

# NASA LaRC UAS Operations Overview 2001 through 2014



Presented to the Virginia Aeronautical Society  
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# Outline

- Provide overviews of several Unmanned Aerial System (UAS) projects at NASA LaRC
  - Airborne Sub-scale Transport Aircraft Research (AirSTAR) project (2001 to 2009)
  - Prognostic Decision Making project (2008 to present)
  - Unmanned Aerial System Airspace Operations Challenge (UAS-AOC) project (2013 to 2014)
  - Great Dismal Swamp Fire Flyer (2011 to present)



# AirSTAR

- Descendent from LaRC Drop Model Testing
  - Dropped from helicopters at ~10k ft
  - About 1 minute of flight time
- UAS employed to conduct research on manned aircraft
  - Dynamic stability/maneuvering
  - Very-high angle of attack flight
- AirSTAR research objectives
  - Flight test adaptive control laws
  - Perform System IDentification research
  - Generate world-class high-alpha aero data for piloted simulation training



AirSTAR T-2

# AirSTAR Research-1

- Adaptive control applications
  - Spawned in the aftermath of UA 232 (Sioux City)
    - Pilots used thrust to control aircraft
    - Many survived that accident
  - AA 587: Pilots' overuse of rudder leads to vertical fin failure
- Can all the controls be used to compensate for a crippled aircraft?
- Objective: to maintain sufficient handling qualities for a hard landing with many survivors
- AirSTAR could “simulate” loss of rudder, failed controls, etc.
  - AOA vanes/sensors to drive rudder movements to “zero out” rudder effect
  - Could also manipulate roll, pitch damping and pitch stability
  - And fail controls: elevators, rudder, etc.

UA 232



AA 587



# AirSTAR Research-2

AF 447

- System IDentification (SID) and Recovery from Extreme Flight Conditions
- SID can be used to determine aerodynamic models from aircraft motions
- Current piloted simulator aero models are not required to model post-stall/high angle of attack flight
- Challenging to obtain dynamic aerodynamic parameters from wind-tunnels or CFD
- SID testing generated aero models from extreme flight conditions to improve pilot training, mitigate similar risks from AF-447
- SID Reference: Klien, V.; Morelli, E: *Aircraft System Identification Theory and Practice*.



# AirSTAR CONOPS

- External and Internal pilots required
  - External pilot: PIC, performs takeoffs, landings, monitors research operations, recovers vehicle when required
  - Internal pilot: SIC, performs research test cards
- External pilot provided mitigation of risk from research systems as well as “see and avoid” capability
- Performed within line of sight of External pilot
  - 0.5nm radius

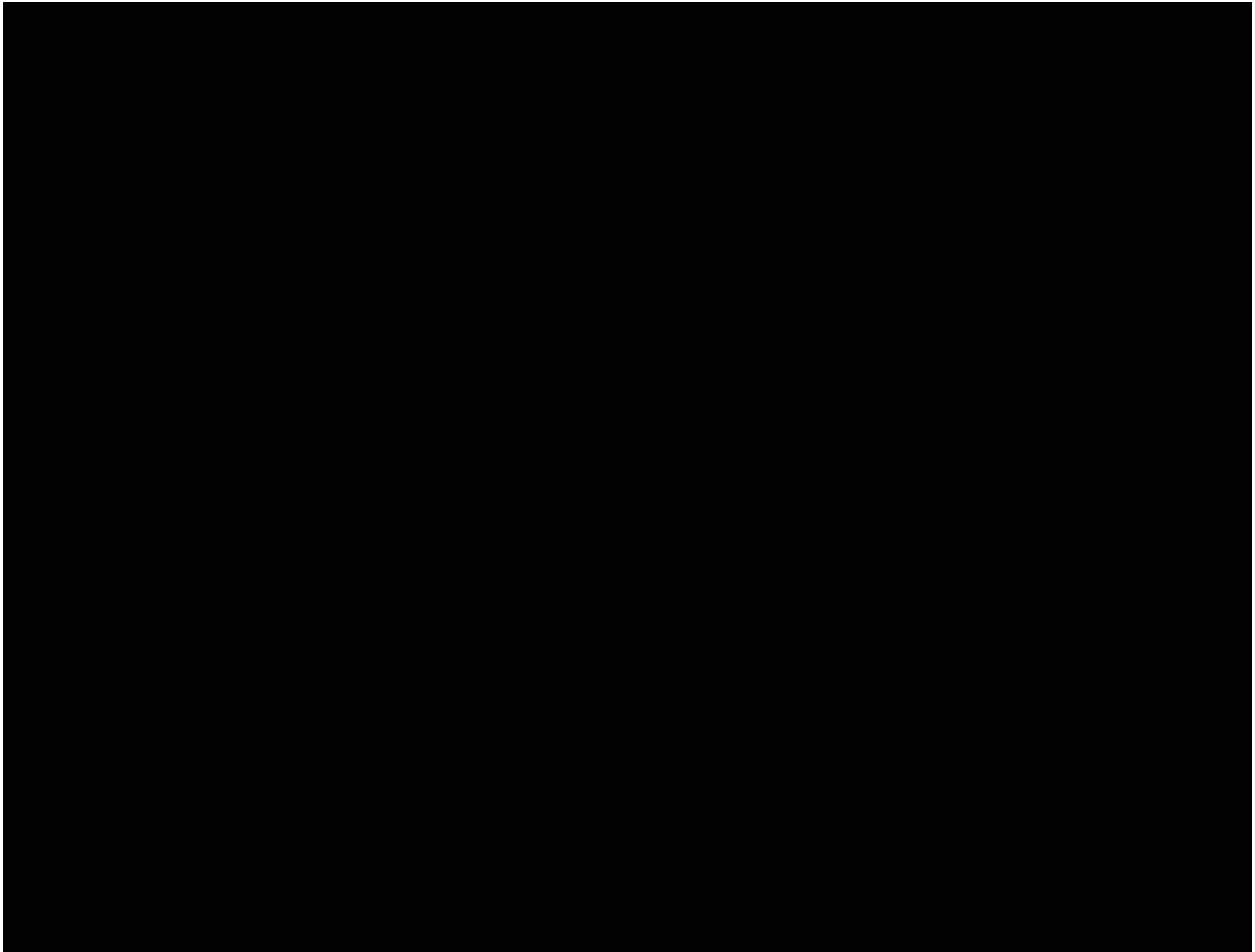


## T-2 numbers:

- Weight: 55 lbs
- Thrust: ~30 lbs
- Stall speed: ~50 kts
- Approach speed: 70 kts
- Max speed: ~100 kts
- Landing rollout: ~1,000 ft

# AirSTAR Public Affairs Video

# Post-Stall Testing



# AirSTAR training operations

- LaRC invested in pilot/crew training through the course of the AirSTAR project
- Flight rates were established for currency
- Pilot qualification metrics also established
- Investment/mitigation of pilot risk greatly contributed to the success of the project
  - A total of 58 flights were performed for T-2
  - Met all research milestones
  - “Without a scratch”



# AirSTAR Training Vehicles

BVM F-100 Super Sabre



BVM King Cat



T-1 trainer



# Prognostic Decision Making Project

- Battery Health Monitoring
  - Cooperative project with NASA ARC
  - Funded by Aviation Safety Program
- Autopilot development
  - Focused on low-cost micro autopilots
  - State estimation for low-cost sensors



# Future of UAVs/UASs/Drones

- Use of small drones predicted to increased radically in the next decade
  - Package delivery (Amazon prime air/Google Project Wing)
  - Movie video
  - Sports teams (practice monitoring)
  - Traffic monitoring
  - Law enforcement
  - Search and Rescue
  - Fire detection, etc, etc.
- FAA is working hard to support UAS-NAS integration
  - FAA is having trouble keeping pace
- Current regulations restrict UAS flights for hire



# UAS Airspace Operational Challenge (UAS-AOC)

- A NASA Centennial Challenge
- Safe Airspace Operations:
  - Separation Assurance using ADS-B
  - 4 Dimensional Trajectories
  - Ground Control Operations
- Robustness to System Failures:
  - Lost Link
  - GPS Unavailable
  - GPS Unreliable
- Preparation for Phase 2 Competition:
  - Uncooperative Air Traffic Detection



# UAS AOC Concept of Operations

- Squadron of aircraft (4) provide cooperative and non-cooperative live traffic
- Contestants need to fly 4-D flight paths, ident and avoid traffic
- Large, long endurance ~40% scale COTS traffic aircraft vehicles selected
  - To minimize startup time
  - Capable of 2+ hr endurance
- Project failed due to planning and resources

Dave's Aeroworks 40% Carbon Cub



Horizon 33% Pawnee

# Great Dismal Swamp Fire Flyer

Great Dismal Swamp 2011

- In 2011 the Great Dismal Swamp had a massive underground fire
- Major environmental impacts
- NASA is exploring use of low-cost UAVs to improve monitoring
- Prevent wild-fires
- Low-cost UAVs can:
  - Provide quicker response time (than manned aircraft)
  - Can perform operations at lower-cost (1 to 2 orders of magnitude less)
  - Overall, quicker, more extensive area coverage and fire spotting



# GDS Flyer Video



# NASA LaRC UAS Projects

- Long history of UAS use for research supporting manned aircraft
  - Drop models
  - AirSTAR
- Recent efforts aimed at UAS development and implementation
  - PDM
  - UAS-AOC
  - GDS Flyer
- Future of small UAS is very large
  - Myriad of applications for small UAS vehicles
  - Integration into the NAS is a primary challenge
  - “See and Avoid” and protection of the general public are primary challenges