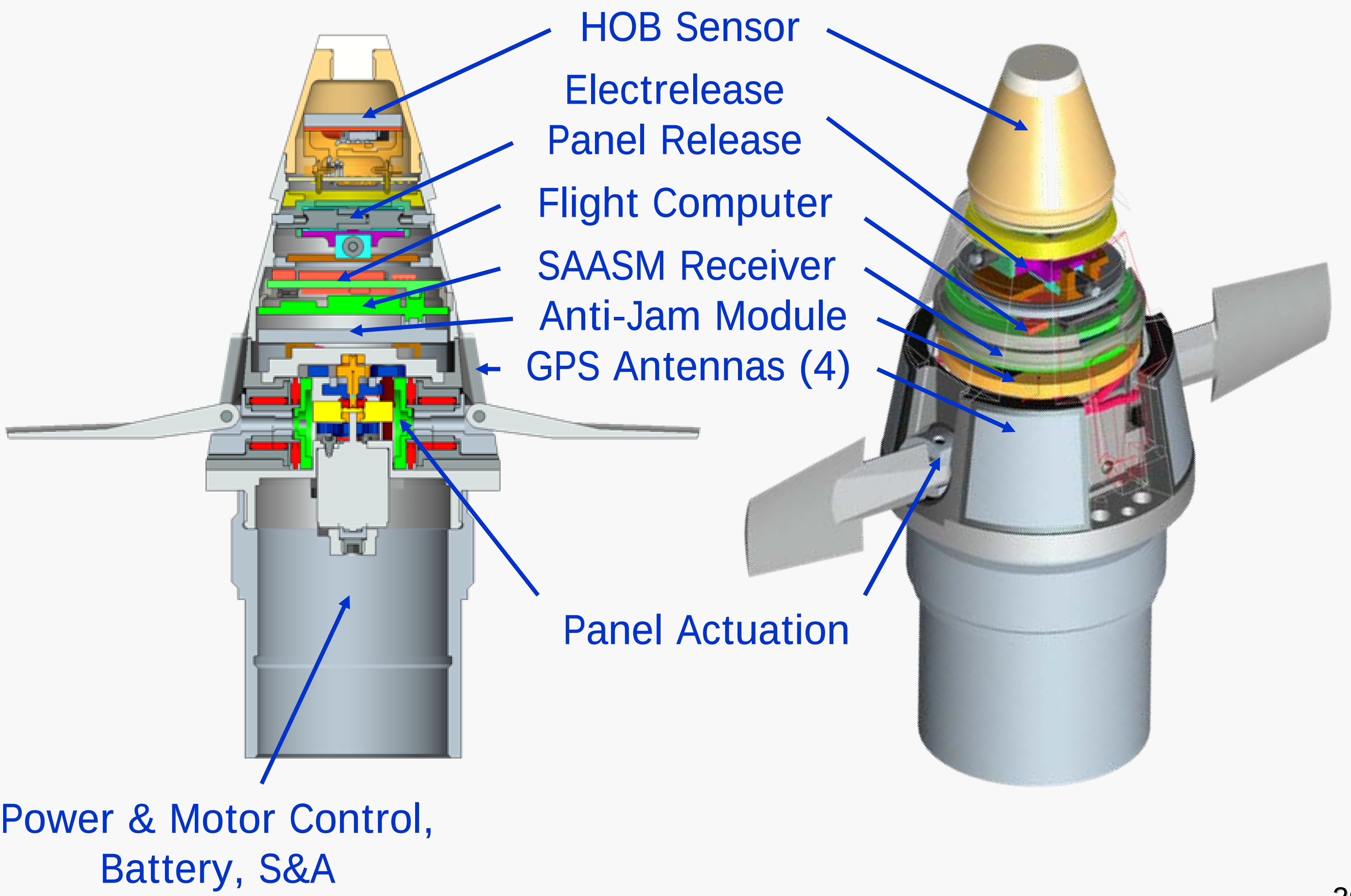


- In FY 2006:
  - The Army’s 155mm, M549 RAP projectile became the primary proof of concept projectile type (was M795).
  - CEP defined at 30-50 Meters
  - Design need not conform to a NATO standard contour.

- The GIF fuze had marginal control authority on a M549 projectile body per wind tunnel data.

- The Navy decided to pursue an in house guided fuze design which performed independent of the projectile body.

# “VIPER” Sectioned View



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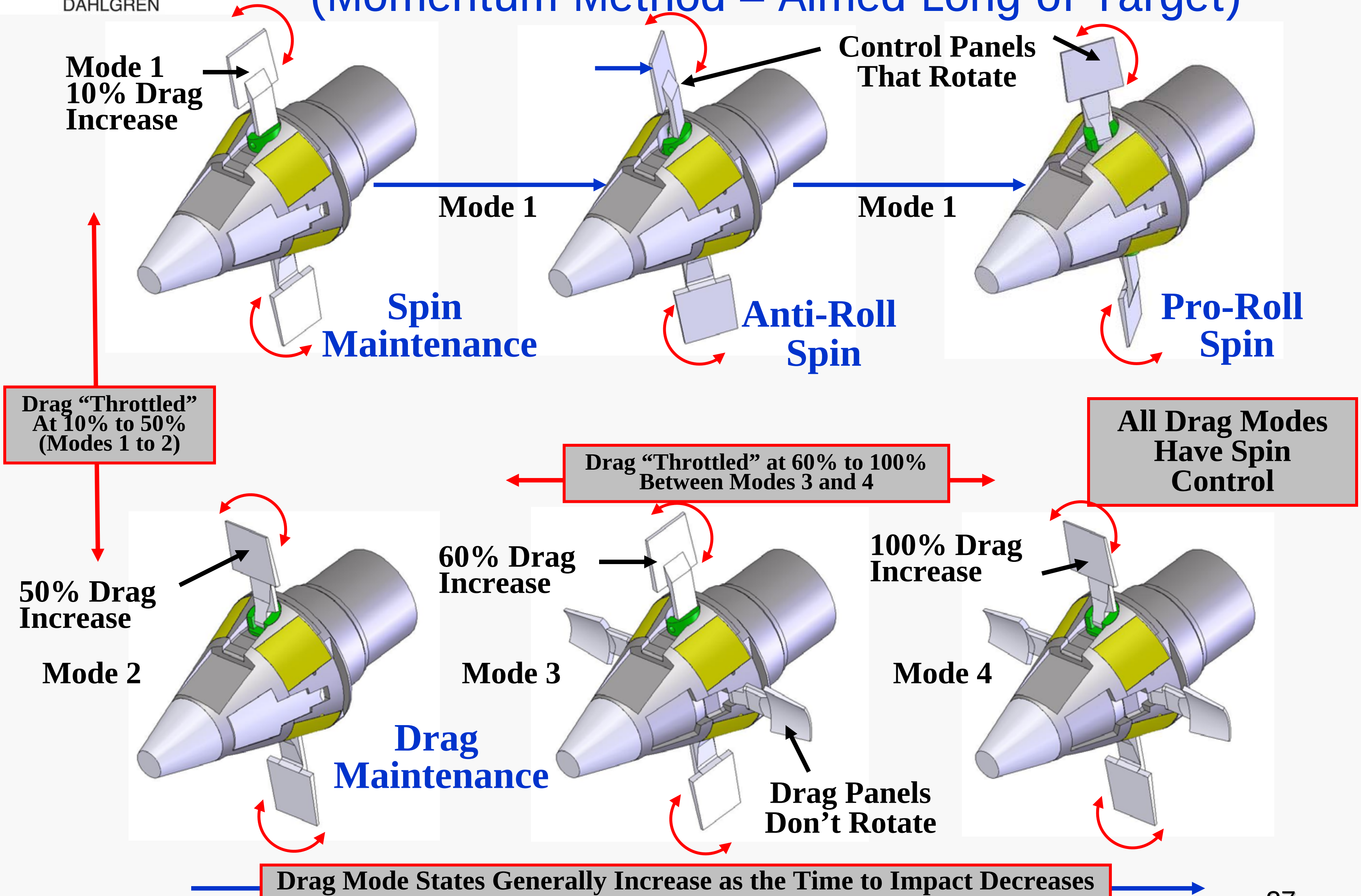
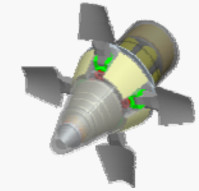
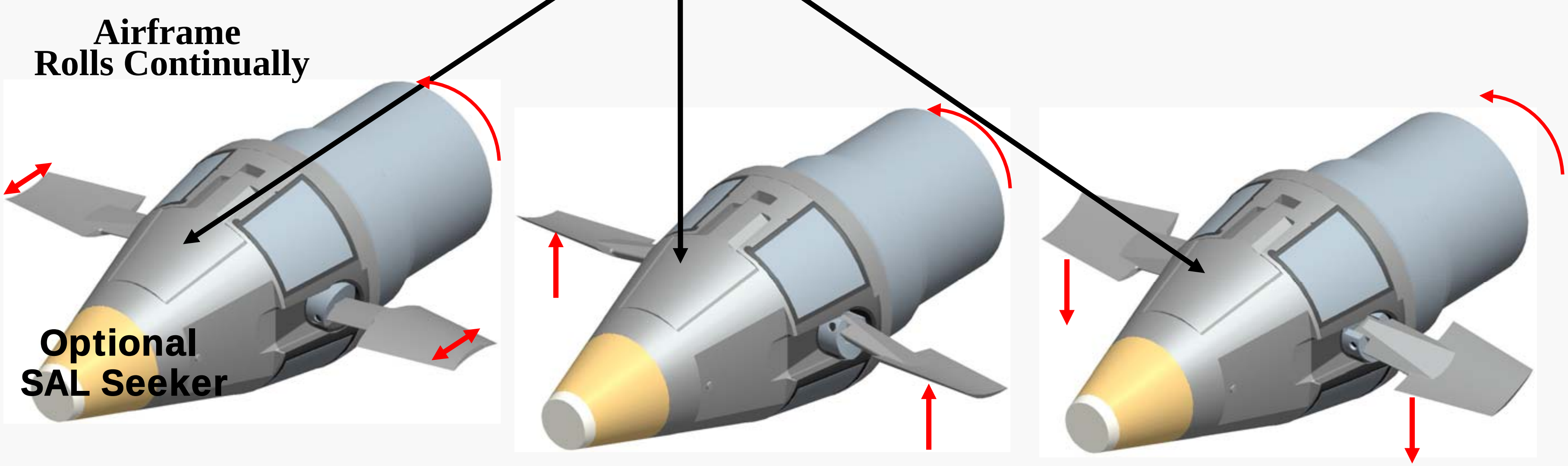
# VIPER Control Modes
## (Momentum Method – Aimed Long of Target)



# VIPER Control Modes
## (Lift Method)



Control surfaces move together in a sinusoidal pattern as the airframe rolls. Drag panels can be deployed if necessary.



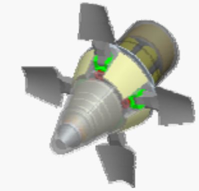

0 deg Deflection

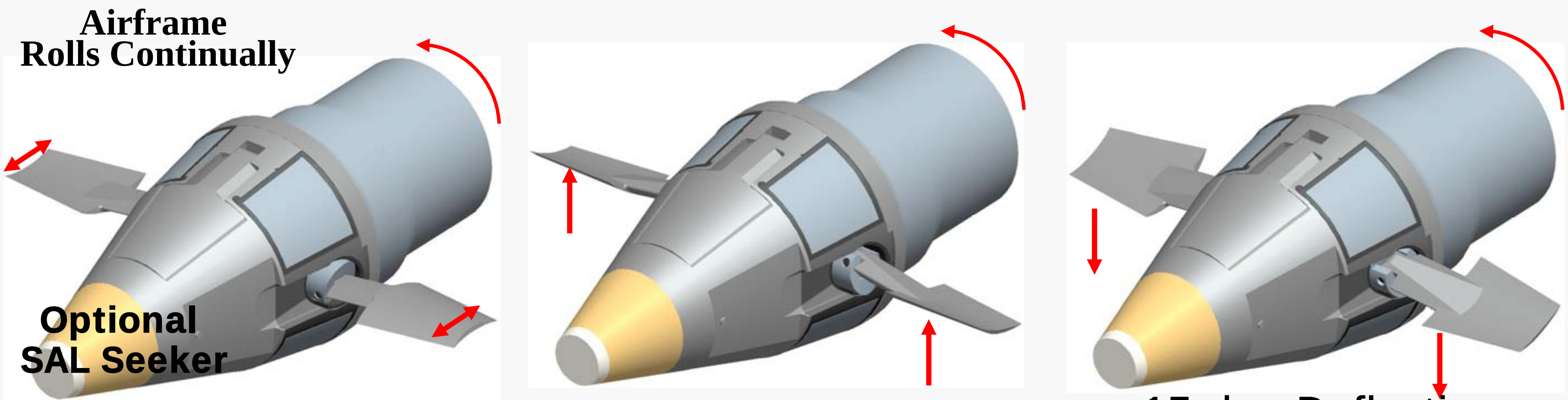
+15 deg Deflection

-15 deg Deflection

- All Fin-Stabilized munitions roll continuously due to fin cant. VIPER can shift to it's "Lift Mode" Configuration.

# VIPER Control Modes
## (Lift Method) Cont’d






0 deg Deflection    +15 deg Deflection    -15 deg Deflection

- In this mode, the VIPER control system modulates its control surfaces in phase with the desired maneuver correcting both range and cross range errors.
- A CEP of less than 10m using GPS and approximately 1m with an Optional Semi-Active Laser (SAL) Seeker can be achieved.


# QUESTIONS