

# ***HQ U.S. Air Force Academy***

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*Integrity - Service - Excellence*

## **High Performance Computing Research Center**



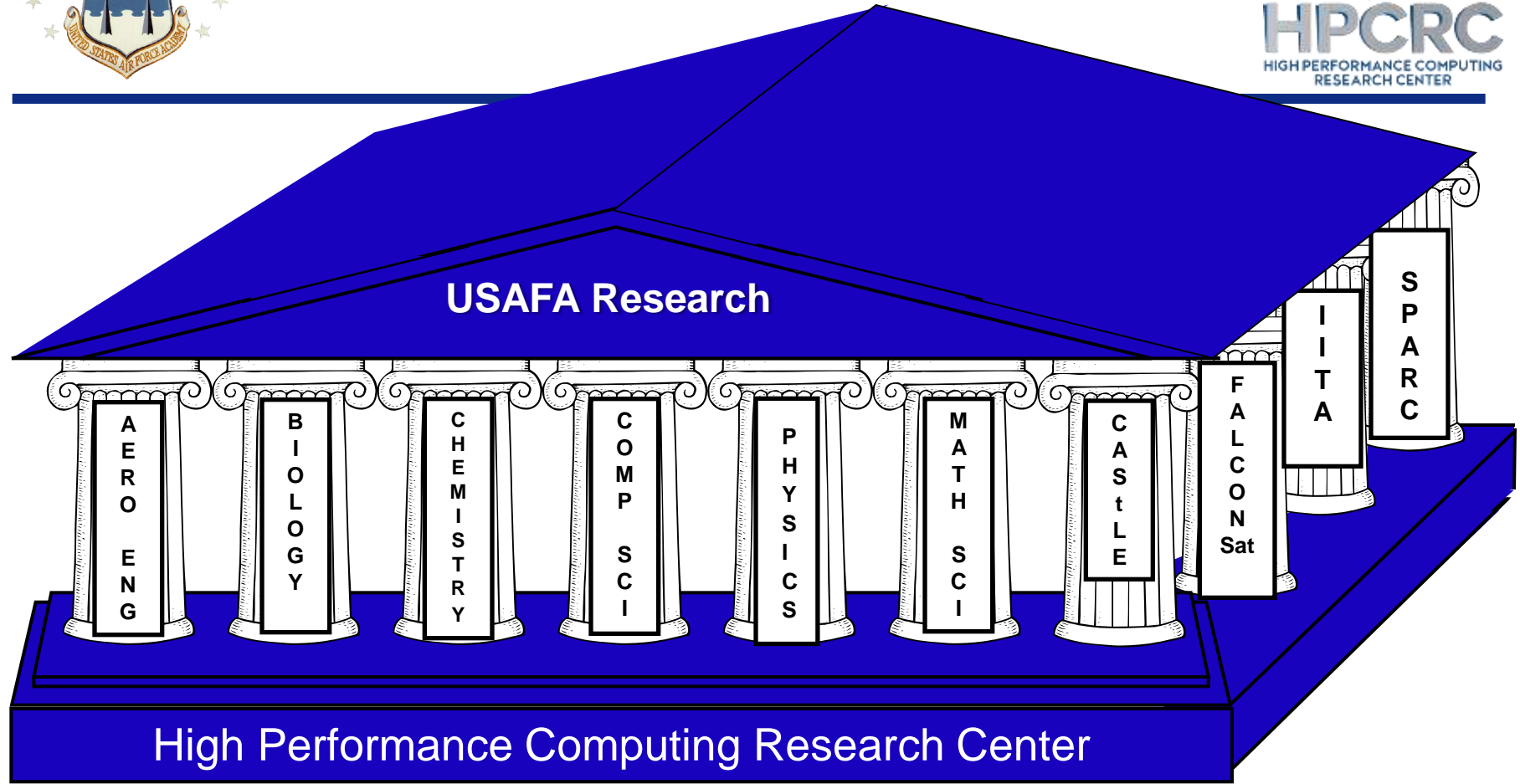
**Lt Col Andrew Lofthouse**  
**Director**

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# HPC Research Concept



**HPCRC:** Provides the computational foundation in expertise, equipment, and personnel to facilitate M&S and HPC research at USAFA

**Payoff:** Enriched cadet experience. Well prepared graduates in M&S and HPC who immediately contribute to AFRL and other AF organizations missions



# DoD HPC Resources



DSRC*	Compute Cluster	Architecture	Cores	PFLOP/S**
AFRL	Spirit	SGI ICE X	73,440	1.50
	Thunder	SGI ICE X	120,904	4.30
Army ERDC	Garnet	Cray XE6	150,912	1.50
	Topaz	SGI ICE X	125,440	4.62
Navy	Conrad	Cray XC40	50,928	2.00
	Gordan	Cray XC40	50,928	2.00
	Armstrong	Cray XC30	29,352	0.786
	Shepard	Cray XC30	28,824	0.817
Maui	Riptide	IBM iDataPlex	12,096	0.252

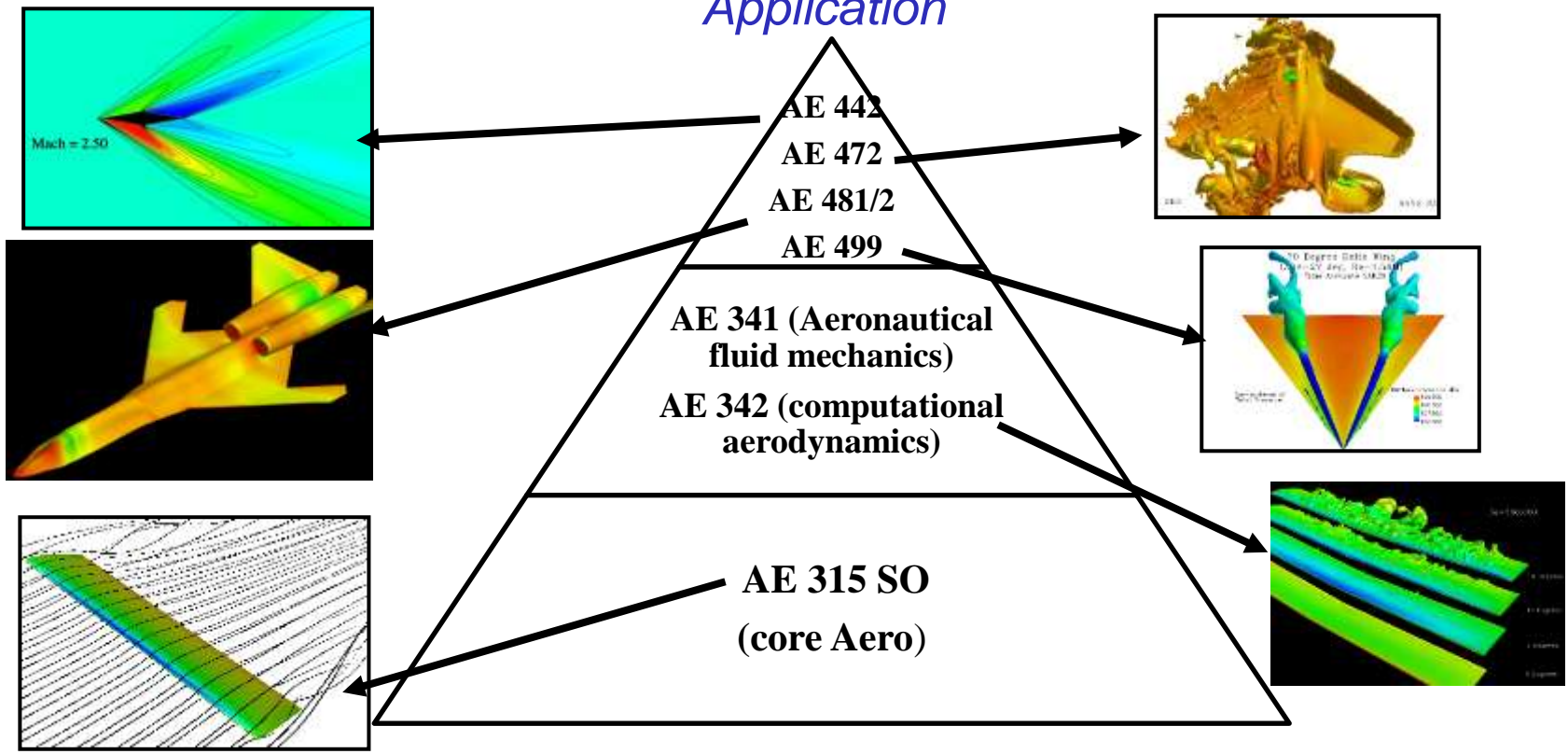
\* DSRC = DoD Supercomputing Resource Center      \*\*  $10^{15}$  Floating Point Operations per Second



# Computational Aerodynamics across the Aeronautics Curriculum



## Application



## Demonstration

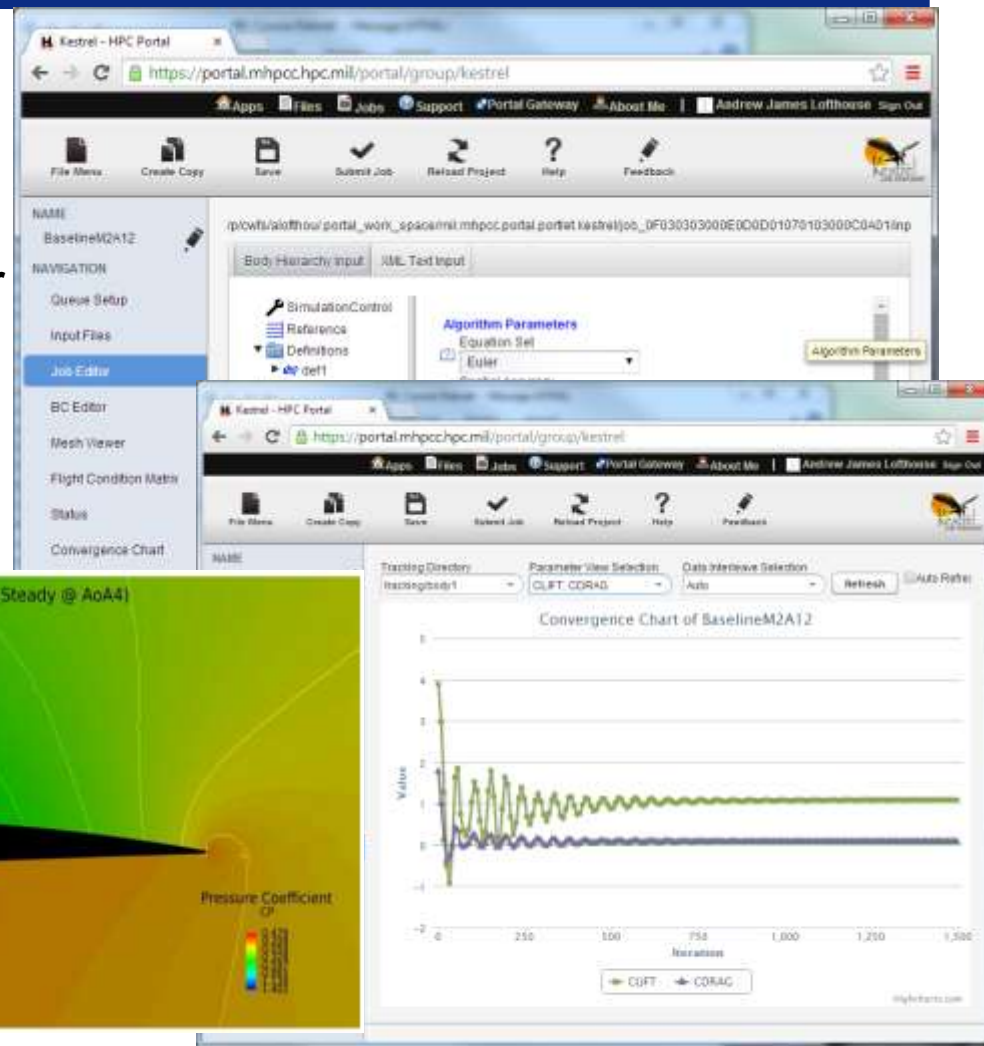
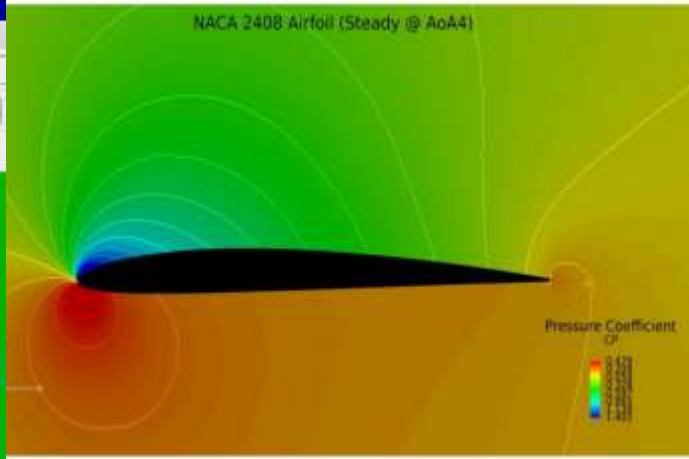
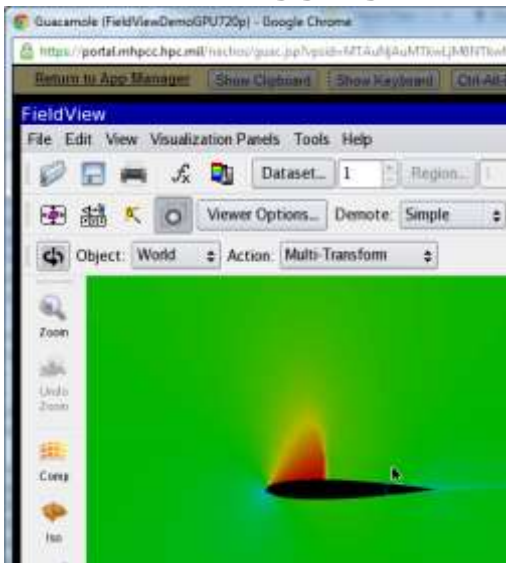
**Note:** AE 442 (Adv Aerodynamics), AE 482 (Aircraft Design), AE 499 (Cadet Research), AE 472 (Adv CFD)



# AE 342: Computational Aerodynamics



- ALL Aero majors exposed to physics-based Modeling & Simulation
- Cadets use real HPC machines via HPC Portal – Only need Web browser on CAC-enabled machine!
- Close relationship with developers for debugging







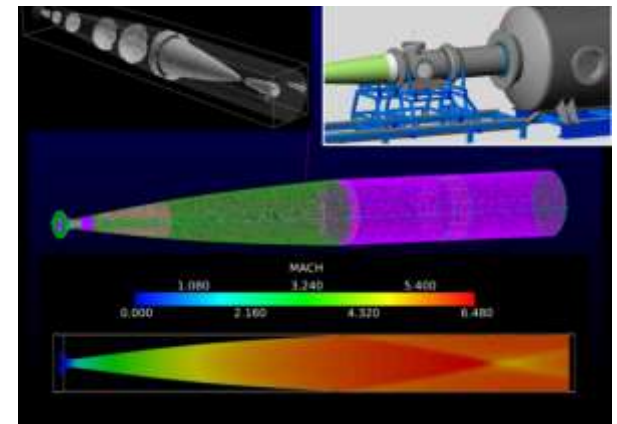
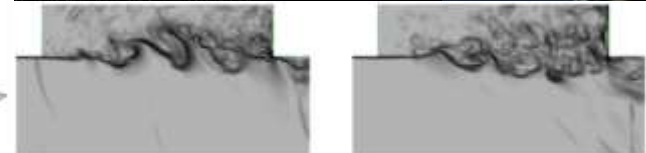
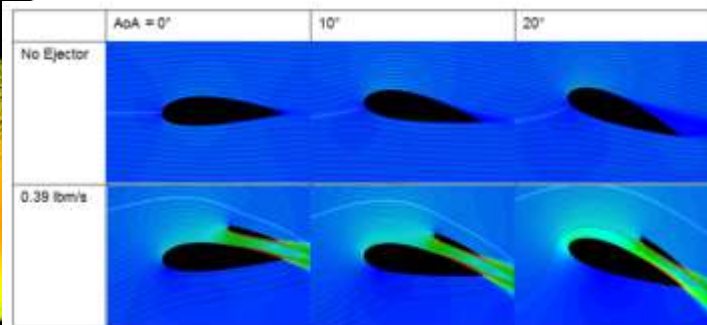
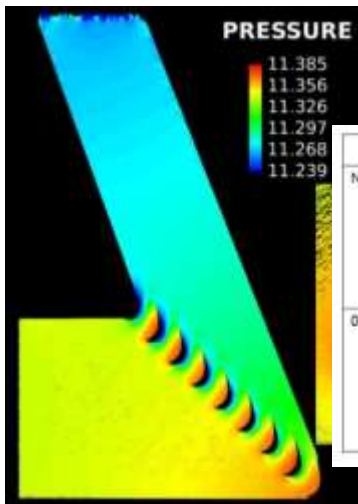
# AE 472: Adv Computational Aerodynamics



- Research-project based, elective
- Projects include (Fall 2014):
  - B-52 Simulator Aeromodel (AFGSC)
  - KC-135 Wake Effects (AFGSC)
  - Non-Repeatable Store Separations from internal bay (AFSEO)
  - Ludwig Tube
  - Transonic Cruiser
  - Propulsive Wing (DARPA)
  - Turbine Cascade Wind Tunnel



Boeing B-52H refueled by Boeing KC-135A  
©USAFA Museum Photo Archives

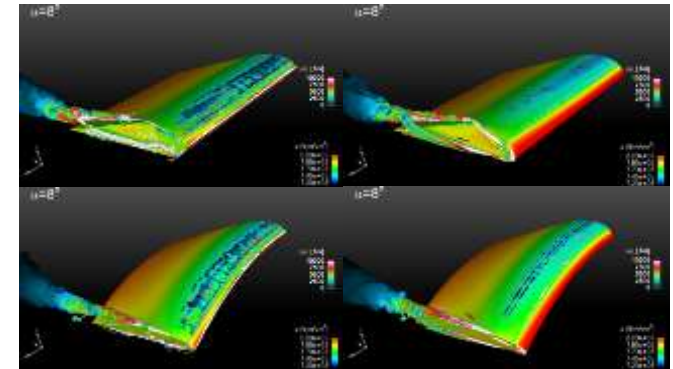
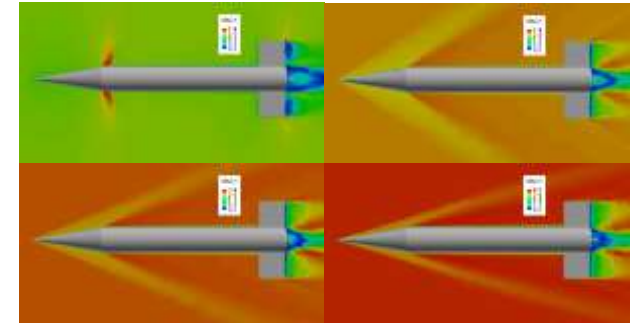
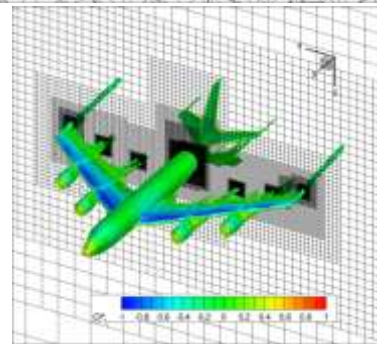
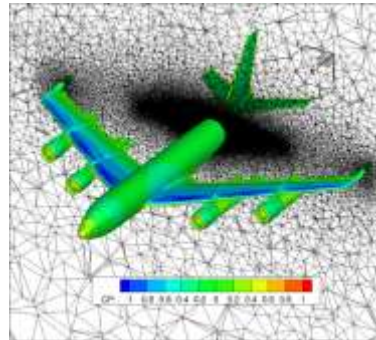
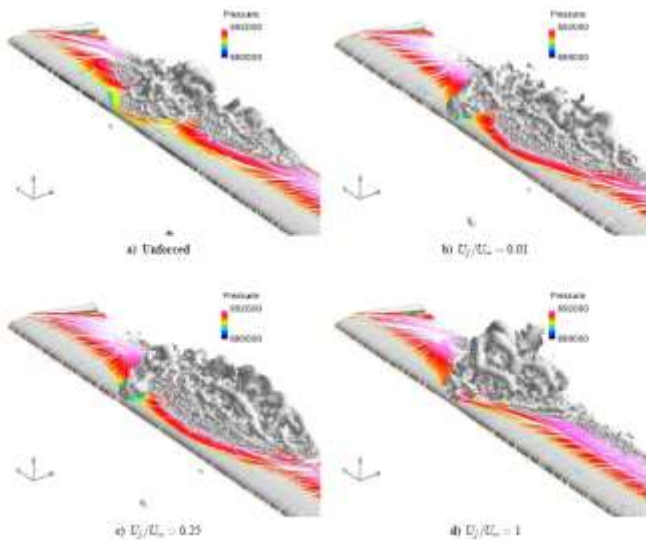




# AE 472: Adv Computational Aerodynamics



- Research-project based, elective
- Projects include (Fall 2015):
  - B-52 Simulator Aeromodel (AFGSC)
  - C-130 Formation (AMC)
  - Supersonic S&C ROM (NAVAIR)
  - Flexible Wing (AFOSR)
  - Parachute (Natick)

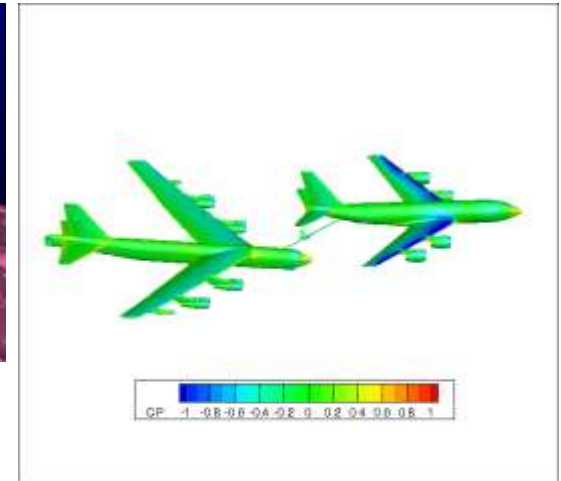
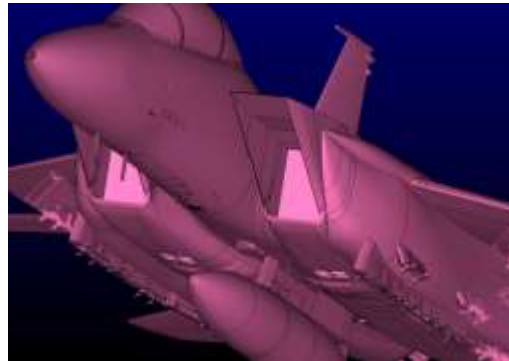




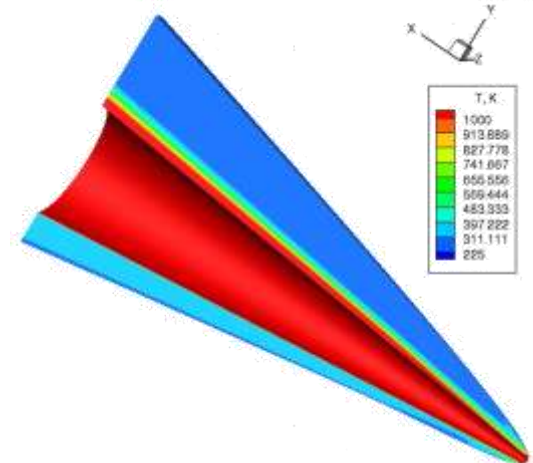
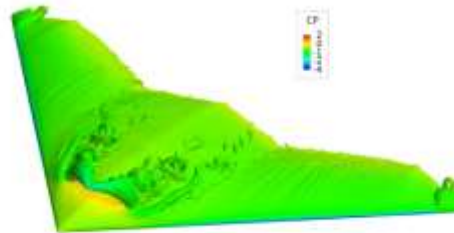
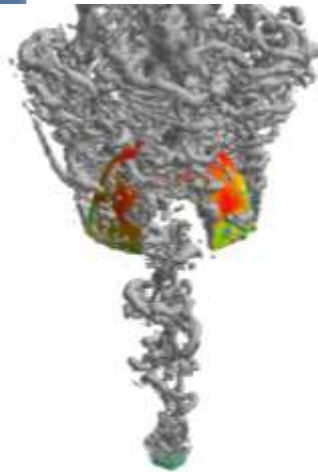
# AE 472: Adv Computational Aerodynamics



- Research-project based, elective
- Recent projects (Fall 2016):
  - B-52 / KC-135 Aeromodel
  - Cruciform Parachute
  - F-15E
  - Hypersonic Wake
  - Ram-Air Parachute
  - NATO UCAV Control Surfaces and Engine Integration



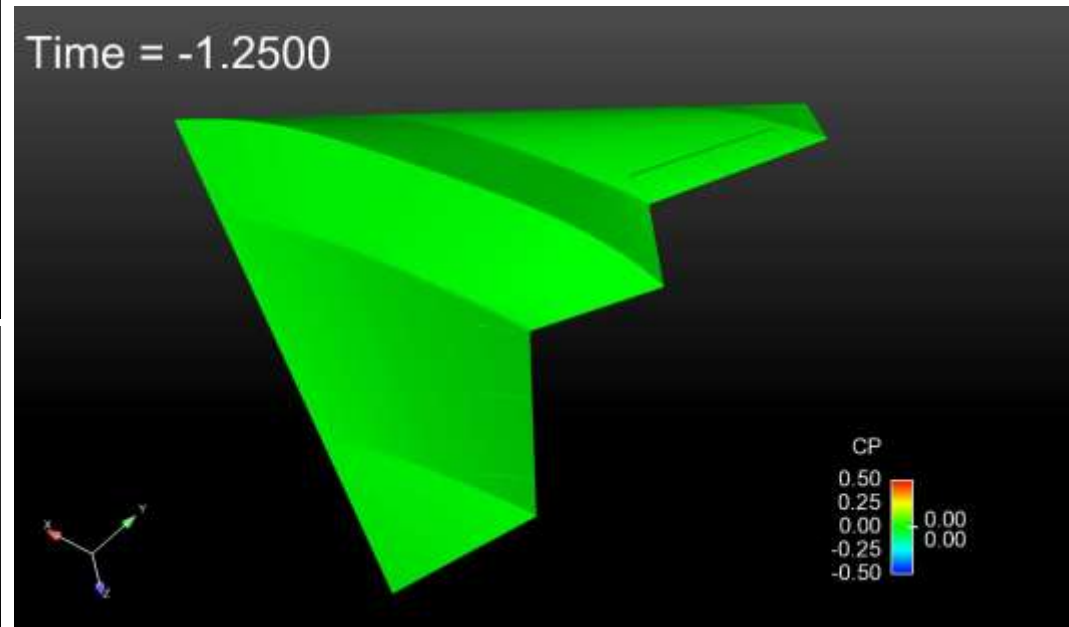
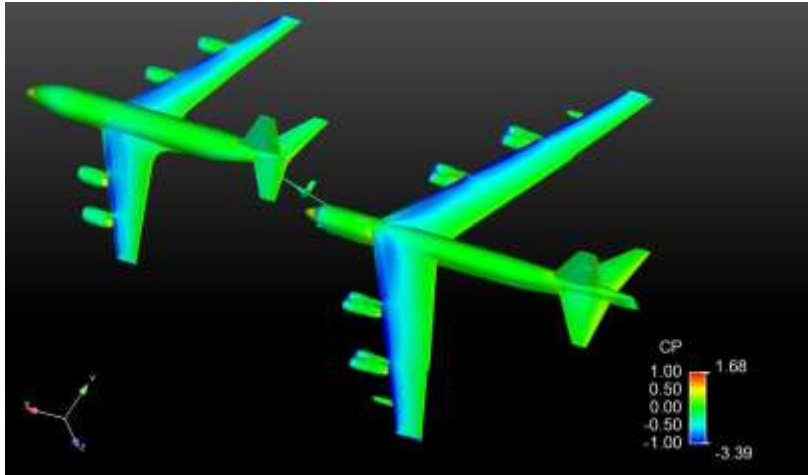
Cruciform canopy







# Virtual Flight Testing



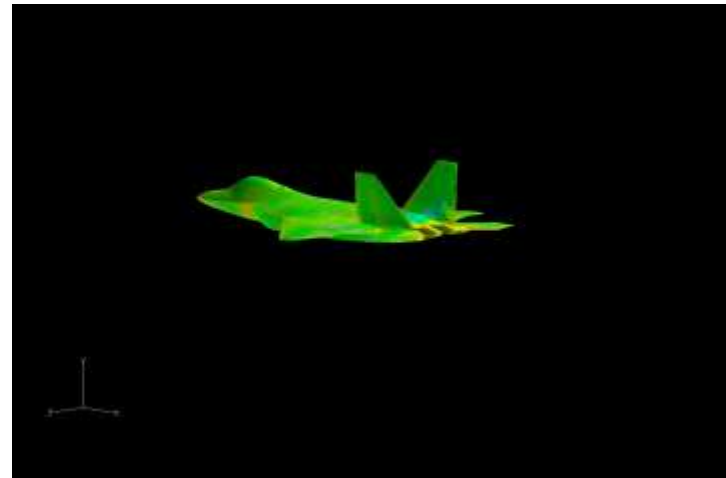
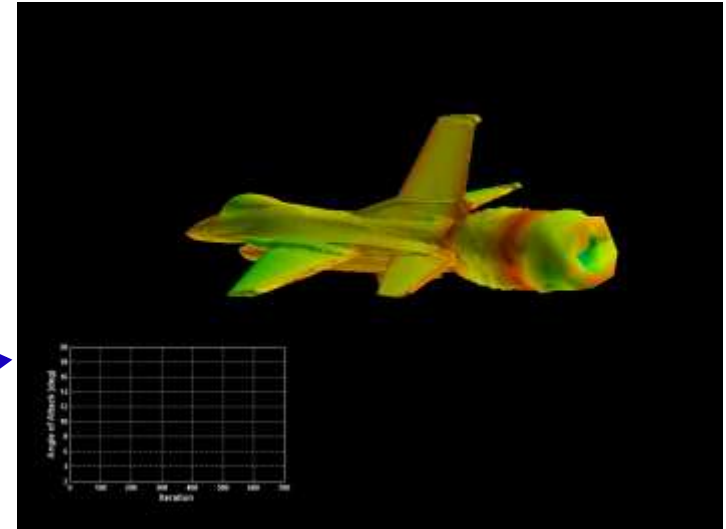
NATO AVT-251 MULDICON with control surfaces



# Stability & Control (S&C) Estimation Methods



- **Semi-empirical**
  - Limited to traditional configurations and linear aerodynamics
- **Full-order modeling** →
  - Computationally expensive
- **Reduced-order models**
  - Training maneuvers →
  - Interpolation schemes



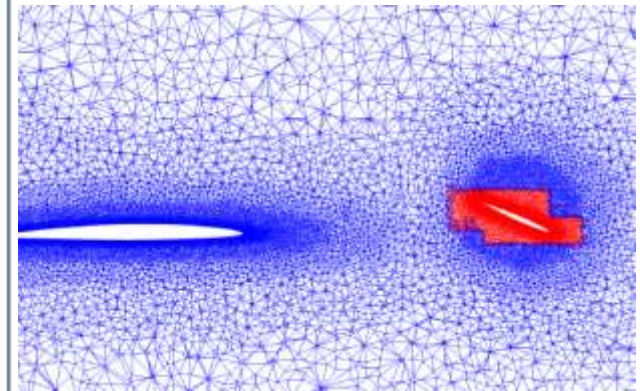
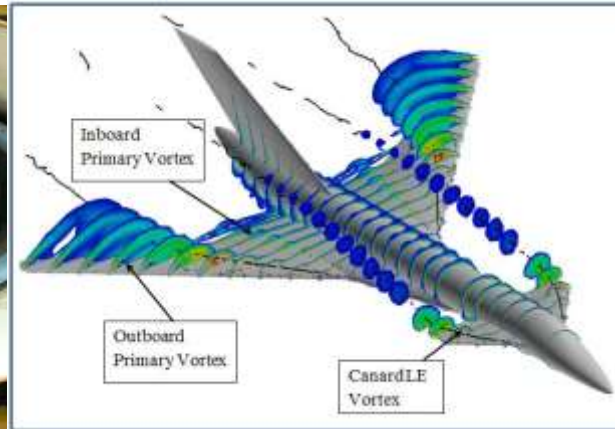
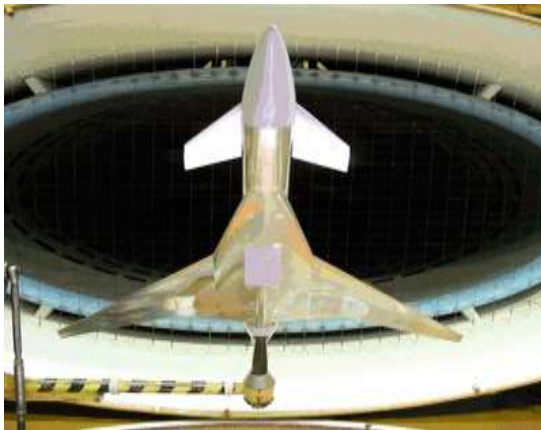
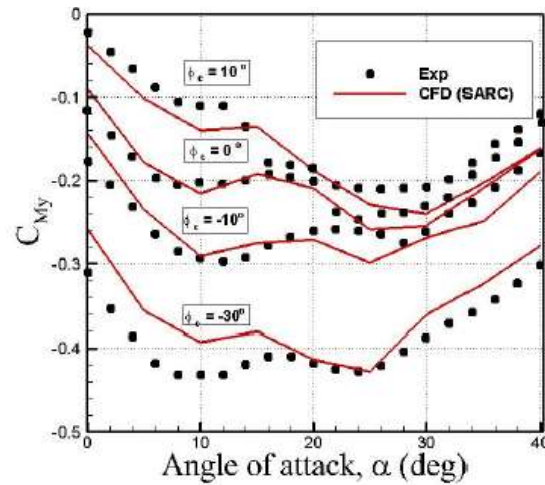
**Want to Know S&C Characteristics  
Early in Design Process**



# Transonic Cruiser



- Validate CFD with wind tunnel
- Analyze flow physics
- Investigate effects of canard downwash on wing performance



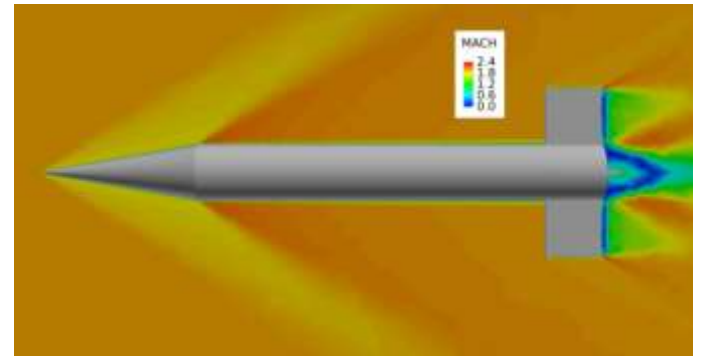
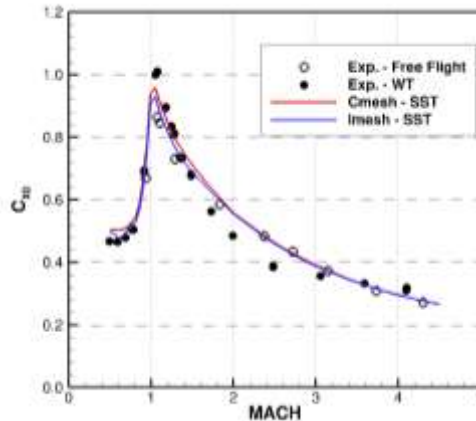
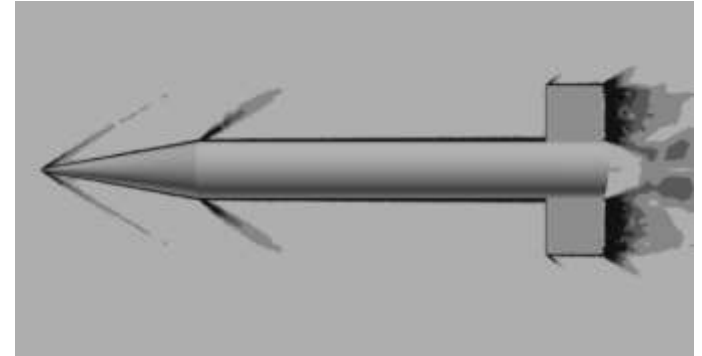
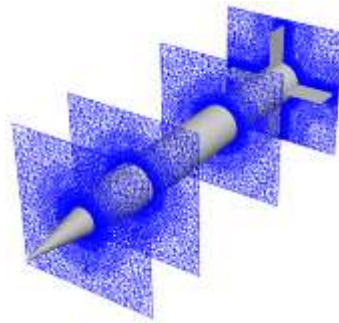


NAV  AIR

FINNER



- Verify DoD CREATE tools for predicting aerodynamic characteristics
- Lower development costs and improve design cycles by conducting high-accuracy analysis before building prototypes
- System identification methods applied to a generic missile configuration



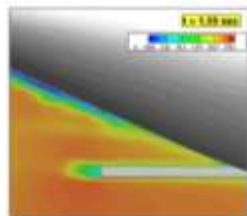
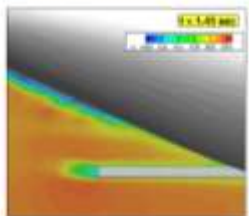
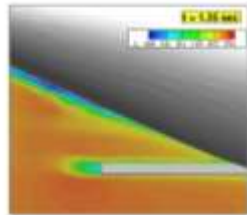
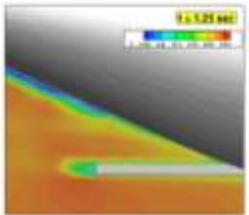
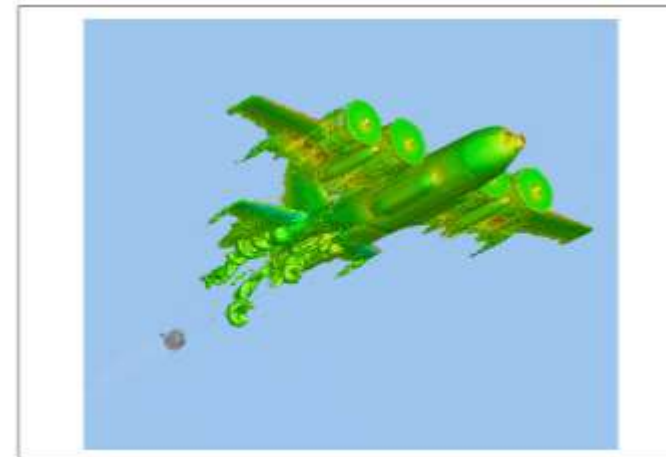
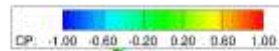
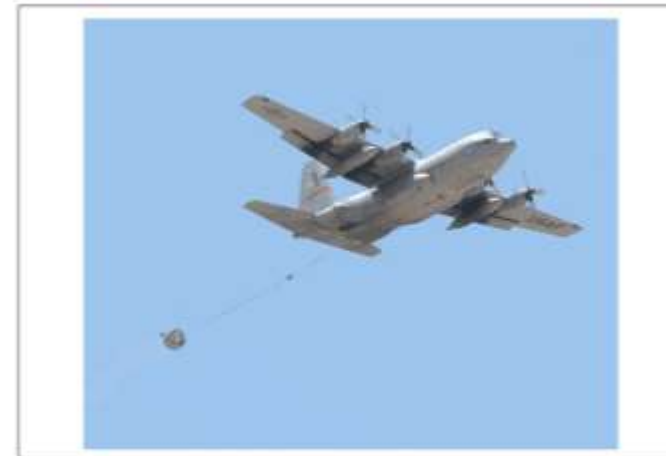
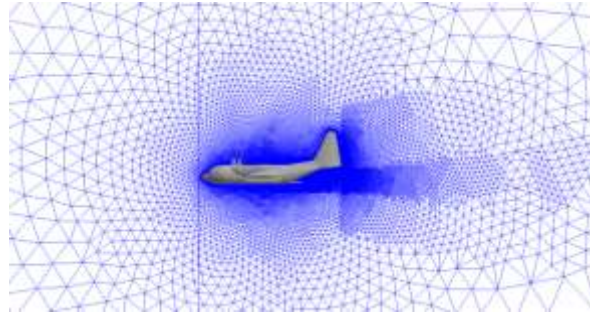




# C-130 Near-Body Wake



- Analyze flowfield of C-130 Hercules
- Determine flowfield characteristics near troop door and rear ramp to eliminate mishaps.





# Researcher Expertise



- **Lt Col Andrew Lofthouse: Hypersonics, Full Aircraft, HPC, Mesh Gen, ...**
- **Capt Matt Satchell: Hypersonics**
- **Dr. Mehdi Ghoreyshi: Reduced-Order Modeling**
- **Dr. Pooneh Aref: Propulsion/Airframe Integration**
- **Dr. Adam Jirasek: Turbulence Modeling, FSI, Code Development, Mesh Generation**
- **Mr. Robert Decker: High Speed Gas Dynamics, Technical Support**
- **CA with UCCS for Graduate Student Support**