National Aeronautics and Space Administration

# Forging Future Flight

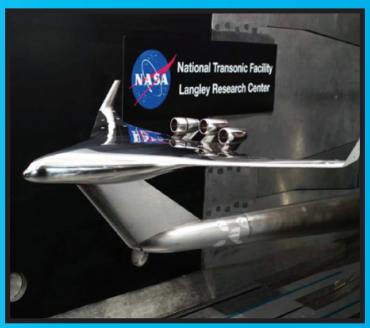
## Aeronautics Research Asset Capabilities at the NASA Langley Research Center

## *The NASA Langley Research Center (LaRC)*

LaRC was established as the nation's first civilian-led aeronautics research laboratory in 1917. It serves as a world leader in "cutting edge" aeronautics research. $180 Million was invested in aeronautics at LaRC in 2011, leading to major advancements in the science of flight. Aeronautics research is conducted in LaRC's unique arsenal of research facilities under the auspices of the Aeronautics Research Directorate (ARD). These facilities include major ground test facilities operated by the Ground Facilities and Testing Directorate (GFTD), aircraft and flight simulation facilities operated by the Research Services Directorate (RSD), and various materials, acoustics, and air traffic labs operated by the Research Directorate (RD).

## *Ground Facilities and Testing Directorate (GFTD)*

### *Aeronautics Research Capabilities*




- GFTD offers customers timely and financially responsible, high quality data
- GFTD offers a variety of co-located facilities that enable analysis of vehicle aerodynamics over a broad range of speed regimes
- GFTD offers the availability of subject matter experts capable of providing solutions to testing and vehicle systems problems
- GFTD offers exclusive testing procedures and data visualization aids
- GFTD offers a protected and safe testing environment

## *Ground Facility Capabilities*

***14- by 22-Foot Subsonic Tunnel:*** (Speed Range: Mach 0 to 0.3) An atmospheric, closed-return tunnel that provides the opportunity to test both powered and unpowered models of various fixed and rotary-wing configurations. The facility is used to assess aerodynamic performance of civil and military aircraft over a wide range of takeoff, landing, cruise, and high angle-of-attack conditions.

***Low Speed Aeroacoustics Wind Tunnel (LSAWT)***: (Speed Range: Mach 0.10 to 0.32) Realistic flow conditions of commercial and military aircraft engine exhausts are simulated in the anechoic environment of the LSAWT.

***20-Foot Vertical Spin Tunnel (VST):*** (Speed Range: 0 to 90 ft/s) The only tunnel in the United States that can conduct dynamically-scaled, free-spin model tests.

***Transonic Dynamics Tunnel (TDT):*** (Speed Range: Up to Mach 1.2) For more than four decades, the TDT has provided a unique national testing capability for identifying, understanding, and developing solutions for complex aeroelastic and non-aeroelastic phenomena. The TDT is dedicated to providing accurate research data and experimental validation.

***National Transonic Facility (NTF):*** (Speed Range: Mach 0.1 to 1.2) The world's largest pressurized cryogenic wind tunnel, the NTF, possesses unique capabilities to duplicate actual flight conditions. The NTF supports advanced aerodynamic concept development and assessment, advanced computational fluid dynamics tool validation, and risk reduction for vehicle development.

***0.3-Meter Transonic Cryogenic Tunnel (0.3-M TCT):*** (Speed Range: Mach 0.1 to 0.9) Research testing of two-dimensional airfoil sections and other models has been conducted in this highly adaptable research facility in which the ceiling and floor can be streamlined in order to significantly reduce wall effects on the model.

***20-Inch Supersonic Wind Tunnel (SWT):*** (Speed Range: Mach 1.6 to 5.0 [0.35 to 0.75 for airfoils]) This versatile blow-down facility has a unique injection/projection support system for high-speed sting mounted models or models can be mounted on the floor or sidewall.

***4-Foot Supersonic Unitary Plan Wind Tunnel (UPWT)***: (Speed Range: Test Section No.1, Mach 1.5 to 2.9; Test Section No.2, Mach 2.3 to 4.6) This heavily used supersonic wind tunnel is synergistically matched with other Langley facilities to provide comprehensive testing capability across the speed range from subsonic to hypersonic conditions for developing, assessing, and optimizing advanced aerospace vehicle concepts

***Langley Aerothermodynamic Laboratory (LAL):*** The LAL consists of four hypersonic blow-down-to-vacuum tunnels that represent 100% of NASA's and over half of the Nation's conventional aerothermodynamic test capability. These economical facilities are relatively small, and ideally suited for fast-paced aerodynamic performance and aero-heating studies aimed at screening, assessing, optimizing, and benchmarking advanced aerospace vehicle concepts and basic fundamental flow physics research.

***8-Foot High Temperature Tunnel (HTT):*** (Speed Range: Mach 3, 4, 5, and 7) The nation's largest hypersonic blow-down test facility which simulates true enthalpy at hypersonic flight conditions for testing advanced, large-scale, flight-weight aerothermal, structural, and propulsion concepts.

***Supersonic Combustion Ramjet (Scramjet) Test Complex:*** The Scramjet Test Complex is a leading-edge ground test capability comprised of several distinct facilities. The complex includes a direct-connector combustor test facility, two small-scale complete engine test facilities, the Mach 4 Blow-Down Facility, and the 8-Foot High Temperature Tunnel for large-scale complete engine tests.

***Combined Loads Test System (COLTS):*** A unique structural testing complex in which aircraft fuselage section components of commercial transports are subjected to combined loading conditions that simulate realistic flight load conditions.

***Landing and Impact Research Facility (LandIR):*** A National Historical Landmark, the LandIR vehicle structural testing complex, better known as the "gantry", was first built in 1963 to train astronauts to land on the moon. Since that time the 240-foot high, 400-foot long, 265-foot wide, A-frame steel structure has been used to provide crucial research test data on the crashworthiness of General Aviation (GA) aircraft, commercial aircraft and rotorcraft.

## *Research Services Directorate, Simulation Development and Analysis Branch (SDAB)*

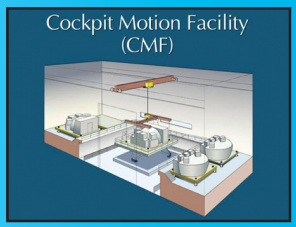
### *Aeronautics Research Capabilities*

- Performing flight simulation since the 1950s supporting aeronautics
- Works to pioneer and advance simulation systems technologies for aerospace and scientific studies
- Serves as a software supplier for flight tests
- Designs, implements, tests, and validates concepts in simulation and in flight for both aerospace and scientific development
- LaRC simulation facilities are a major component of the NASA Strategic Capabilities Assets Program (SCAP) and are described as follows.

## *NASA Langley Flight Simulation Facility Capabilities*

### *Cockpit Motion Facility (CMF)*

- World-Class, 6 DOF, State-of-the-Art motion system
- Features three fixed-based motion-based simulator cockpits
  - Research Flight Deck (RFD) Simulator
  - Integration Flight Deck (IFD) Simulator
  - Generic Flight Deck (GFD) Simulator
  - Available space for a 4th simulator
- State-of-the-art Infrastructure
- Real-time computers for aerospace vehicle and environment modeling
- Display and graphics computers for flight deck instruments
- High performance visual scene image generation computers for window scenery
- Fiber optic video distribution
- High speed SCRAMNet+ and Ethernet fiber optic data communications
- Hydraulics and power systems
- System Integration Laboratory (SIL)



### *Generic Flight Deck (GFD) Simulator*

- Advanced all “glass” generic cockpit which can be used to represent a large range of vehicle types
- Operated in fixed-base mode or in motion-base mode
- Two crew and three observers seats
- Four large LCD’s in main instrument panel, three LCD’s in overhead, and two LCD’s in center aisle stand
- LCD’s can be configured with touch-sensitive functionality
- Interchangeable control inceptors (side sticks – hydraulic and electric, wheel/columns – hydraulic, center-sticks-hydraulic)
- Visual system (four collimated – two forward and two side window units)
- Used in Blended Wing Body and past and present SupersonicTransport studies.

### *Research Flight Deck (RFD) Simulator*

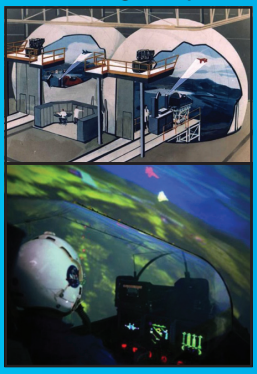
- Hybrid B-787 and B-777/MD-11/A-320 functionality
- Two crew and three observers seats
- Focus on evaluation and refinement of research concepts in an advanced high fidelity, full-systems flight-operations environment
- Studies support Aviation Safety Program and Air space Systems Program

### *Integration Flight Deck (IFD) Simulator*

- Closely replicating Boeing 757 Flight Deck with Pilot Side Modified with Research Equipment
- Two crew and three observers seats
- Evaluation and refinement of research concepts aimed at existing transport aircraft, control upset/ unusual attitudes, etc.
- Studies include development and support of flight tests in commercial, business, and general aviation aircraft

### *Differential Maneuvering Simulator (DMS)*

- Provides for two aircraft operated piloted or unmanned in a differential mode
- Provides air combat simulation and allows testing of future aircraft designs, up grades to existing aircraft, handling qualities, control system design, and display design including helmet-mounted displays
- Two identical 40-foot dome simulators
- 360° out-the-window visual scene
- High resolution area of interest projection, audio cues, control loaders
- High resolution target projection
- Vibration simulation using buffeting effects
- Capable of unmanned aerial systems simulation studies



### *Development and Test Simulator (DTS)*

- B-777/MD-11/A-320 functionality
- Two crew and three observers seats
- Full mission functionality; operating in fixed base mode
- Allows for evaluation and refinement of research concepts in an advanced high-fidelity, full-systems flight operations environment
- Studies include Aviation Safety Program and Air space Systems Program

### *System Integration Lab (SIL)*

- Human-in-the-Loop Simulator integrates with System Integration Lab for Hardware-in-the-loop, End-to-End Mission Simulation
- Hardware Systems for testing include Avionics; Command, Control, Communications, and Information (C3I); Audio, Voice, and Video
- Equipment interfaced directly with simulator facilities
- High speed communications network
- Video and audio distribution
- Full simulation of actual vehicle signal busses (ARINC, discrete, analogs, serial, telemetry)
- Lab has communication and navigation capabilities via roof-mounted VHF blade, L-band, and GPS antenna
- Virtually any avionics hardware or protocol can be integrated into lab
- Flight management computers
- Flight control computers

## *Research Services Directorate, Laboratories and Flight Research Aircraft*

### *Aeronautics Research Capabilities*

- LaRC has a variety of platforms that can cost effectively meet nearly any flight test development and integration requirement
- One-stop shop including electrical/structural design, fabrication and integration of payload, airworthiness certifications, and operations
- Large hangar (300 ft x 300 ft x 65 ft – max tail height) and ramp located adjacent to Langley Air Force Base
- Available platforms (described as follows)

### *Available Platforms*

B200 King Air
UC-12B Military King Air
OV-10A Bronco
UH-1H Iroquois
C206 Stationair
SR22 Cirrus
LC-40 Cessna Columbia 300

Cirrus SR22 used for Small Aircraft Transportation System (SATS) development, Air Force Research Lab 3D Audio Cueing System and as an Unmanned Aerial System Surrogate Research Aircraft

UH-1H Iroquois
used in the past for drop model spin testing and currently being used in instrument development studies

LC-40 Cessna Columbia 300

C206 Stationair used for synthethic vision, airborne pilot eye tracker, voice activated flight planning, and EPA sensor integration research

OV-10A Bronco used in atmospheric science studies

B200 King Air Research Platform

## *Research Directorate, Crew Systems & Aviation Operations Branch (CSAOB) Aeronautics Research Capabilities*

### *Air Traffic Operations Laboratory(ATOL)*

The ATOL provides air traffic management (ATM) concept and procedure simulation capability. This capability, referred to as the Airspace and Traffic Operations Simulation (ATOS), is made compatible with current aviation system architectures and the evolving National Airspace System (NAS) infrastructure. The ATOL hosts over 500 computing platforms (12 of which are single-pilot stations). Each aircraft is referred to as an ASTOR, or Aircraft Simulation for Traffic Operations Research. This arrangement allows active airline pilot test subjects to fly new concepts in high density traffic scenarios. Three en-route and

two terminal Air Traffic Control (ATC) stations are incorporated in the ATOL and give live controllers the capability to communicate with the pilots via voice and data link communication systems. The ATOL can be connected to air traffic and flight simulations at other facilities via the AviationSimNet to implement more comprehensive simulations. The ASTOR arrangements allow researchers to simulate a variety of airspace and air traffic situations while also evaluating advanced decision aids and airborne communication, navigation, and surveillance (CNS) systems. The ATOS also provides the capability to evaluate crew workload and performance, and can be linked up with ATM and flight simulation labs across the country. The simulation environment fostered by the ATOL can be used to conduct: operational feasibility assessments, system-level requirements definition, airborne and ground-based CNS technology requirements determination, and human-centered design and assessment of ATM concepts and flight deck systems.

## *Engineering Directorate*
## *Aeronautic Systems Engineering Branch (ASEB)*
## *Aeronautics Research Capabilities*

### *Airborne Subscale Transport Aircraft Research (AirSTAR)*

AirSTAR was developed to provide a flexible and efficient flight test capability that can be used to conduct flight research experiments in support of advanced controls and modeling research funded by NASA's Aviation Safety Program (AvSP). Consisting of three major and distinct components: the air, ground, and test facilities, the testbed has allowed researchers both internal and external to Langley to fly their control system and modeling experiments, receive feedback and data in real-time, and to be present while the experiments are being flown. The ability to use remotely piloted, subscale aircraft to acquire this type of data reduces the risk and cost associated with full scale flight testing and allows more aggressive maneuvering of the aircraft during research flight experiments. Acquisition of world-class flight-test data from the AirSTAR testbed is valuable in improving aerodynamic models and pilot training simulators of transport aircraft at extreme flight conditions.

## *New Business Contacts:*

### *Interested in doing testing with us?*

***Please contact any of the following individuals to explore working with us:***

***Brian Beaton: 757-864-2192, brian.f.beaton@nasa.gov***

***For Wind-Tunnel test arrangements, please contact:***

***Peter Jacobs: 757-864-2855, peter.f.jacobs@nasa.gov***

***For Flight Testing arrangements, please contact:***

***Frank Jones, 757-864-5271, frank.p.jones@nasa.gov***

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