



Airborne Testing of Passive Wireless Sensors and their uses in Commercial and Experimental Aircraft

Michael Christopher | Aerospace Sales Manager

Outline

- Introduction
- Calspan Summary
- PWST Use Cases in Civil Aviation
- PWST Testing and Certification
- Conclusion

PWST Use Cases in Civil Aviation

- “2026, annual data generation should reach 98 billion gigabytes, or 98 million terabytes”¹
- “The current A350 model has a total of close to 6,000 sensors across the entire plane and generates 2.5 Tb of data per day”²
- “Bombardier showcased its C Series jetliner that carries Pratt & Whitney’s Geared Turbo Fan (GTF) engine, which is fitted with 5,000 sensors that generate up to 10 GB of data per second”³

- ¹(<https://www.forbes.com/sites/oliverwyman/2017/06/16/the-data-science-revolution-transforming-aviation/#70046f3d7f6c>)

- ²(<https://www.datasciencecentral.com/profiles/blogs/that-s-data-science-airbus-puts-10-000-sensors-in-every-single>)

- ³(<http://aviationweek.com/connected-aerospace/internet-aircraft-things-industry-set-be-transformed>)

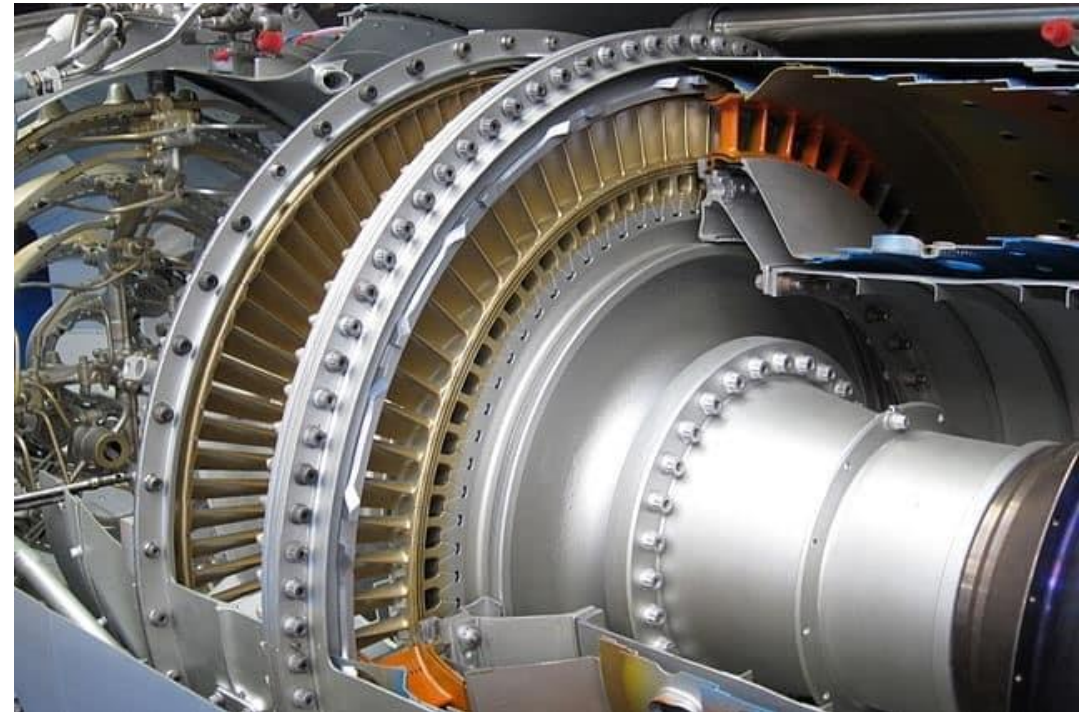
PWST Use Cases in Civil Aviation

- “If you removed all the wires from a widebody passenger jet and strung them end-to-end, you could connect St. Louis to Chicago or London to Amsterdam, distances of approximately 500 kilometers. If you rolled these 100,000 wires into a ball with the harnesses that hold them to the aircraft structure and put the ball on a scale, it would tip to nearly 7,400 kilograms or about 3 percent of the aircraft’s weight.”¹
- Delays in 787 Manufacture

¹<https://aerospaceamerica.aiaa.org/features/war-on-wiring/>

PWST Use Cases in Civil Aviation – System Specific Applications

- Engine Environment
 - Health of the Turbine Blades and Bearings
- Fuel Systems
- Structures Fatigue
- Aerodynamic Data Collection
- Cockpit Data Collection
- Operational Benefits:
 - Maintenance Planning
 - Turn Time Reduction



PWST Use Cases in Unmanned Aerial Vehicles (UAVs)

- Engine and Systems Health
- Sense and Avoid
- UAV Swarming
- Loyal Wingman Operations
- Aerial Refueling



Northrop Grumman MQ-4C Triton



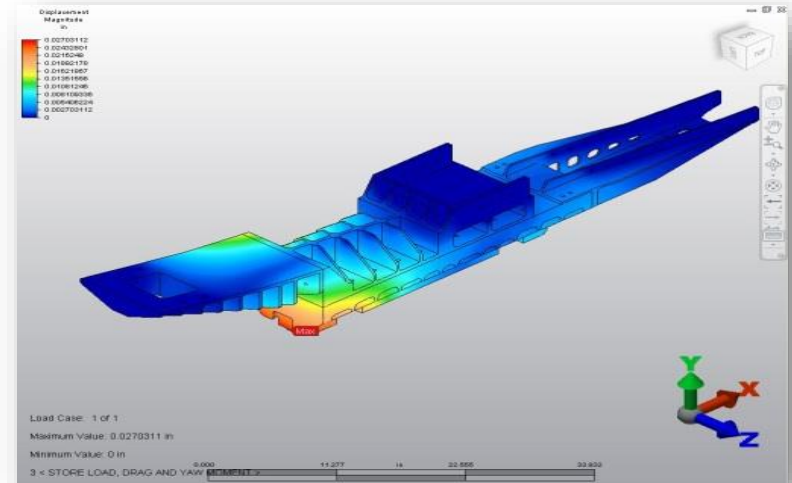
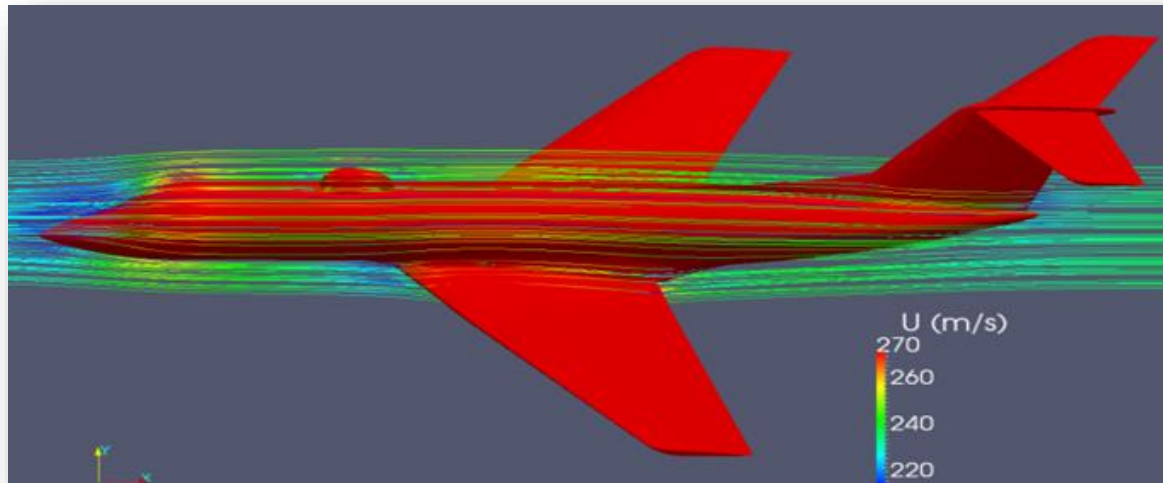
PWST Testing

- Experimental Category Aircraft with FAA Program Letter
- Data Collection with In-Flight Hardware



PWST Certification

- Original Type Certificate
- STC (Supplemental Type Certificate) by a DER (Designated Engineering Representative)



Calspan Corporate Headquarters



- Headquarters: Buffalo, NY, USA
- 400 + Employees
- Most with Engineering & Technical degrees

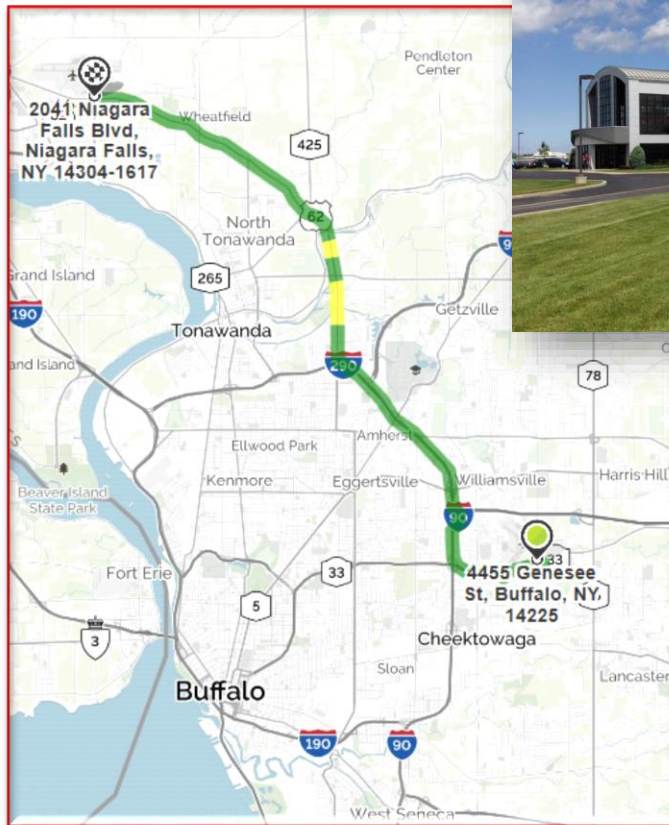


- Transonic / Subsonic Wind Tunnel
- Crash Test Facility
- Sled Test Facility
- Tire Test Facility
- ATD Lab
- Crash Research and Investigations Unit

Flight Operations

Main Facility – Base of Operations

2041 Niagara Falls Blvd
Niagara Falls, NY 14304



- Fleet of 9 fully modified airborne testbeds
- State-of-the-art facility at IAG (Niagara Falls International Airport)
 - 80,000 ft² hangar with backshops
 - Sheet metal / machine shop
 - Avionics / Electronics / Hydraulics

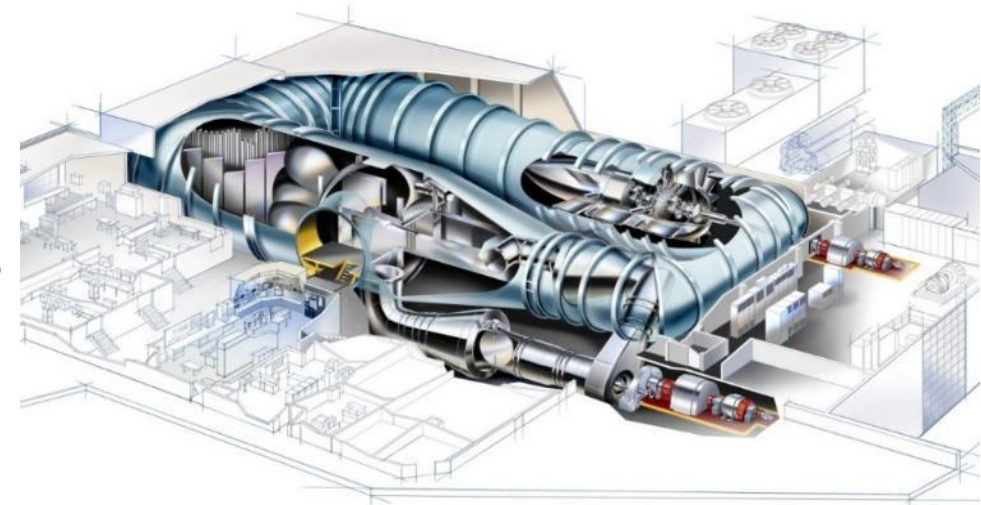


Other Locations:

- Edwards AFB, CA (VISTA F-16, Learjet)
- Patuxent River NAS, MD (Learjet, Saab 340 ASTARS)

Transonic Wind Tunnel

- 8 ft. x 8 ft. test section
- Maximum Mach number of 1.30
- Stagnation pressures of 0.25 to 3.25 atmospheres
- Dynamic Pressure
 - 700 lb./ft² [33.5 kPa] – Conventional Operations
 - 1,800 lb./ft² [86.2 kPa] – Ejector Augmented
- Reynolds Number
 - 4×10^6 /ft. [13×10^6 /m] – Transonic, Conventional Operations
 - 8×10^6 /ft. [26×10^6 /m] – Subsonic, Conventional Operations
 - 11×10^6 /ft. [36×10^6 /m] – Transonic, Ejector Augmented
- Up to 50,000 ft. [15,000 m] simulated altitude
- Auxiliary Air Supply to Model
 - Primary air delivery: Up to 2,000 lb./in² [13,790 kPa] at up to 15 lbm/s [6.8 kg/s]
 - Secondary (low volume) air delivery: Up to 100 lb./in² [690 kPa] at 0.02 lbm/s [0.009 kg/s] to 0.10 lbm/s [0.045 kg/s]



Calspan Customers

THALES

LOCKHEED MARTIN



Gulfstream®
A GENERAL DYNAMICS COMPANY



AIRBUS



Raytheon

NORTHROP GRUMMAN



Intelsat

Honeywell



**GENERAL
DYNAMICS**

**Rockwell
Collins**



Global Reach



Flight Operations



Core Business – Aircraft Modifications and Flight Test

- Aircraft Modifications

- Unique, one-of-a-kind
- Airborne Testbeds
 - Gulfstream G-III (2)
 - Learjets (5)
 - Saab 340A (1)
 - VISTA NF-16D (1)
 - Penguin C UAV (1)
- FAA Part 145 Repair Station



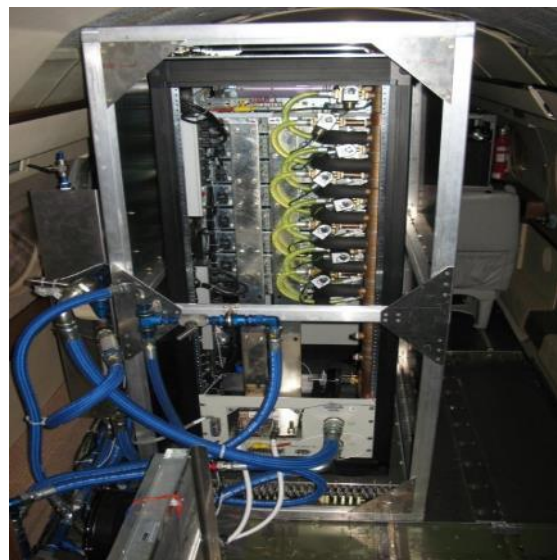
- Flight Test

- In-Flight Simulation
- External stores
- Sensors
- Satellite Communication
- UAV Surrogates
- Test Pilot Training



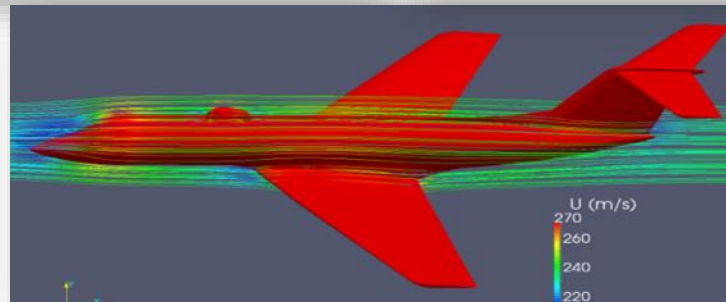
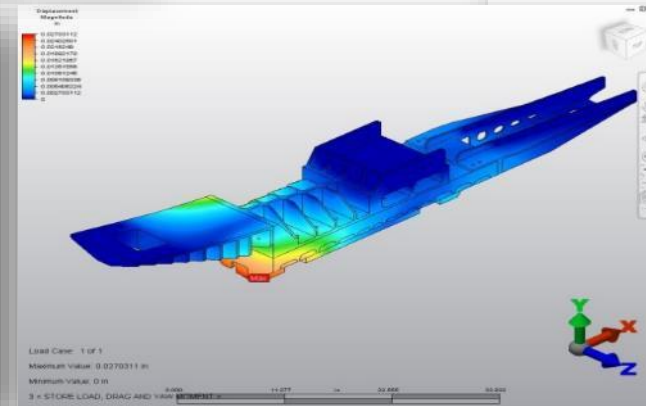
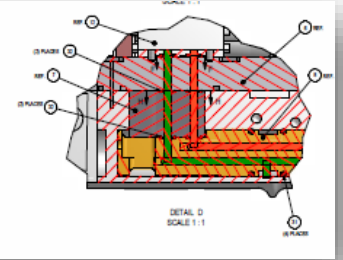
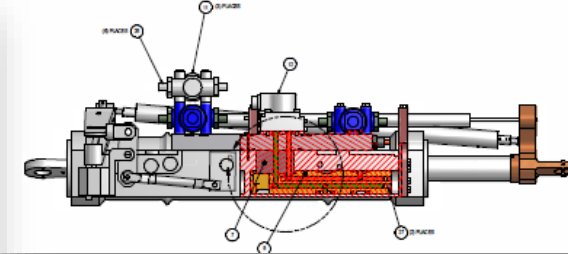
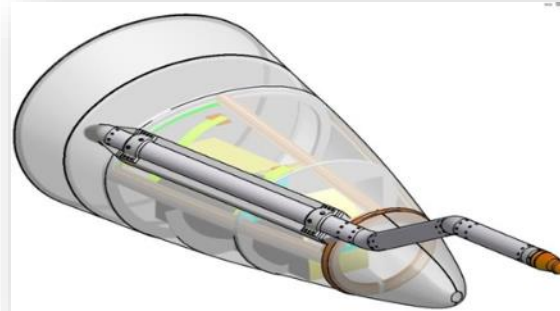
Aircraft Modifications

- Unique, one-of-a-kind mods
- Vertically integrated
 - Design
 - Fabricate
 - Integrate
 - Install
 - Ground Test
 - Flight Test
 - Airworthiness certification
- 70+ years experience
- FAA Part 145 Repair Station



Design Capabilities

- Design
 - Stability and Control
 - Aerodynamic
 - Mechanical
 - Electrical
 - Hydraulic
- Analysis
 - Stress (including FEA)
 - Cooling
 - Electrical Loads
 - Hydraulic Loads
- Documentation
 - 2-D / 3-D Drafting
 - Reports



Document No.: TM-FRG-ASTARS-0001-R00



FLIGHT RESEARCH GROUP

ESTIMATE OF ASTARS
F-16 RADOME AND MX-15 TURRET
AERODYNAMIC LOADS AND EFFECT
ON STATIC STABILITY

Contract No. N00421-09-C-0103

Author: *Ryan P. McMahon* Date: 26 Feb 2009
Ryan P. McMahon
Senior Aeronautical Engineer

Marco Lettieri Date: 26 Feb 2009
Marco Lettieri
Lead Aeronautical Engineer

Approved: *Paul T. Schiffrer* Date: 9 Oct 2009
Paul T. Schiffrer
Technical Manager, Flight Research Group

Denotes Change |

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Calspan Aircraft Modification Genealogy

C-131B Total In-Flight Simulator
(TIFS)



1970



1975



1998

Saab 340 ASTARS

2010



Sense & Avoid
Radar



2011

Automated Aerial
Refueling Probe



2013

NGC Next Gen Jammer

2012



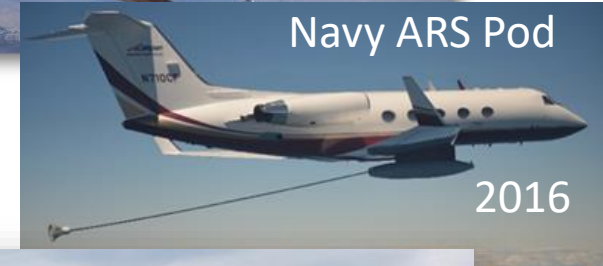
Raytheon Next Gen Jammer

2014



Navy ARS Pod

2016



SatCom System

2018



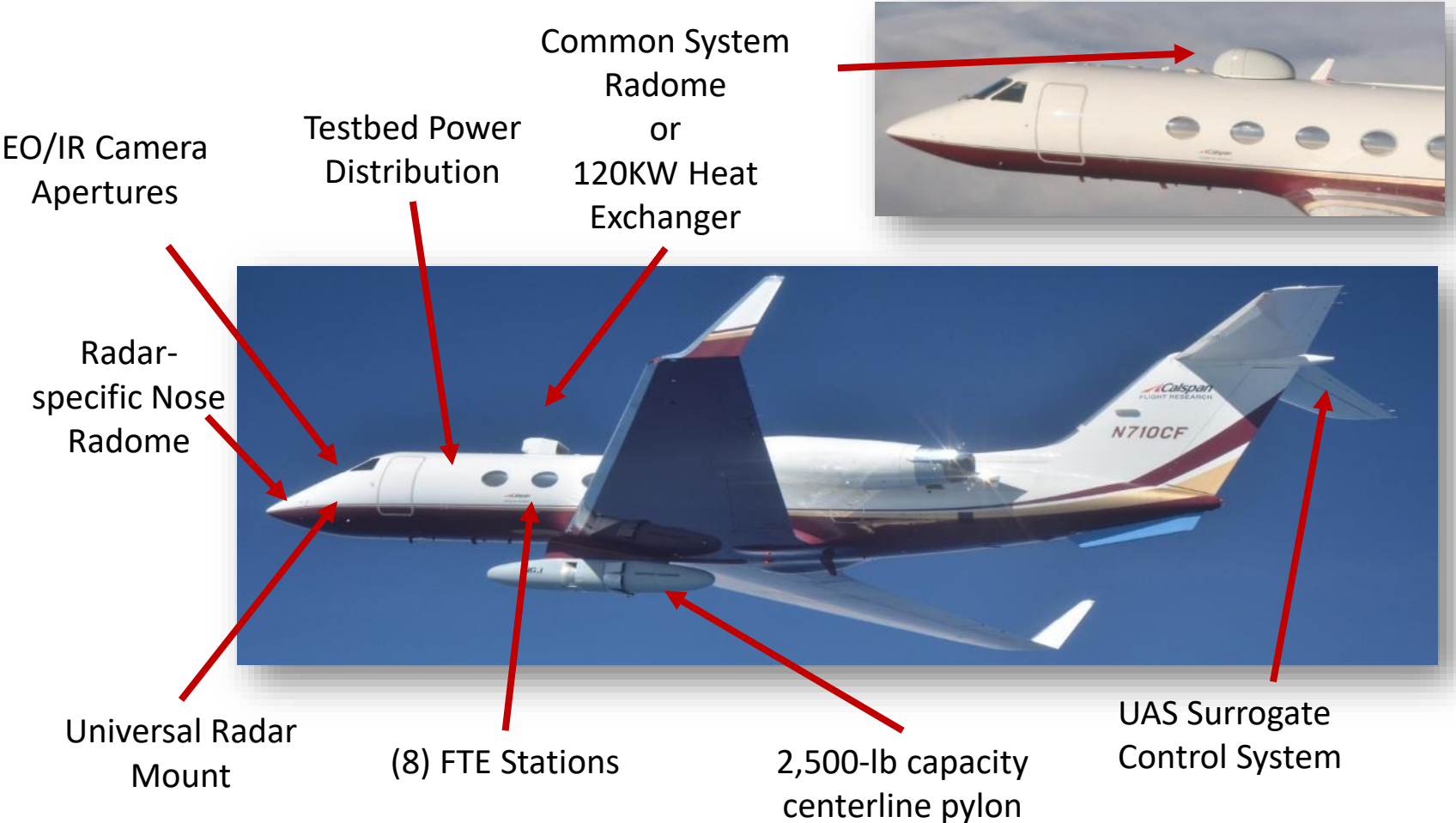
Mission Systems

- Electro-Optical
- Infrared
- Multi-Spectrum RF
- Satellite Communication
- Datalinks
- Navigation
- Onboard Processing



Calspan has experience integrating all of these mission systems on a FTB

Current G-III Airborne Testbed Features




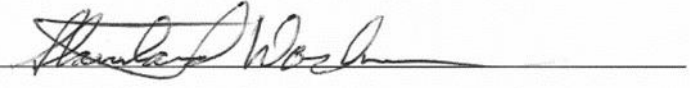
Calspan Modification Approach

- Modular concepts
 - Multiple configurations
 - Roll-on, roll-off cabin
 - Universal power system
 - ARINC 429 bus taps
- FAA Certification Approach
 - Multiple equipment configurations
 - Permanent structures on FAA 8110-3
 - Systems under test on FAA 337 field approvals



FAA Certification

- Aircraft operated under FAA Experimental Research and Development airworthiness certificate
- Coordinated through FAA's Rochester, NY Flight Standards District Office (FSDO)
- General and **program-specific** limitations

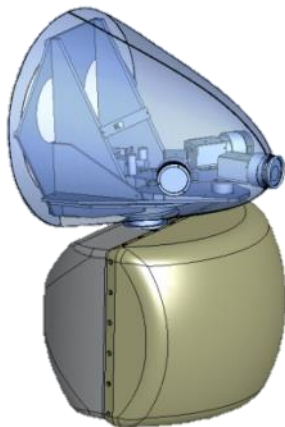
 U.S. Department of Transportation Federal Aviation Administration	FLIGHT STANDARDS DISTRICT OFFICE, EA-23 One Airport Way, Suite 110 Rochester, New York 14624 (585) 436-3880
Date: 10/03/2014	
Builder: Gulfstream Model: G1159A Serial Number: 448 Registration Number: N710CF	Owner: Calspan Corporation Address: 4455 Genesee St. Buffalo, NY 14225
<p align="center"><u>10/03/2014 AMENDMENT TO EXISTING EXPERIMENTAL</u> <u>- RESEARCH AND DEVELOPMENT, MARKET SURVEY, & CREW TRAINING</u> <u>LIMITATIONS DATED 12/23/2013</u></p>	
AMENDED LIMITATIONS:	
<p>(2) No person may operate this aircraft for other than the purpose of Research and Development, Market Surveys, and Crew Training, to accomplish the flight operation outlined in the program letter dated 09/30/2014 describing compliance with §21.193(d). In addition, this aircraft must be operated in accordance with applicable air traffic and general operating rules of part 91, and all additional limitations herein prescribed under the provisions of § 91.319(i).</p>	
<p>(4) All flights when operating under Research and Development must be conducted within the geographical area indicated on the chart as follows: NAS Point Mugu, CA (KNTD), Los Angeles International (KLAX), and NAWS China Lake, CA (KNID), (see attached maps labeled A, & B).</p>	
<p>(28) The aircraft may be flown with a combination of an Extended range passive GPS antenna mounted on the upper fuselage, Customer equipment in the aft cabin and aft baggage compartment racks, Upper fuselage heat exchanger, Lower rear fuselage ventral fin and a MAU-40 ejector rack installed on the lower centerline fuselage station. A RAYTHEON FDP POD MAY BE INSTALLED ON THE MAU-40 EJECTOR RACK WHILE OPERATING UNDER THESE OPERATING LIMITATIONS, BUT MUST BE PHYSICALLY DISABLED TO PREVENT INADVERTENT OPERATION WHEN OUTSIDE THE TEST AREAS NOTED IN THE 09/30/2014 PROGRAM LETTER.</p>	
In addition; The program letter dated 09/30/2014 must be carried with these limitations	
Staniland Wochner DAR DART831148EA	

In-Flight Simulators

- Original Design Missions
 - Handling Qualities Research
 - Development of Fly-by-Wire (FBW) Flight Control Systems
 - Test Pilot Training
- Unmanned Air Vehicle (UAV) Surrogacy
 - Autonomous Aerial Refueling (AAR)
 - Sense and Avoid (SAA)
 - Remotely Piloted Aircraft (RPA)
- Upset Recovery Training



Sense & Avoid Flight Tests



- Global Hawk prototype radar
- SAA Flights started in Fall 2012
- More flight tests in 2013
- Follow-on for USAF in early 2015



Automated Aerial Refueling Flight Tests

GPS



Laser detectors
IR Cameras



Inert "dry"
refueling boom



Received full NAVAIR flight clearance to engage drogue

Program Personnel

- Highly-experienced, multi-disciplined group
- Experimental Test Pilots
 - U.S. Air Force or Naval Test Pilot School grads
- Engineers
 - Aerospace, Computer, Electrical, Mechanical, Software
- Mechanics
 - All FAA Airframe and Powerplant (A&P) rated
 - Three are FAA Inspection Authorized (IA)
 - Each has their own fabrication specialty
- Technicians
 - Circuit board fabrication to aircraft system integration

All required personnel are in-house



A large, stylized red swoosh graphic that curves upwards and to the right, positioned behind the 'Thank You' text.

Thank You