Air Force SEEK EAGLE Office

Think, Innovate, Deliver

U.S. AIR FORCE

Physics-based Modeling: Supporting the Seek Eagle Mission and the Air Armament Enterprise

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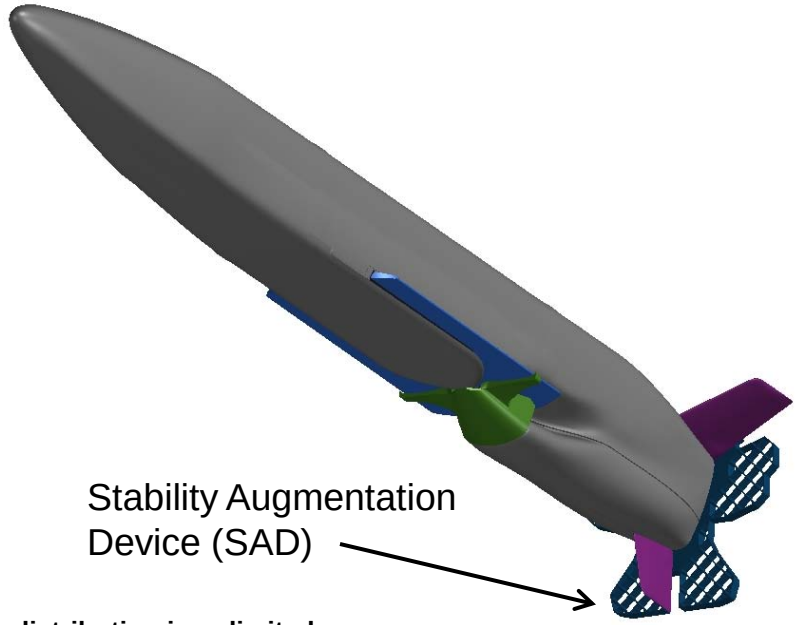
Overview

- Air Force SEEK EAGLE Office (AFSEO), 46th Test Wing, EGLIN AFB FL
  - Ensure new warfighter capabilities through the application and transfer of aircraft-store compatibility expertise.
  - Accomplish through test, analysis & physics-based modeling & simulation
  - Provide direct support to the Air Armament Enterprise delivering warfighter capability across USAF platforms and flight regimes
  - DoD High Performance Computing (HPC) assets critical to reducing test & program risk while optimizing available test resources
  - Primary Engineering Disciplines: Store Separations, Computational Fluid Dynamics, EMC/EMI, Stability & Control, Aircraft/Store Loads, Flutter

- Physics-based modeling discussion highlights:
  - ADM-160 Miniature Air Launched Decoy (MALD)
  - Emerging Applications: Flight Mechanics & Fluid Structure Interaction
  - Challenge Case Study: B-52H

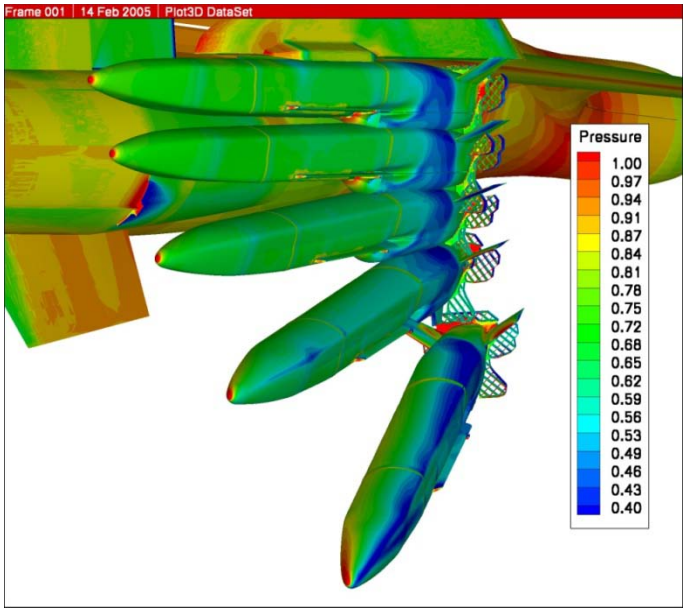
Miniature Air-Launched Decoy (MALD)

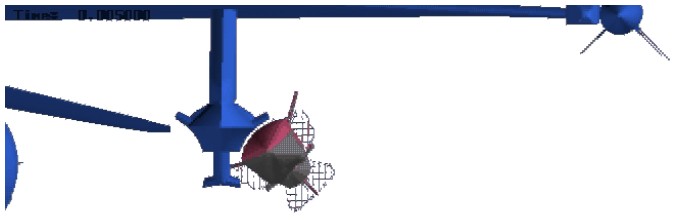
- Raytheon-designed 250-lb store duplicates flight profiles & signatures of USAF aircraft
- Unpowered separation from F-16 & B-52 in multiple carriage configurations
- SAD mounted at the rear of the store to maintain stability during separation from a/c & ejected before engine ignition
- CFD effort launched during final design stages to validate safe & effective separation throughout flight envelope & support wind tunnel test
- Phases of CFD effort:
  - Validated w/ freestream wind tunnel data
  - Static runs w/ aircraft present
  - Prediction of store separation trajectories
- DoD HPC assets critical to success of CFD effort

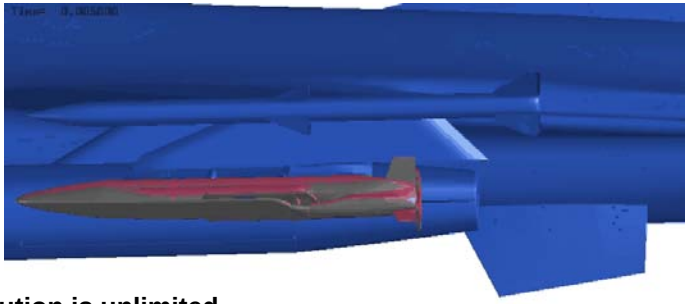


Miniature Air-Launched Decoy (MALD)

- CFD results showed at high Mach/Airspeed:
  - MALD separates safely from the aircraft
  - Significant downward pitching, outward yawing & excessive rolling
- Implication: Employment at desired max carriage limit brought into question
- Flight test program proposed & executed to address M&S concerns
- Flight Test
- CFD (red) vs. Flight Test (gray) – front view
- CFD (red) vs. Flight Test (gray) – side view
- Flight test confirmed concerns found by CFD
- Early ID of employment challenges to desired limits enabled design changes, avoiding wind tunnel re-entry with redesigned MALD ($500K+)
- Effort: 500K CPU hrs & labor costs of $65K
- MALD now fielded on F-16 to required limits

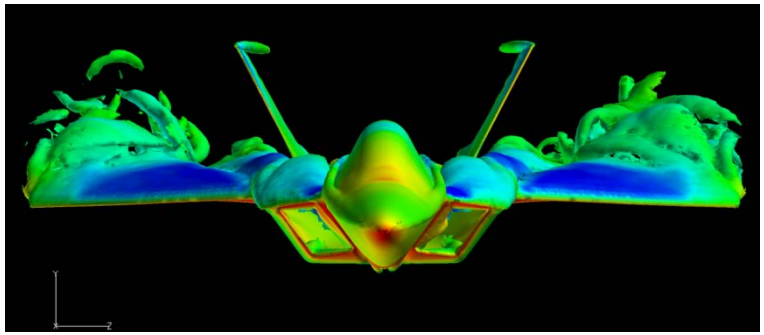


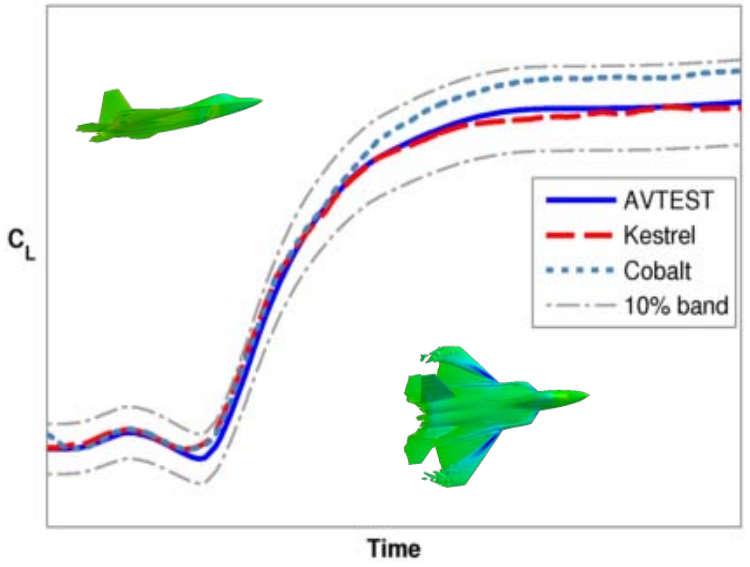




Emerging Applications:
Flight Mechanics & Fluid Structure Interaction

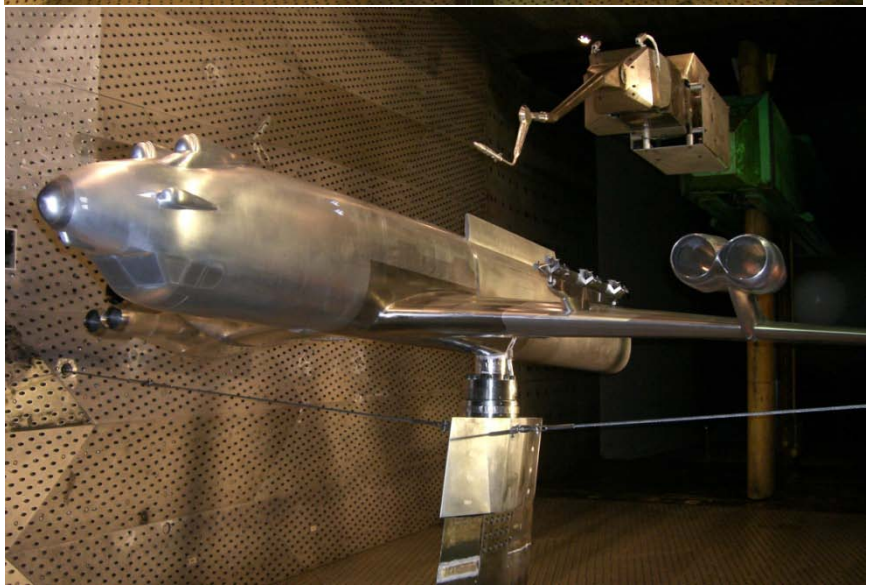
- Desired Capability: virtual flight test simulation in CFD with 6-DOF, moving controls, control laws, propulsion & flexible structure
- Current Status: rigid body, prescribed motion of realistic flight test maneuvers & match to validated test data
- Simulation: F-22 Wind Up Turn, Mach = 0.6
- LM F-22 ATLAS used to simulate maneuver & generate CFD prescribed motion file
- LM AVTEST Aerodynamic database used as validation data
    - 1:1 comparison → rigid body, aero only, no engine/thrust/flex effects, controls at 0/0/0
- Grid: 16M cells; Maneuver Length: 12s; Iterations: 30,000; Δt: 0.0004s; CPU hrs: >29,696; Clock Time: 29 hrs on 1,024 procs
- Play Movie





Challenge Case Study: B-52H

- Warfighter requires enhanced guided weapon capability on the B-52H
- Existing computational tools & HPC resources insufficient to meet schedule requirements
- Phase I: Delivering 7 weapons in various carriage configurations & positions
- Program required new 10% scale model
- Testing in AEDC 16T
- Data points:
  - 500+ freestream runs
  - 5,500+ interference flowfield grid pts
  - 475+ captive trajectories
- Flight test assets: > 20
- Program Cost: $20M+
- This program-type is the carrot M&S must chase to reduce acq & program costs



Final Thoughts

- Physics-based modeling critical to accomplishing the Seek Eagle mission, supporting the Air Armament Enterprise & delivering timely capability to the warfighter
- M&S complements test and enables us to optimize available test resources
- Models must be validated and applied appropriately → engineering judgment
- DoD HPC capability must not be allowed to atrophy
  - Seek Eagle alone used over 35M CPU hrs in FY11 across several machines
  - Since FY01, over 200 projects & programs have relied on HPC
  - M&S/HPC use is accelerating to fill test & data gaps across systems & engineering groups
  - Next-gen M&S tool-suite required to tackle these problems efficiently
- **Highly-trained, educated, motivated workforce critical to pushing the envelope**

Questions?