

GENERAL DYNAMICS

Armament and Technical Products



APKWS Flight Test Results

Validation of Aerodynamic Coefficients

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April 27, 2005

40th Annual Gun & Ammunition/Missiles & Rockets Conference & Exhibition



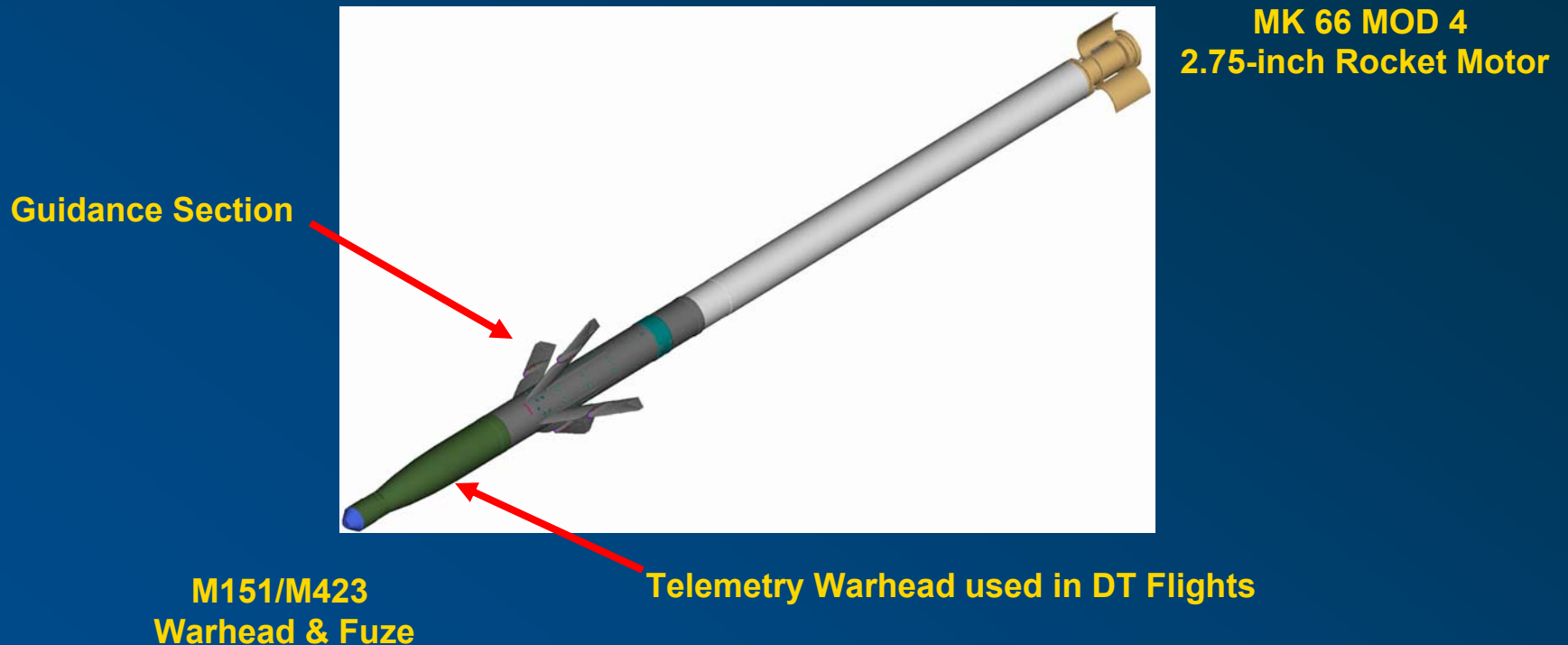
Agenda

- APKWS Guided Rocket
- F-4 Telemetry Data
- Validation of Aerodynamic Coefficients
- Preprogrammed Flight F-4 Maneuvers
- Inertially Guided Flight F-4
- F-4 Post-flight Analysis
- Guided Flight F-6A
- Lessons Learned

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APKWS Guided Rocket



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F-4 Telemetry Data

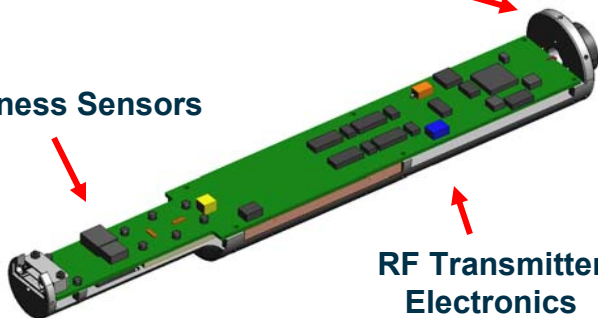
**RTTC M151
Telemetry Warhead**



Wireless IR Interface

Witness Sensors

**RF Transmitter
Electronics**



Witness Sensors Provide:

- Axial acceleration
- Lateral acceleration
- Normal acceleration
- Yaw rate
- Pitch rate
- Roll Rate
- Y axis magnetic field strength
- Z axis magnetic field strength

Guidance Section IMU Provides:

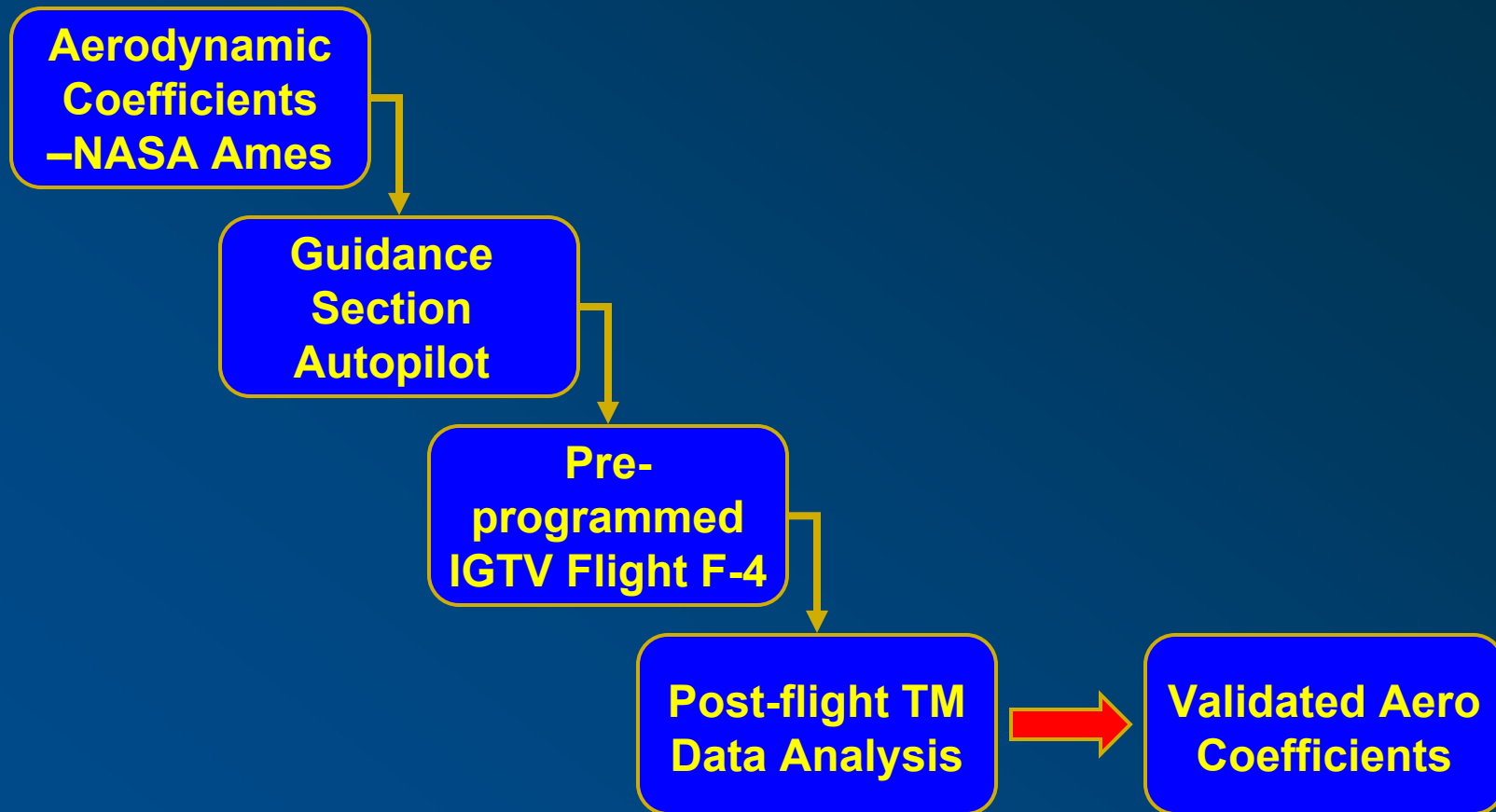
- Yaw rate
- Pitch rate
- Roll rate

Other G&C Data:

- Seeker Angle and LOS Rates
- CAS Data

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Validation of Aerodynamic Coefficients



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Preprogrammed Flight F-4 Maneuvers



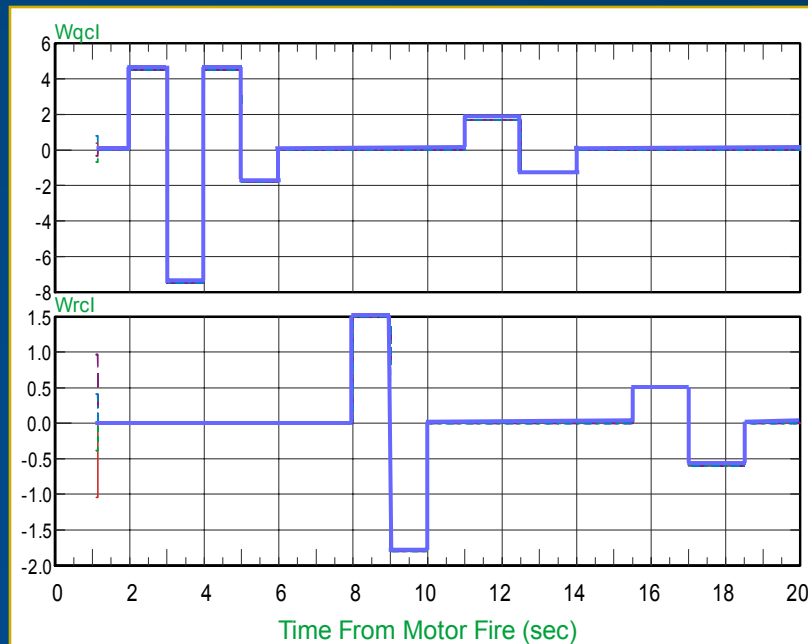
- Preprogrammed Autopilot Rate Commands
 - Aerodynamic coefficients from NASA Ames Tunnel data
- Flight Path Angle Rate Commands Processed Through Lead Compensation
 - Provides steady trim conditions for validating aerodynamic control derivatives
 - Resulting body rates indicate aerodynamic control power
- Roll, Pitch, and Yaw Fin Test Tones Added to Observe Control Derivatives at Trim Conditions
 - Roll fin tone: 3 degrees at 20 Hz
 - Pitch/Yaw fin tone: 6 degrees at 10 Hz

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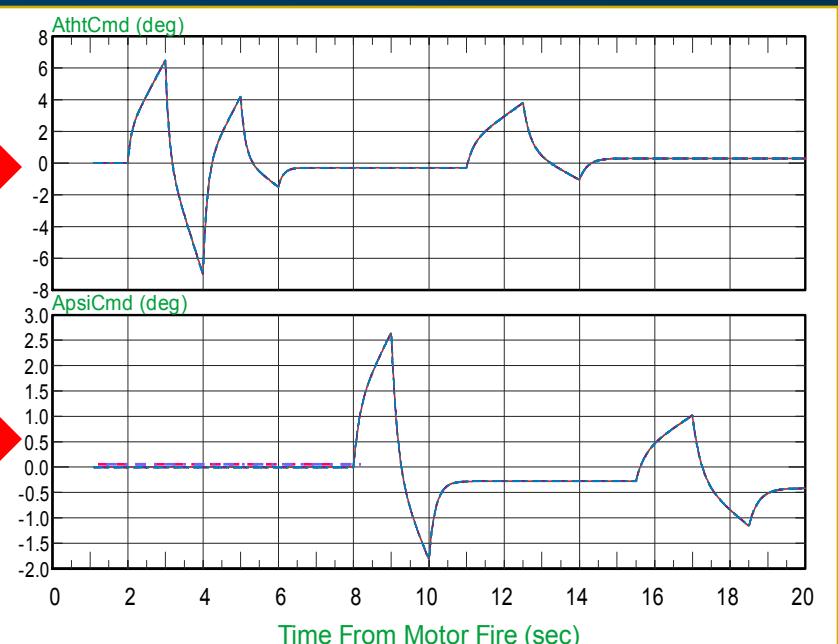
IGTV Flight Path Angle Rate Commands and Body Attitude Commands



Flight Path Angle Rates (deg/sec)

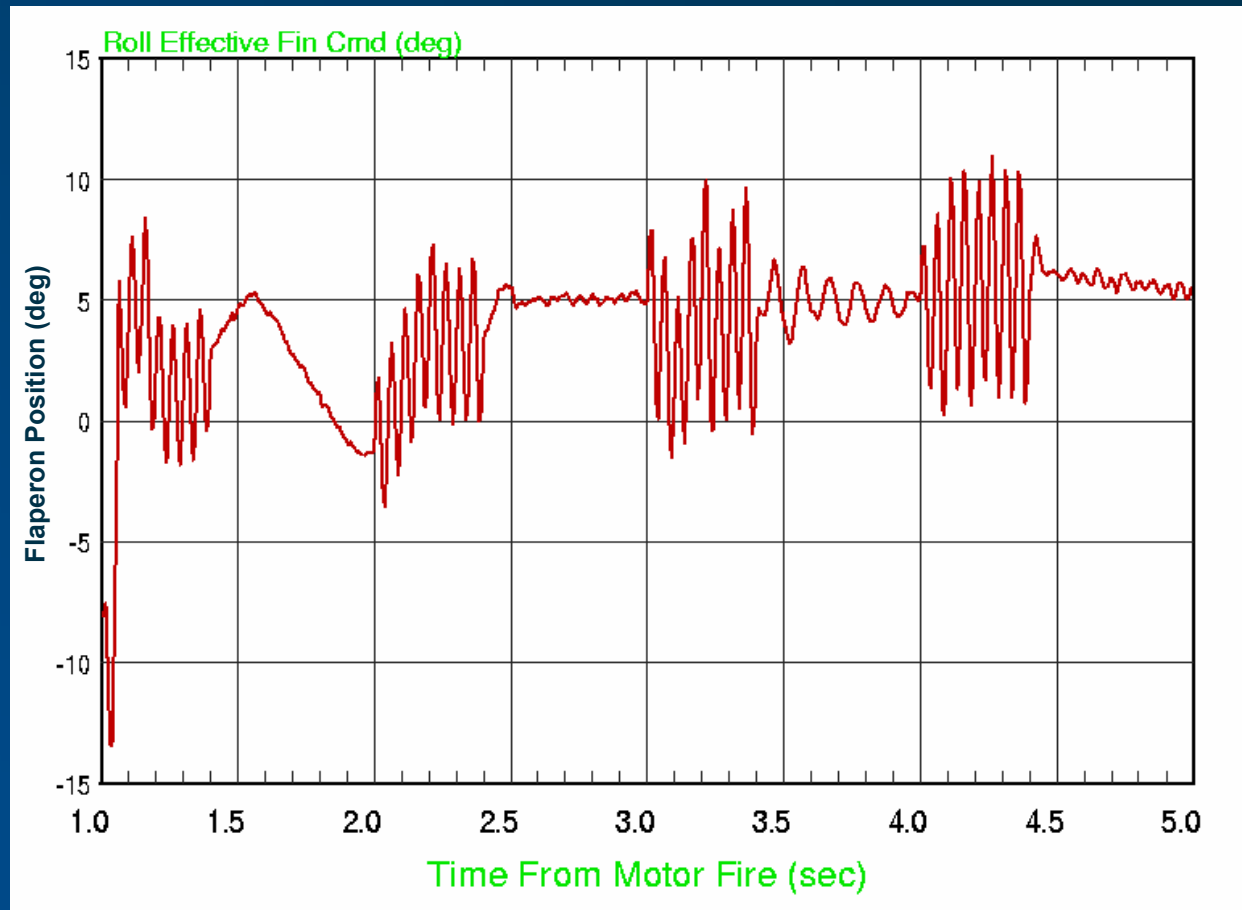


Body Attitude Commands (deg)



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Roll Fin Tones



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IGTV Flight Test F-4

- Inertially Guided Test Vehicle Flight F-4
 - Guidance loop intentionally deactivated
 - Ambient Temperature
 - Ground Launched: Army M260 Launcher
 - Target Range: 5 km
 - Target Board: 15.3% reflectivity
 - Target Remote Laser Designator: 0.8 km
- Test Results
 - Wings deployed and airframe de-rolled
 - Seeker acquired target during limited period
 - Preprogrammed flight maneuvers and tones executed
 - Characterized airframe performance over 38 sec flight

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APKWS F-4 Flight Test Video

May 20, 2004 – Site C-7, Eglin AFB



FLIGHT TEST F-4

ARMY APKWS

PROJECT UZZE0068

MISSION # 3204

DATE: 05/20/04

SHOT# R0002

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F-4 Post-flight Analysis

- Post-flight Analysis Of F-4 Telemetry Data Revealed Differences In Flight Test vs. NASA Ames Wind Tunnel Aerodynamic Performance
- 6-DOF Model Simulations Were Matched To Flight Test Data To Obtain Corrected Aerodynamic Coefficients
- New Aerodynamic Coefficients Loaded Into Tactical Software
- Updated Tactical Software Flown On Flight F-6A
 - Guidance loop closed to intercept laser designated target

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Guided Flight Test F-6A

- Ambient Temperature
- Ground Launch: Army M260 Launcher
- Target Range: 5 km
- Target Board: 31% reflectivity
- Remote Laser Designator: 1.9 km
- Guidance Loop Activated

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APKWS F-6A Flight Test Video

September 10, 2004 – Site C-7, Eglin AFB



FLIGHT TEST F-6A

ARMY APKWS

PROJECT UZZE0068

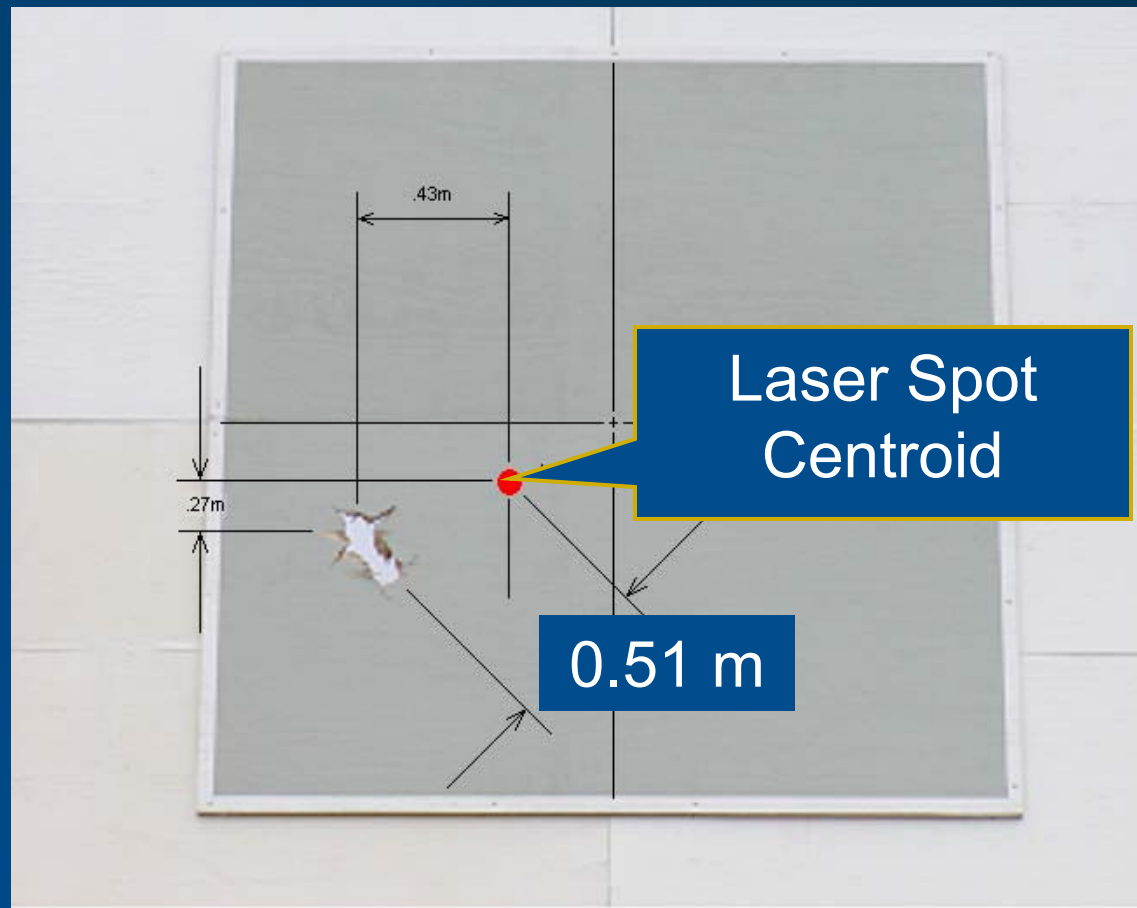
MISSION # 5878

DATE: 09/10/04

SHOT# R0004

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APKWS Flight Test F-6A Target Impact from 5 km Range



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Lessons Learned

- Comparison to NASA Ames Wind Tunnel Data
 - Drag match accomplished with small drag increase
 - TM warhead antenna features
 - Roll aerodynamics matched with reduced
 - roll control power
 - roll damping

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