HPC Research Concept

High Performance Computing Research Center

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
<table>
<thead>
<tr>
<th>DSRC*</th>
<th>Compute Cluster</th>
<th>Architecture</th>
<th>Cores</th>
<th>PFLOP/S**</th>
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* DSRC = DoD Supercomputing Resource Center  ** 10^{15} Floating Point Operations per Second
Computational Aerodynamics across the Aeronautics Curriculum

Application

AE 442
AE 472
AE 481/2
AE 499

AE 341 (Aeronautical fluid mechanics)
AE 342 (computational aerodynamics)

AE 315 SO (core Aero)

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)
  - Ludwieg Tube
  - Transonic Cruiser
  - Propulsive Wing (DARPA)
  - Turbine Cascade Wind Tunnel
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

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
- 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