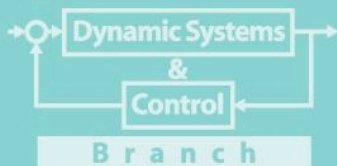


AirSTAR: Simulation and Reduced-Scale Flight Test Facility

Dr. David Cox, Mr. Kevin Cunningham
(NASA Langley Research Center)

Mr. Geoff Brian
(DSTO)



AirSTAR

Airborne Subscale Transport Aircraft Research

AirSTAR is the collection of *Ground Support Systems*, *Subscale Flight Vehicles* and *Operations Expertise* required for conducting remotely piloted flight-dynamics and controls research.

Ground Support Systems:

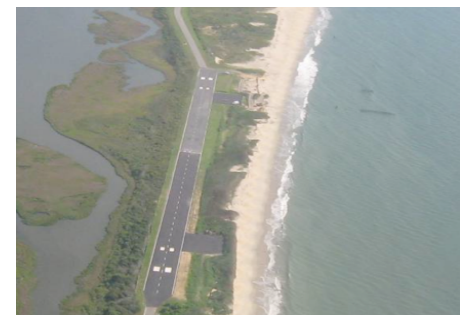
- Pilot Station with camera/synthetic views and HUD.
- Bi-directional RF telemetry system with data logging.
- Flexible real-time control system and live data feed.

Subscale Flight Testbeds:

- Geometrically and dynamically scaled vehicles.
- Multi-surface and multi-engine control effectors
- Calibrated instrumentation (INS/GPS, AirData, etc)

Operations Expertise:

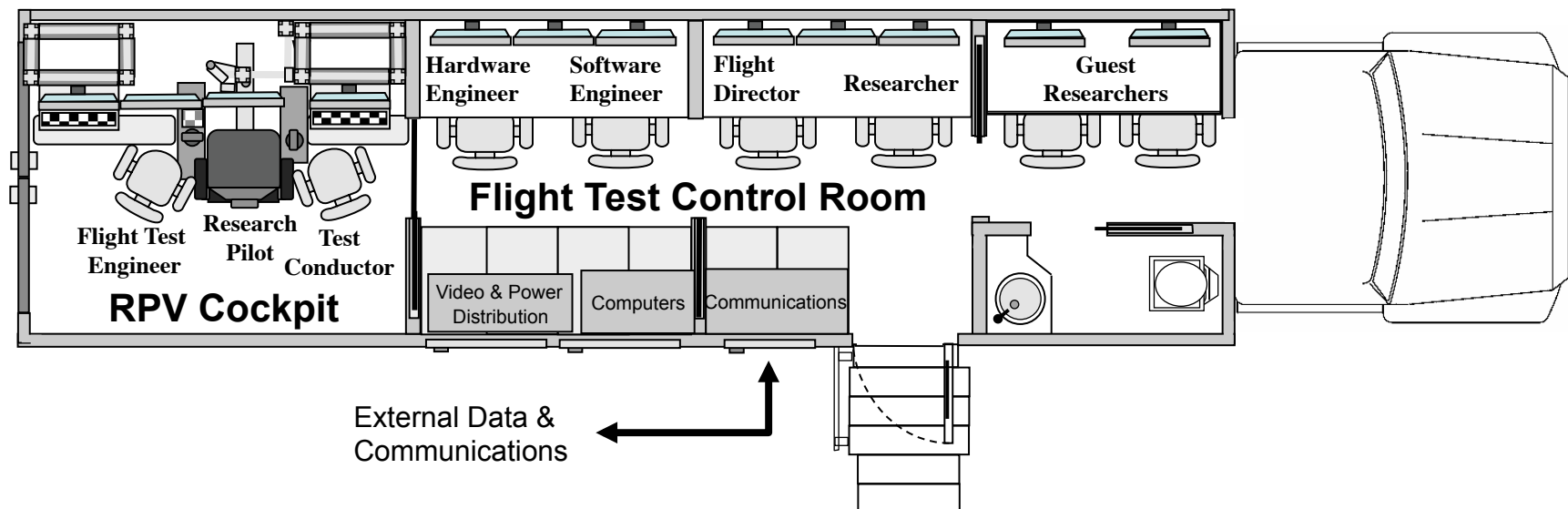
- Trained and proficient safety and research pilots
- Operating procedures and airspace access.
- Deployable capability.



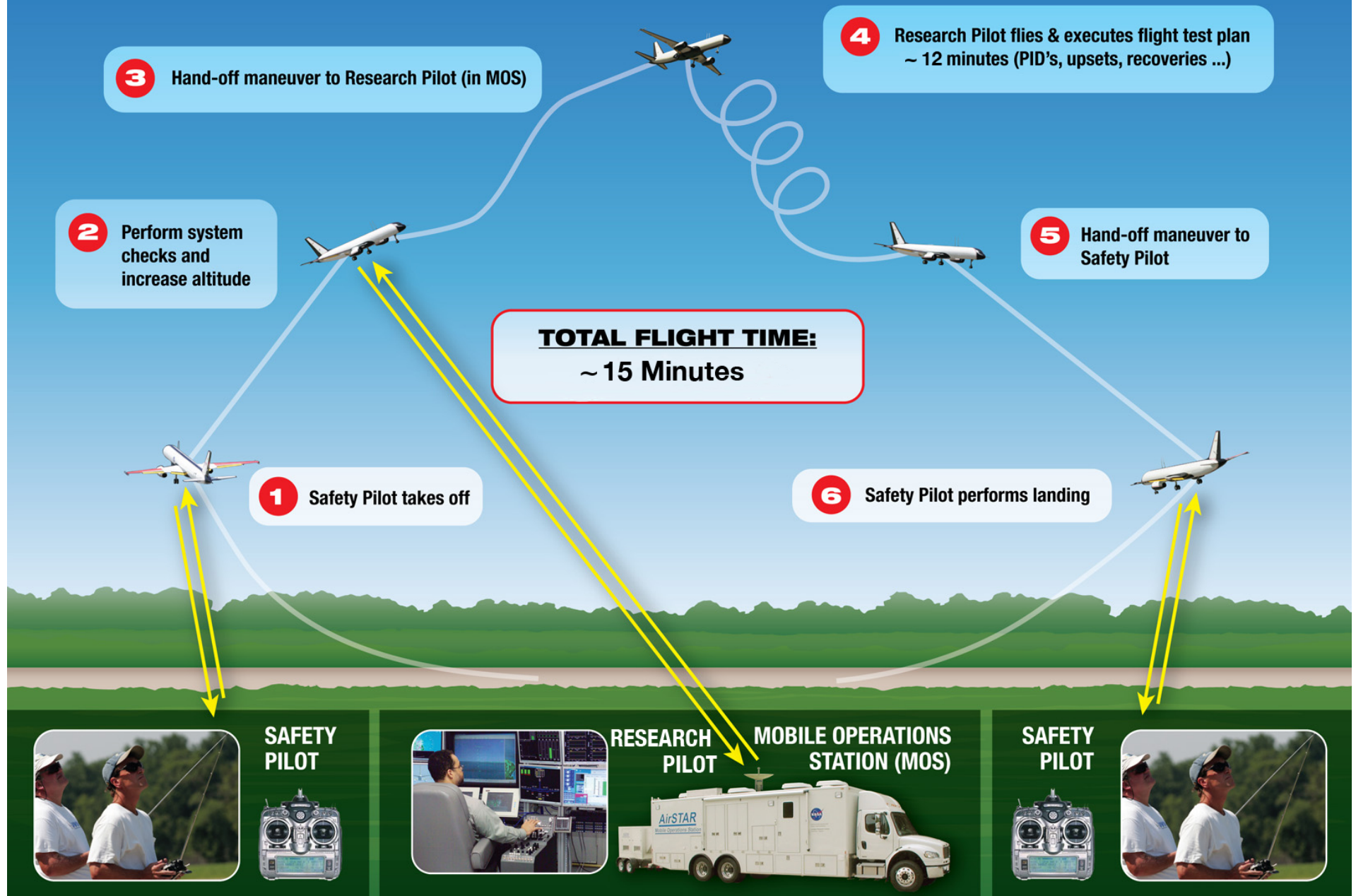
Command and Control Mobile Operations Station (MOS)



- Telemetry tracking antenna
- dSpace real-time data acquisition and control system
- Pilot, researcher, and operational stations
- Data storage and playback
- 60 kW generator



AirSTAR CONOPS



MOS: Research Pilot Station



MOS: Research Pilot Station



Navigation Display:

- Birds Eye View of range limits
- Heading Display
- Estimated Winds Aloft
- No-fly zones, including sun crossing

Aircraft Configuration Monitor:

- Surface Positions, Safety/Research
- Fuel Remaining
- Mode Indications
- Status, non-critical warnings

MOS: Research Pilot Station



Primary Heads-Up Display:

- Out-the-window synthetic view with terrain
- Instrumentation overlay
 - Altitude, airspeed, flight path
 - Alpha and Beta tapes, g-loading
 - Desired/Adequate target bugs, set per card
- Flight Mode Indicators
- Critical warnings and alarms

MOS: Research Pilot Station



MOS: Research Pilot Station

Ground Tracker Camera:

- Tower-View of aircraft
- Primarily used as backup system

Aircraft Nose Camera:

- Cross check on HUD
- Available as backup system



MOS: Research Pilot Station

Mode Control Panel:

- Arm/Engage Discretes
- Analog Inputs
 - Control Law Selection
 - Wavetrain Profile
 - Failure Profile

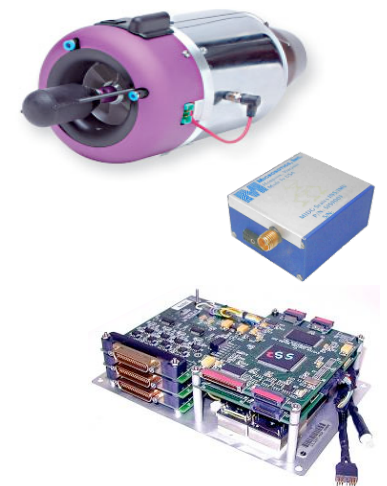
Backup Displays:

- Secondary Heads-Up
- Secondary Navigation
- Redundant computers

TEST AIRCRAFT

GENERIC TRANSPORT MODEL (GTM) – T2

- 5.5% dynamically-scaled
- Takeoff weight: 57 lbs
- Landing weight: 48 lbs
- ~ 7' wingspan, 8' length
- 16 control surfaces:
 - Elevator, spoilers and flaps are split on each side (R/L)
 - Rudder split upper/lower
 - Ailerons right/left
- Independent Turbine Engines (JetCat P70s, 16 lbs thrust)
- Dual air data booms (alpha, beta, static/total pressure)
- IMU (rates, accelerations, magnetometer)
- INS/GPS (rates, accels, mags, Euler angles, position, velocity)
- Pots for control surface positions (12 of 16)
- Engine data (RPM, pump voltage, etc.), Air temp, Battery monitors.



Flight Test Ranges



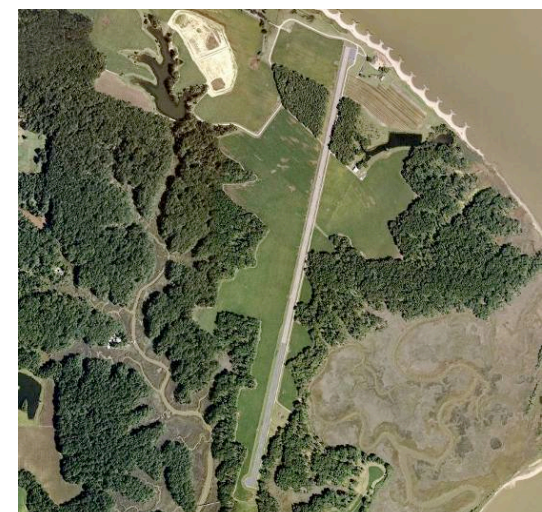
Wallops Flight Facility ***Wallops Island, VA***

- NASA Facility
- 1500' runway
- **Restricted Airspace**
- Weather, radar, RF support



Ft. Pickett ***Blackstone, VA***

- Army National Guard
- 5400' runway
- Current COA
- Tower controlled operations



Aberdeen Field ***Smithfield, VA***

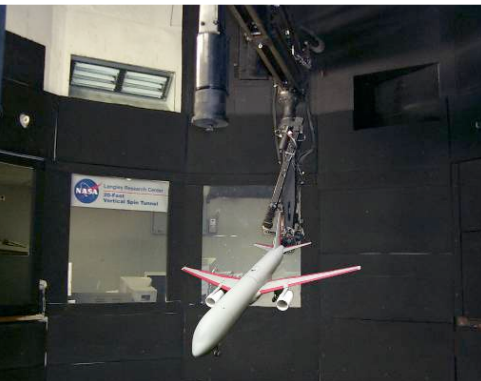
- Private airfield
- 6000' runway
- Current COA
- Minimal support
- Pilot training



Regular range access is critical to both to research and training
FY10: Total of 251 Flights/1495 landings - 36 research flights

AirSTAR

GTM Open-Source Design Simulation



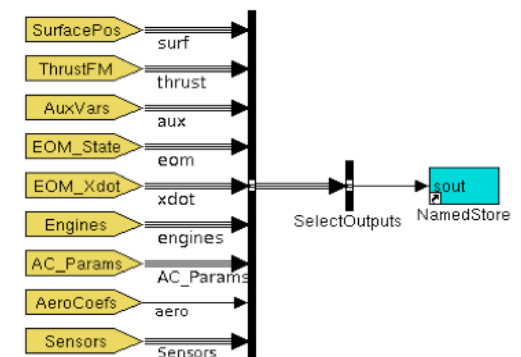
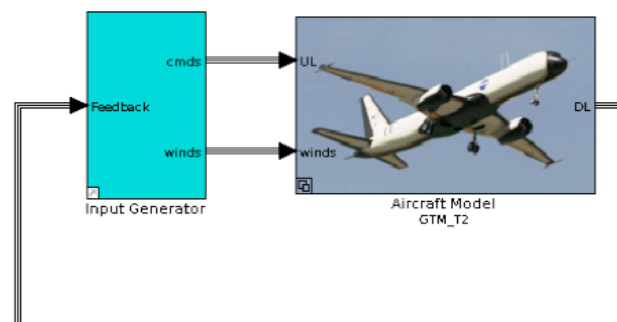
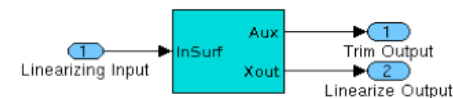
Tunnel Derived Extended Aero Database:

- Static Aero: -5 to 90 deg range in AoA, and +/-45 deg range in sideslip
- Dynamic coefficients from forced oscillation and rotary balance data
- Validation data from free-spin tests in Spin Tunnel

GTM Simulation:

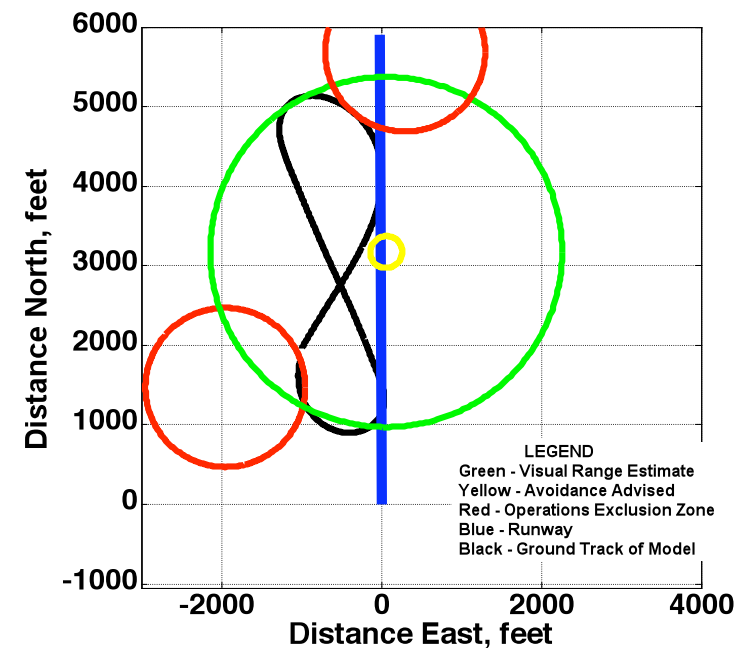
- Open-Source simulation framework
- Includes nonlinear effects, delays, saturation, noise/bias models
- Linearization/Trim utilities provide reduced order models
- Defines interface for control-law code run in real-time system
- Flight Test Planning and Rehearsal

GTM Design-Simulation Model
 Subversion Info: \$LastChangedRevision: 1546 \$
 Last modified by amurch on 04-Jun-2009 10:45:16
 Copyright 2009
 United States Government as represented by the
 Administrator of the National Aeronautics and Space Administration.
 No copyright is claimed in the United States under Title 17, U.S. Code.
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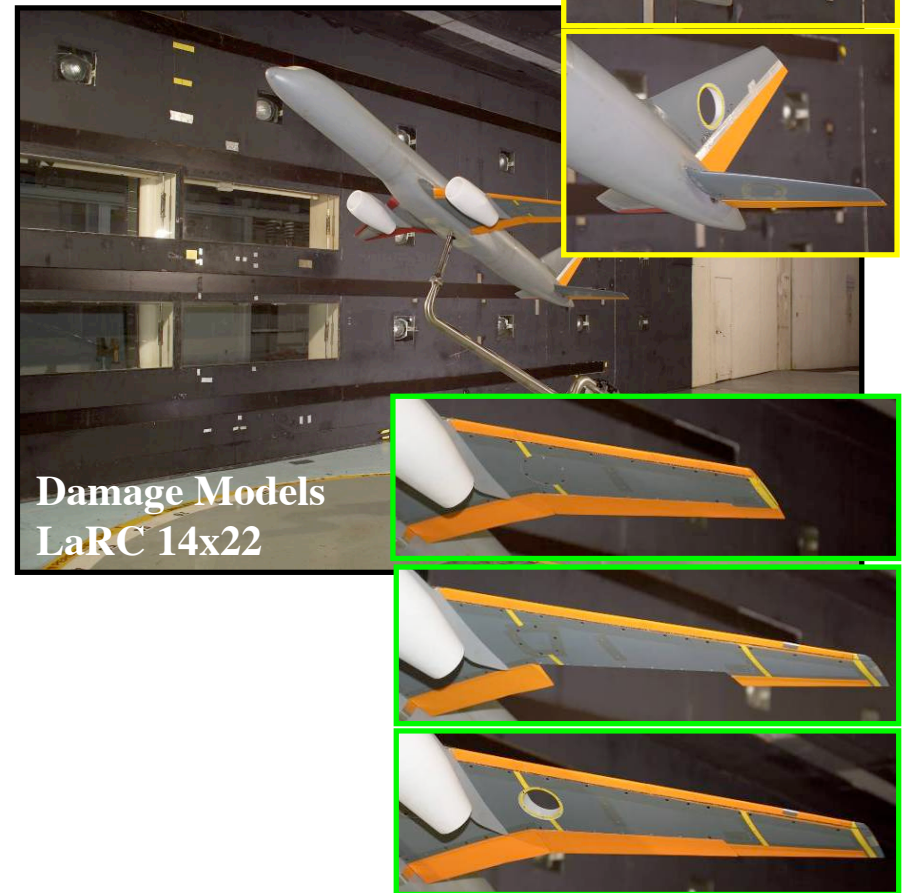
Test Planning and Rehearsal using GTM Simulation

- Piloted Simulations in MOS:
 - Hardware-in-the-loop simulation and testing
 - Test & evaluation of flight control laws, displays, cockpit
 - Abnormal: over speed, functional checks while conducting abusive maneuvers, upset recoveries
 - Profile planning
 - Mission rehearsals: MOS personnel and safety pilot
- Lessons learned:
 - Workload evaluation
 - Communication protocols
 - Test point transition techniques



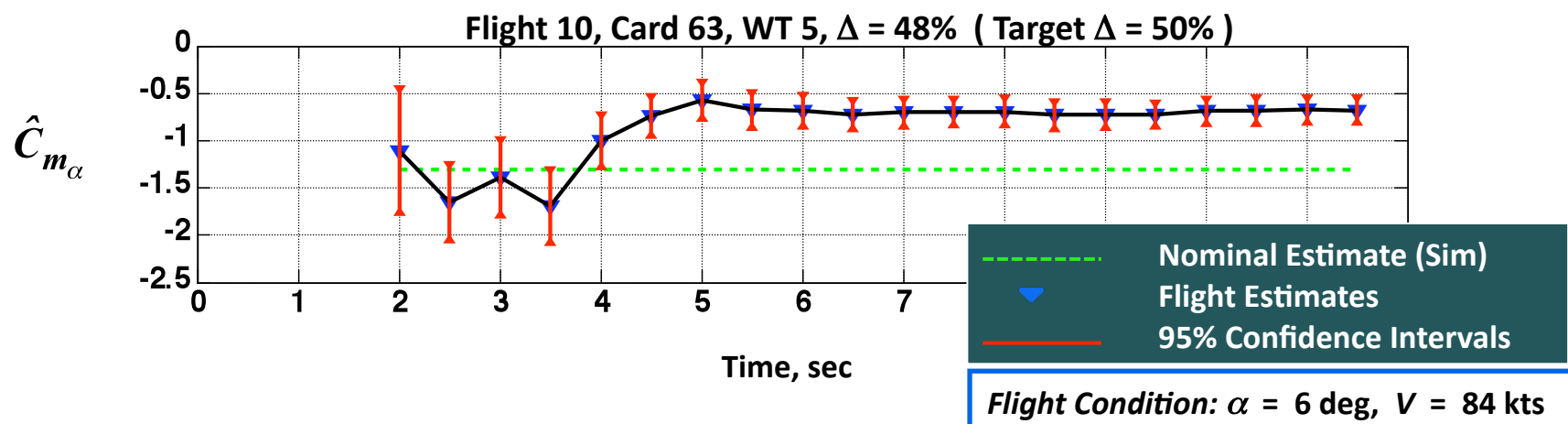
Failure Modeling in GTM Simulation

- Control Surface Locked or Effectiveness Degraded
- Engine Out Conditions
- Six Physical Damage Cases:
 - Rudder Off
 - Vertical Tail Off
 - Left Outboard Flap Off
 - Left Wing Tip Off (25% semispan)
 - Left Elevator Off
 - Left Stabilizer Off
- Physical Damage Cases Include:
 - Mass properties: cg and inertia shift
 - Static aero table increments
 - Dynamic increments on dominate axis rates.
 - Change in control effectiveness

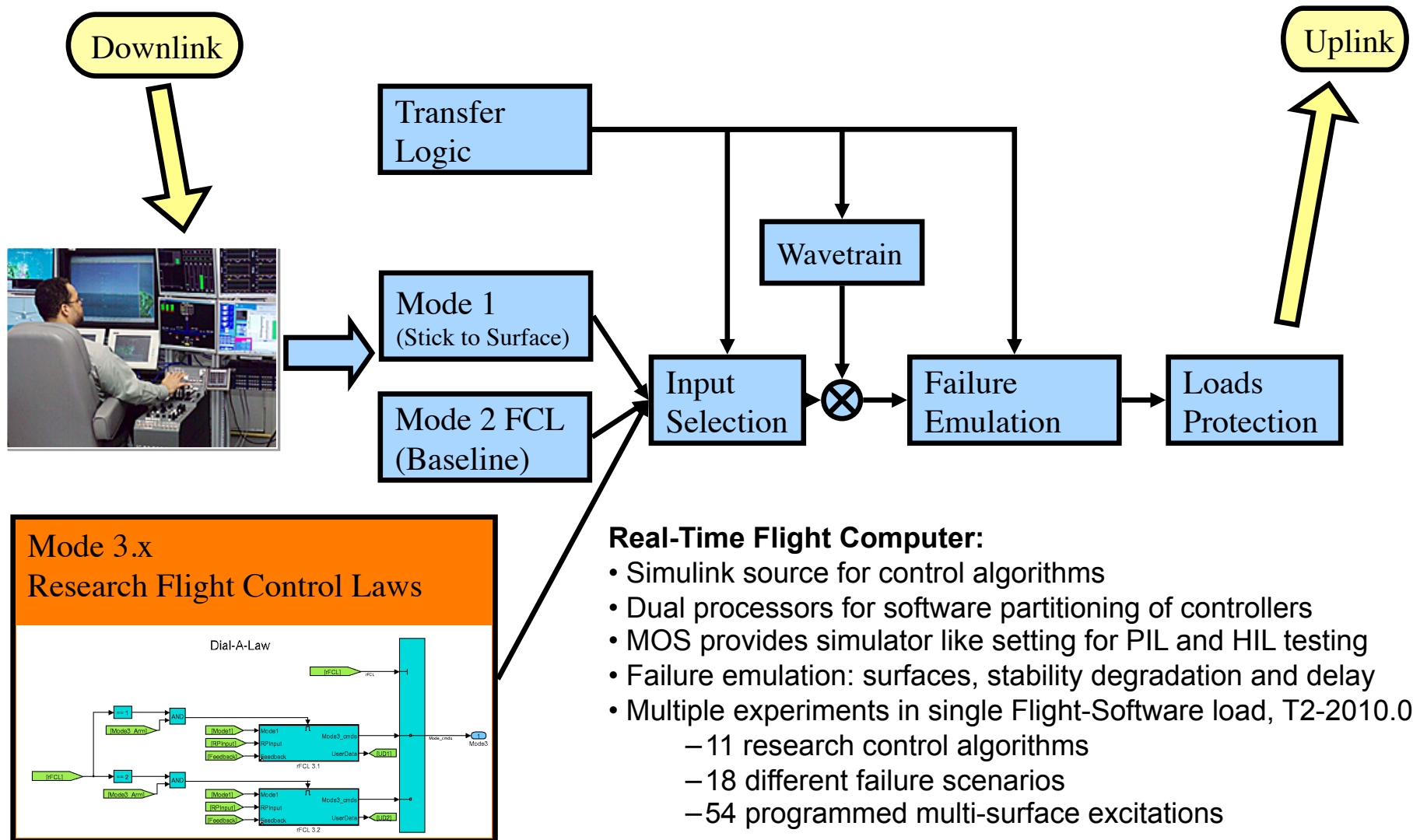


In-Flight Failure Emulation

- Latency Injection:
 - 20 msec-200 msec, in 5 msec increments
- Control Surface Lock:
 - Asymmetric Elevator (fail left side)
- Degraded Damping with partial surface failure
 - Direct destabilizing feedback loop
 - Lower pitch stability and roll damping: C_{ma}, C_{lp}
 - Uses inboard elevators and spoilers.



Real-Time Flight Computer Architecture

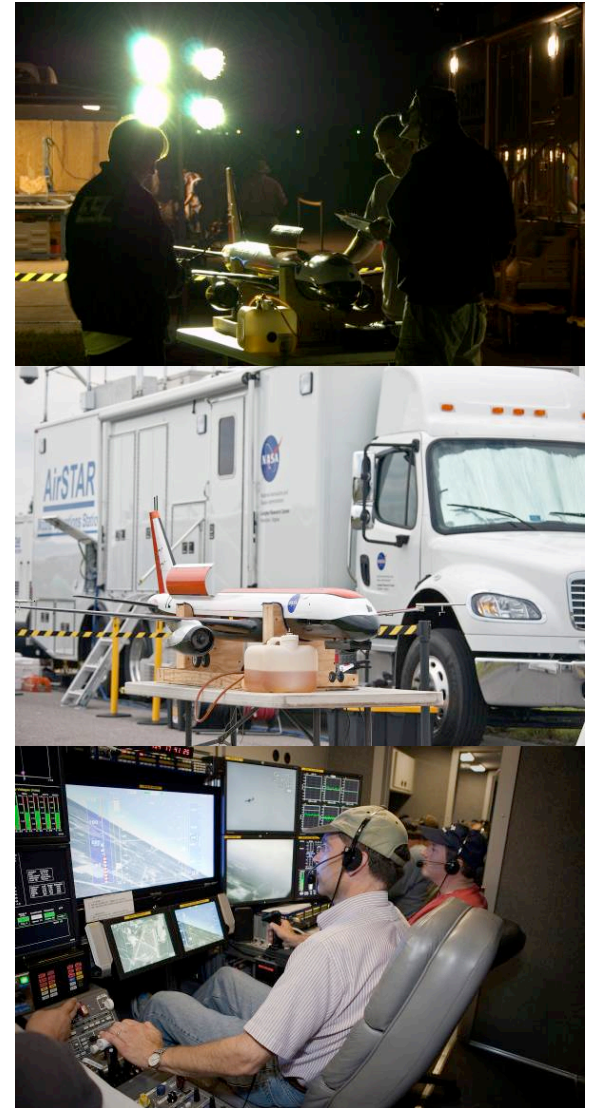


AirSTAR Flight Video



AirSTAR Facility - Summary

AirSTAR facility provides a versatile platform for flight dynamics and controls research and has the ability to implement advanced control algorithms, emulate failures and damage, and obtain piloted evaluations.



Acknowledgements: AirSTAR Team

