HQ U.S. Air Force Academy

Integrity - Service - Excellence

Review of USAFA UAS Research

Mr Ryan Osteroos, PE
DFAN UAS Researcher

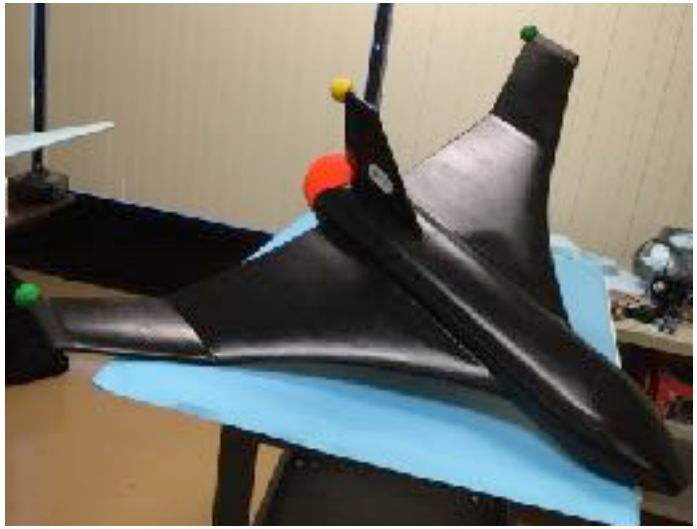
USAFA Research Focus

- Our mission: Develop Officers of Character
- Cadet Based Learning
- Continuous research efforts
  - Not class dependent, but…
  - Must support cadet growth

USAFA Focus

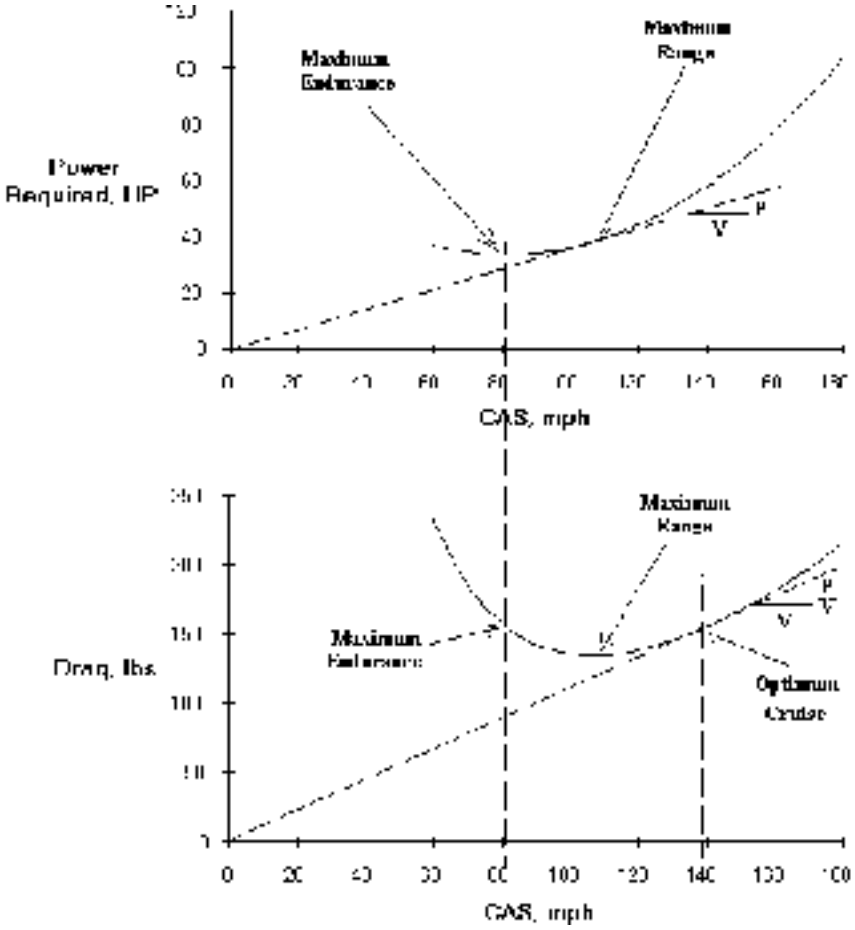
Aeronautics Department UAS Research Focus

- Fabricate and build full or subscale vehicles
- Integrate motor, avionics, autopilot, data acquisition system
- Flight Test Validation
- Flight Control Development



Aeronautics Department
UAS Research Focus

- Aircraft Performance data
  - Drag Polar
  - Pitot statics
  - Climb Performance
  - Glide Performance
  - Max Endurance
  - Max Range



UAS Research Data Products

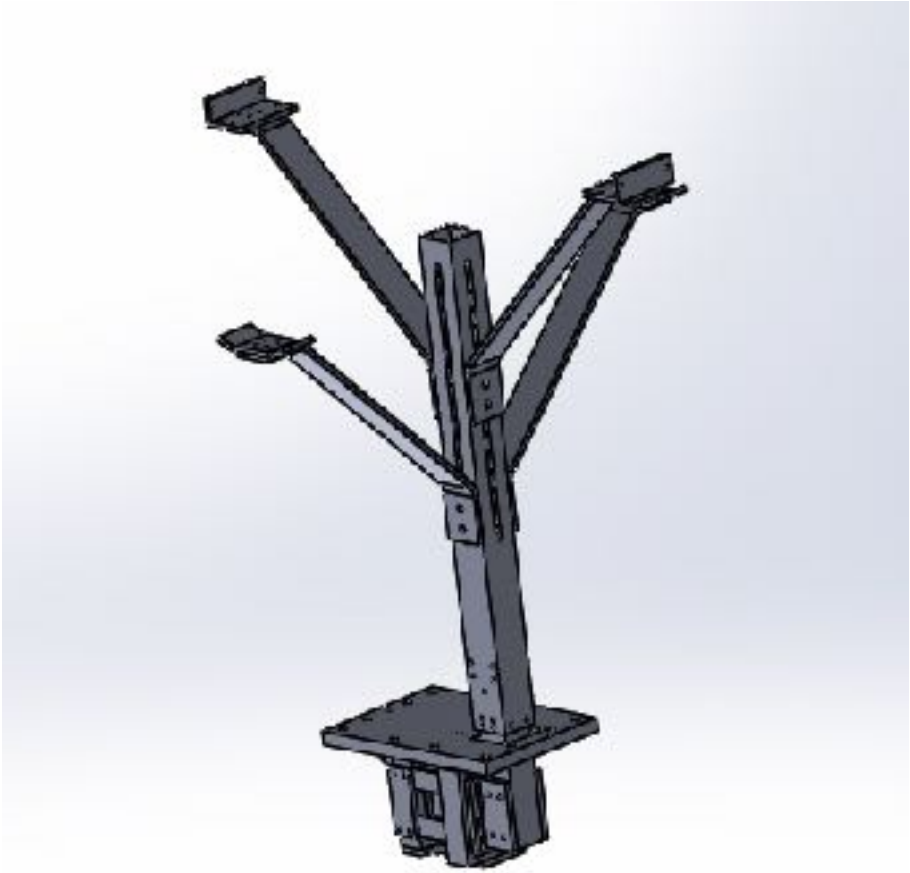
- Flying Qualities
  - Static Stability
    - Difficult to measure from remote control
    - Validate wind tunnel predictions
  - Dynamic stability
    - All axes and modes
    - Classical flight test techniques
  - Flight Control Research
    - Gain Optimization/Gain Set Tuning
    - Advanced Control Topics

UAS Launching Capability

- Truck launch development
  - Historical success with two options
  - Carriage launched or hand launched
  - Data collection includes lift, drag and pitch force measurements – open air wind tunnel

Truck Mounting Device

- Truck Mount of UASs from 3 lbs to 50 lbs
- Quantitative measurements of lift, drag, and pitch/roll force balance
- Release velocities up to 55 knots



Current Projects: TOBS

- TOBS – Tactical Off-Board Sensing Aircraft
  - Hi level design and fabrication of folding wing aircraft to fit in Common Launch Tube
  - Truck launched for research purposes
  - 15 lb, carbon fiber and SLA printed aircarft

Example Safe Release & Flight

- **Launch speed of 31 knots, safe separation to a straight ahead “landing”**

Current Projects: 5GAT

- 5th Generation Aerial Target
  - 1/9th and 1/7th Scale aircraft
  - Basic flying qualities evaluation
  - Pitot Static flight test risk reduction for full scale aircraft

First Flight

Current Projects: ICE

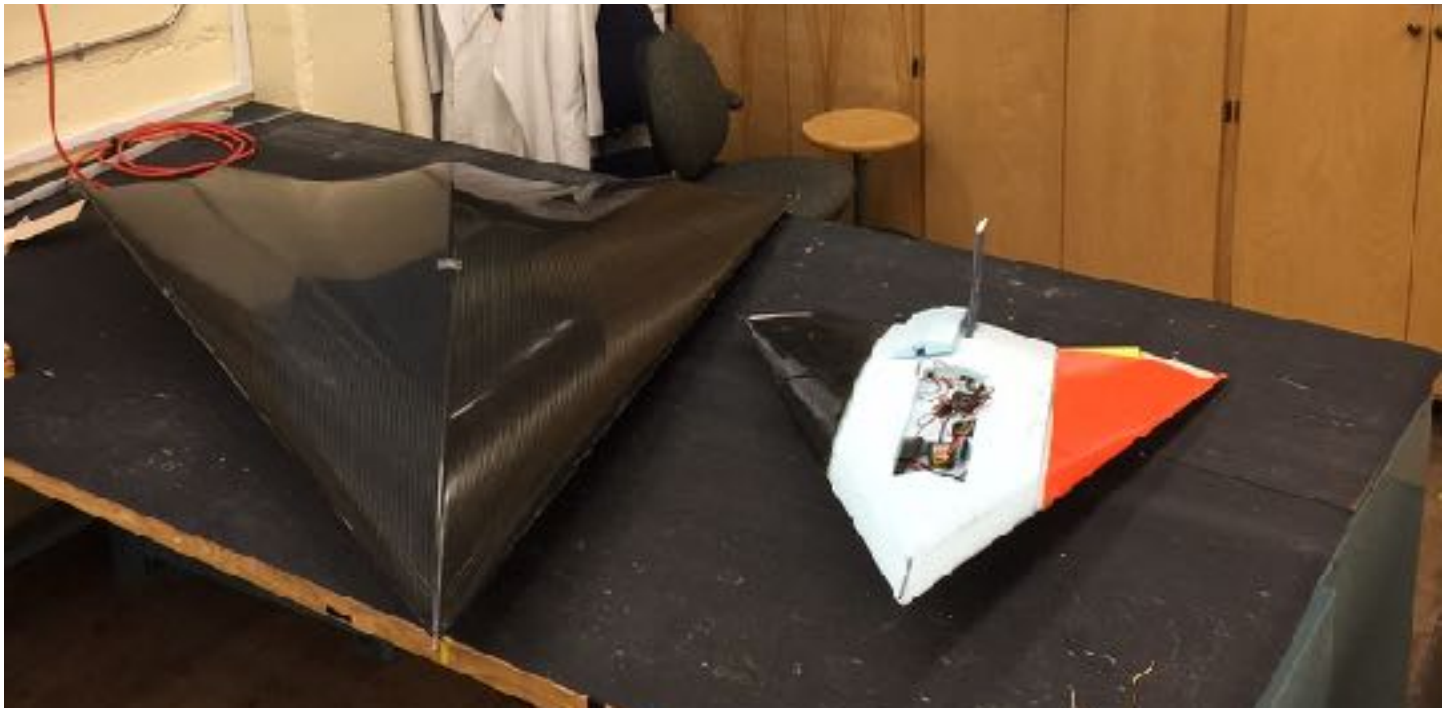
- **INNOVATIVE CONTROL EFFECTOR (ICE-Flow Control)**
  - **Shape designed to generate vortex flow**
  - **Control accomplished through air jet actuation**

Current Projects

- **Research Efforts to date**
  - **3rd Wind Tunnel Investigation**
  - **Demo'd that trimmed flight is possible – Limited AOA**
  - **Developing Matlab/Simulink Model for Sim Testing**
  - **Flying subscales with classic Elevon control**

Current Projects: ICE

- **NEXT Semester: Subscale Flt Tests**
  - **Autopilot Controlled**
  - **Air Jet actuated-flt control stabilized**



Current Projects: FLCR

- FLight Control Research(FLCR) Aircraft
  - Supports Flight Control System testing
    - Form Flight
    - Very Tight FP Tracking
    - Precision landing
  - 2 X autopilot options
  - Optionally active canard
  - Inexpensive to produce and fly

Current Projects: LCAAT

- **SPRING 2016: Low Cost Attritable Aircraft Technology (LCAAT)**

Current Projects: LCAAT

- **SPRING 2017: Low Cost Attritable Aircraft Technology (LCAAT)**

Need to Expand the Way Forward
DARPA-Sponsored Challenge

U.S. Service Academies compete in **25-versus-25** aerial swarm battles

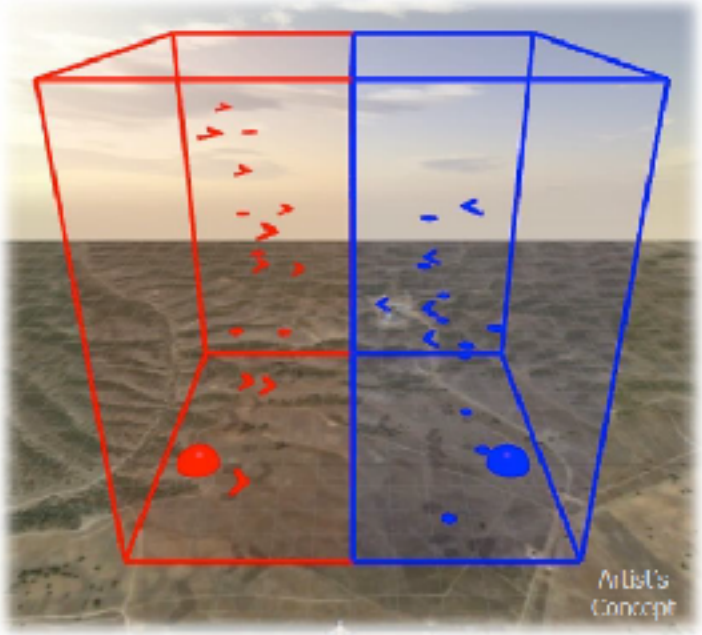
U-CTF Goal 1: Generate and demonstrate swarm and counterswarm tactics

U-CTF Goal 2: Demonstrate "Zero to Swarm" capabilities in <8 months

U.S. Military Academy | U.S. Naval Academy | U.S. Air Force Academy

Red/Blue Swarms
- 50 total UAVs
- Mix of fixed-wing and quad-rotors
- Simulated Sensors and Simulated Weapons

"Battle Cube"
- 500×500×500 m airspace volume
- 50 m above ground



Live-Fly Competition
April 22-26, 2017
Camp Roberts

Virtual Scrimmages
Monthly, Cloud Based

Combat: Accrue the most points for:
- air-to-air "tags"
- air-to-ground "tags"
- swarm logistics

USAFA CONOPS
Notional Combat

- All Combat is via Virtualized Weapons
- Computer Arbiter Validates Shots
- Currently all Aircraft are Altitude Separated fo Collision Avoidance
- All Aircraft have 100% Situational Awareness of all other aircraft
- All Friendly Aircraft Can be Given New Orders (behavior to follow) at Any Time

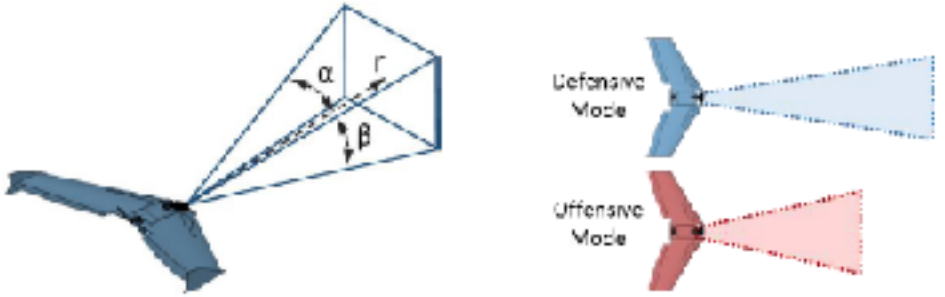
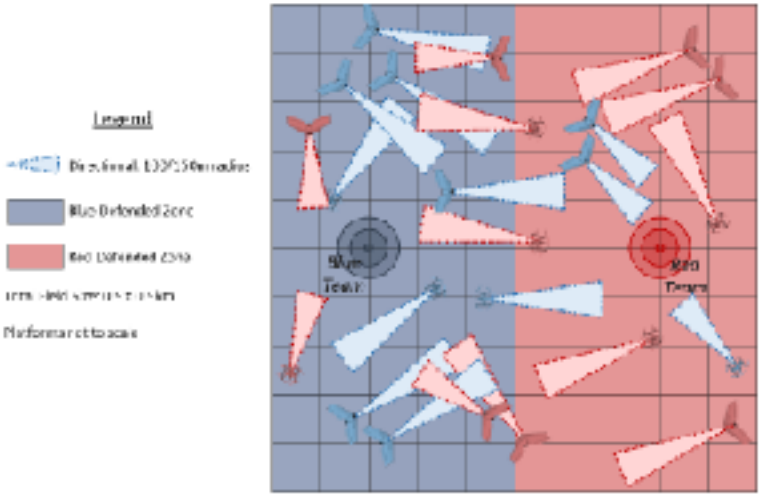
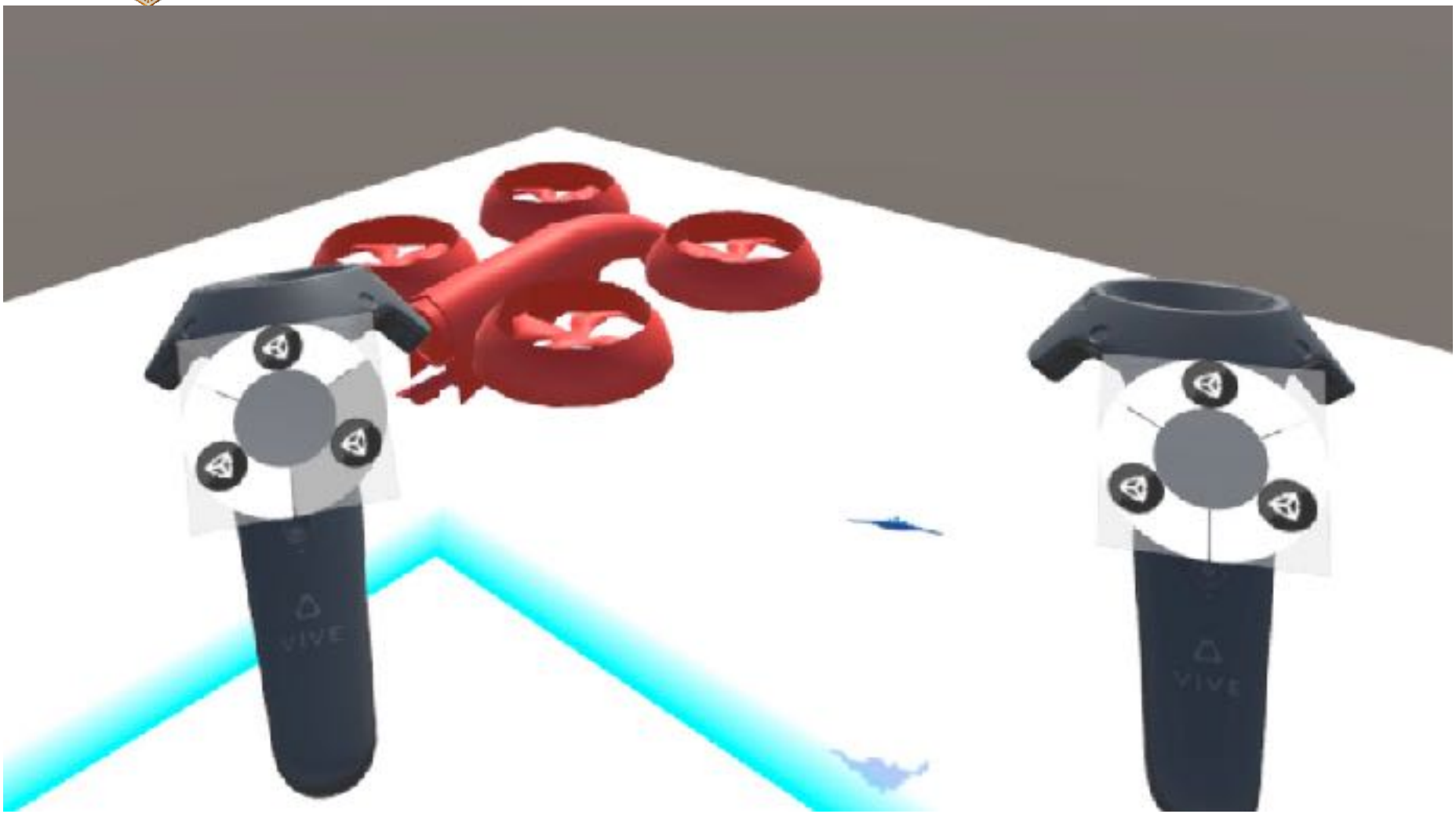


Figure 9: Simulated Weapons.



Command and Control

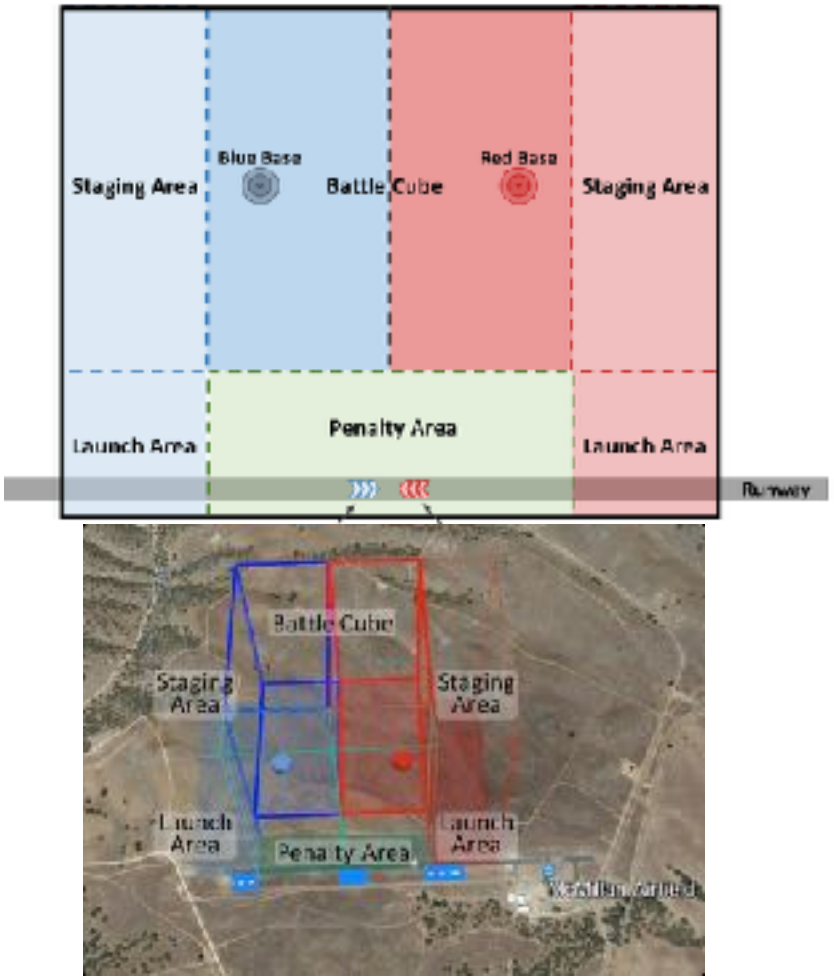


Command and Control

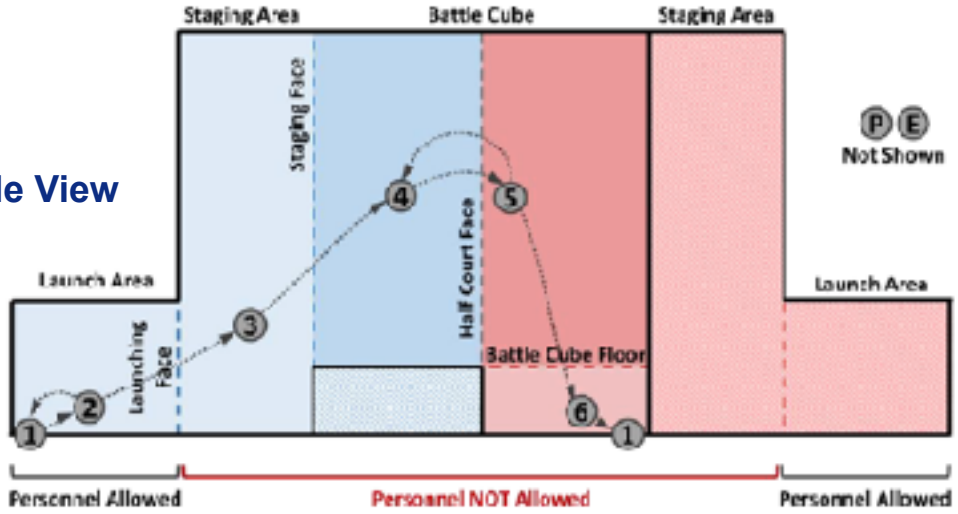
USAFA CONOPS
Airspace Overview

- All flight operations are conducted over personnel-free areas
- All autopilots are 'geo-fenced' into these areas
- Flights at USAFA will follow same rules as DARPA competition area shown (Camp Roberts, CA)

Top-Down View



Side View



Current Projects
CUAS Support

- CUAS Research Support
  - Blue Team and Red Team Support
  - Highly adaptable cadet led teams

Current Projects
CUAS Support

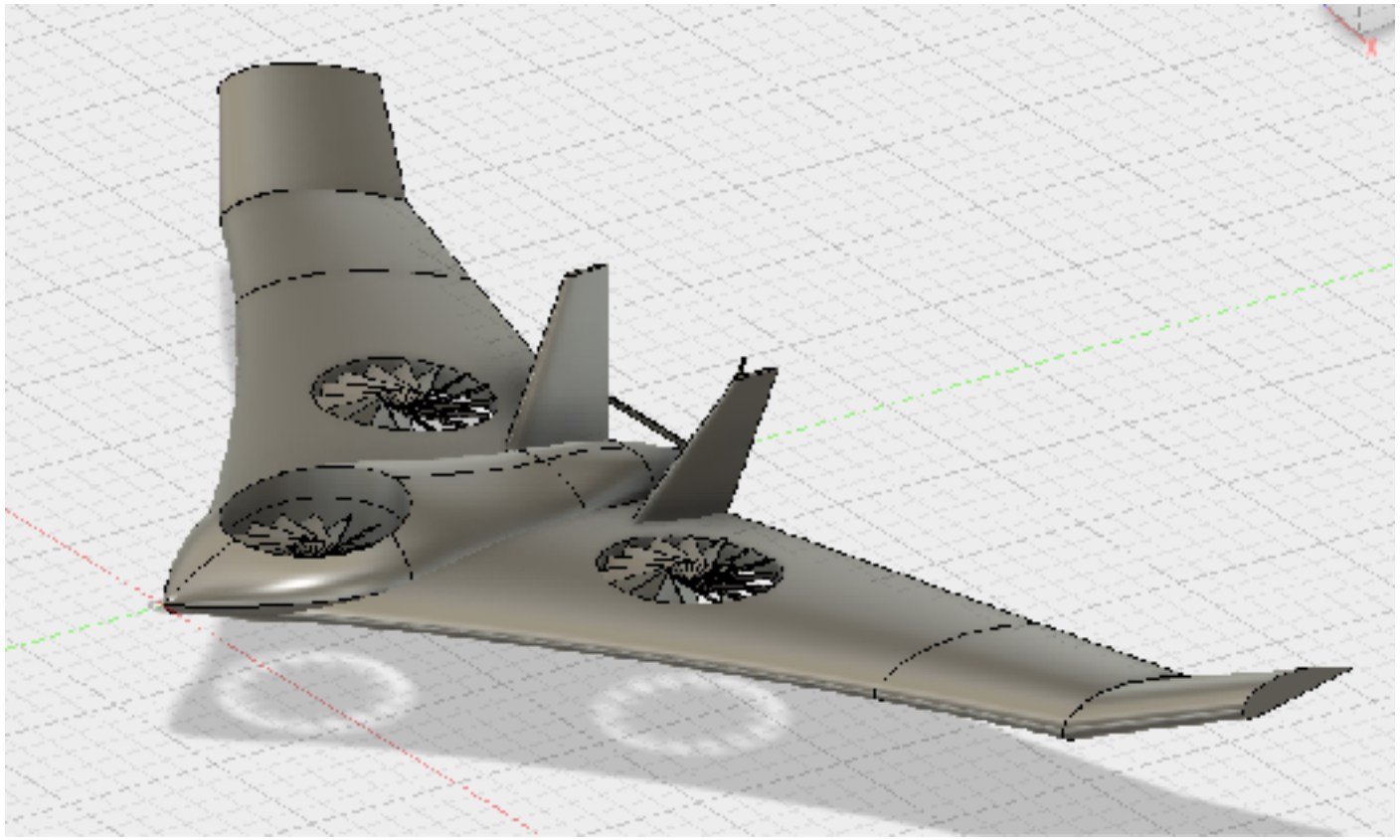
- **Lessons Learned**
  - **This is not an ivory tower fight, it's a Mad Max fight**
  - **Useful results means real aggressors/red air**
    - **Be the bad guys to understand the problem**

Current Projects
CUAS Support

- **Lessons Learned**
  - **The technology is moving fast**
  - **Agility and tech-savy researchers are key**

VTOL-Fixed Wing CONCEPT PLATFORM

Next Semester: VTOL-Fixed Wing Platforms



Q & A

Questions

Mr. Ryan Osteroos, PE, LtCol(r), USAF
USAFA/DFAN UAS Research Lead
Email: ryan.osteroos.ctr@usafa.edu or rkosteroos@engsys.com