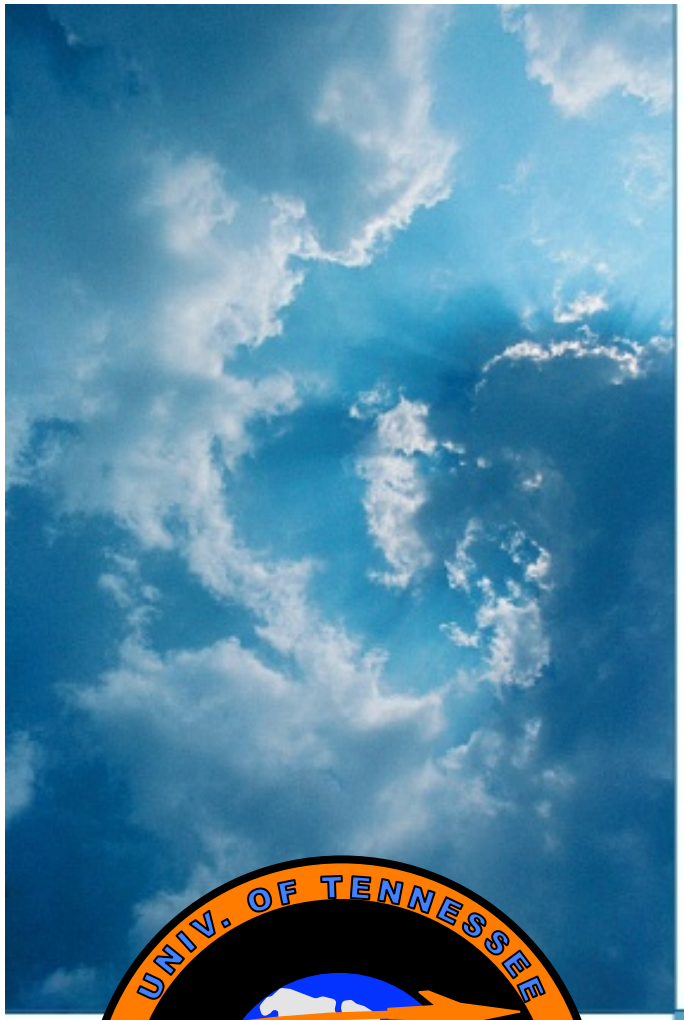

Airborne Science at the University of Tennessee Space Institute

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University of Tennessee Space Institute
Tullahoma, Tennessee
931-393-7289
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August 2012

University of Tennessee Space Institute

University of Tennessee Space Institute (UTSI)

Briefing Agenda

- *UTSI Location and Academic Disciplines*
- *UT Flight Research Laboratory*
- *Examples of UTSI Flight Research*

University of Tennessee Space Institute

- ***University of Tennessee Graduate Education***
- ***Leading Edge Research***
- ***Short Courses***
- ***Close Affiliation with U.S. Air Force Arnold Engineering Development Center (AEDC)***

University of Tennessee System

- **UTSI is part of UT Knoxville Graduate School**
- **UTSI graduate degrees conferred through UT Knoxville**

UTSI Graduate Degree Programs

PhD & MS

Aerospace Engineering

Engineering Science

Mechanical Engineering

Physics

MS

Aviation Systems

Engineering Management

Electrical Engineering

Industrial Engineering

Mathematics

- ***Also offer an MS degree in Engineering Science with a Concentration in Flight Test Engineering***

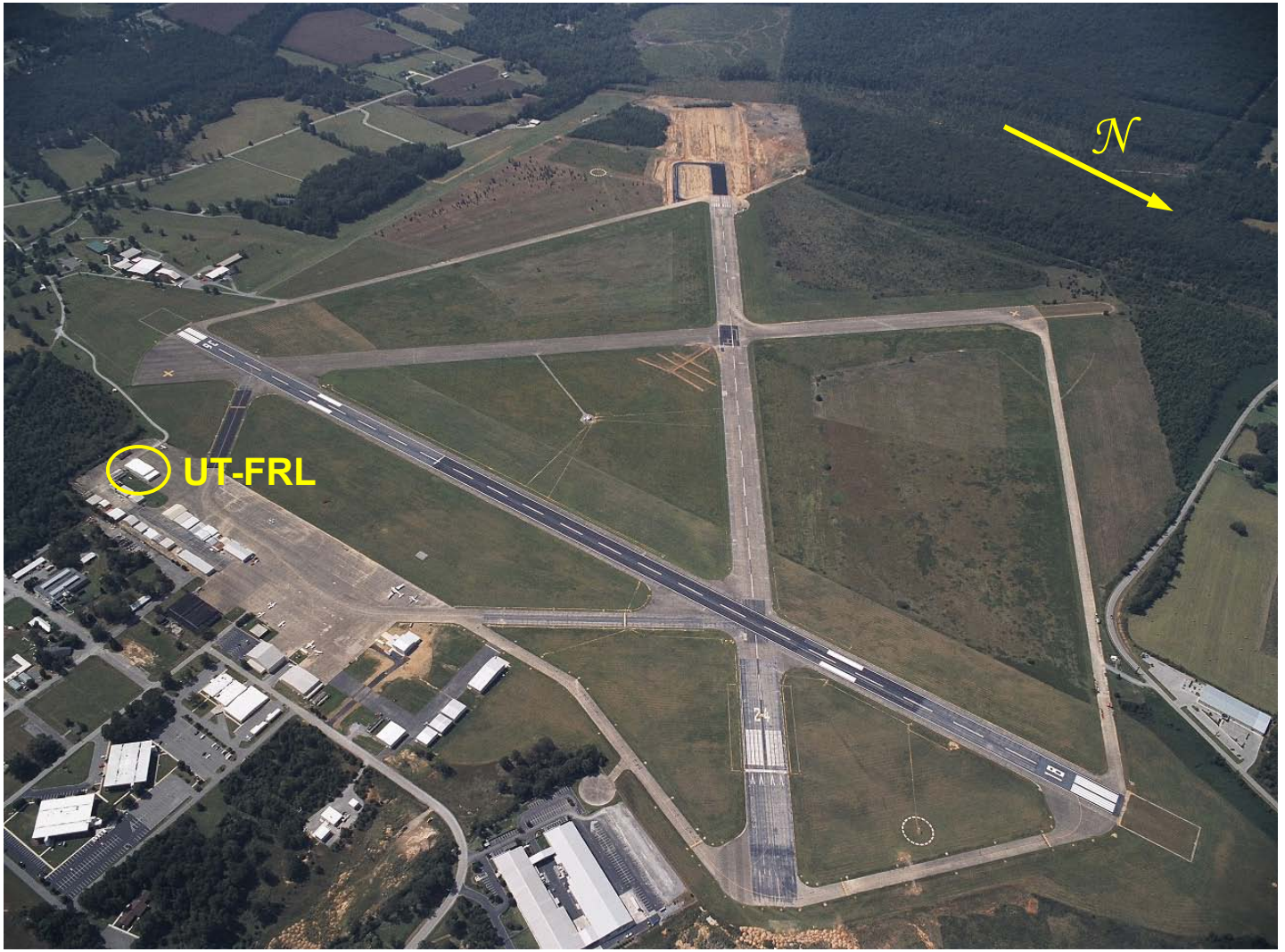
UT Flight Research Laboratory (UT-FRL)

- **Rationale**
  - Conduct substantial flight research with unique UT fleet of research aircraft
  - Available to efficiently and economically support academia, government, and industry flight test / research needs
- **UT-FRL supports UTSI and UT academics**
  - UTSI Aviation Systems
  - UTSI Engineering Science / Flight Test Engineering
  - UT Knoxville Aerospace Engineering

Av Systems Facilities

- ***Faculty and Student Offices at UTSI Main Campus***
- ***Flight Research Laboratory***
  - ***Located on Tullahoma Regional Airport (KTHA)***
  - ***10,000 sq ft, 2-bay hangar***
  - ***Offices, Flight Briefing room, Flight Simulator, and classroom***
  - ***Instrumentation and Fabrication shops***
- ***Flight Simulation Laboratory (at Main Campus)***
  - ***High fidelity Engineering Research Flight Simulator***
  - ***"Desktop" flight simulators***
  - ***Dedicated CFD analysis computers***
- ***Flight Systems Laboratory (at Main Campus)***
  - ***Work benches and tools***
  - ***Systems, instrumentation, avionics hardware and software***

UT-FRL Located at UTSI on Tullahoma Regional Airport



UT-FRL Current Strategic Investment Areas and Customers

- ***Airborne Science***
  - ***NOAA, NASA, DoD***
- ***Aviation Safety (Icing) and Flying Qualities***
  - ***NASA***
- ***Flight Test Engineering (FTE) Education***
  - ***UT academics (Av Systems & MABE Flight Test Engineering)***
  - ***Flight support for MTSU academics***
  - ***Flight Test Short Courses***

UT-FRL Airborne Research and Education Facilities

- ***Airborne Science***
  - ***Piper Navajo***
  - ***Cessna 210***
  - ***Piper Super Cub***
  - ***Extra 300***
- ***Unmanned Aerial Systems (UAS)***
  - ***Navion Surrogate UAV***
- ***Flight Test Engineering Education***
  - ***Piper Saratoga***

Rotorcraft Expertise

- *UTSI previously maintained, modified, instrumented, and operated OH-58A+ rotorcraft*
- *Also, have experience with other rotorcraft that have been used for UTSI research*
- *Used for education (academic courses and short courses) and flight research*

UTSI Piper Saratoga (PA32-301)

- *Fully instrumented, six-place aircraft*
- *Research air data system, including wingtip mounted air data boom*
- *Newly installed modern data acquisition system (DAS)*
- *Primarily used for student flight test engineering courses*

UTSI Extra 300 (EA-300)

- *Fully aerobatic, high-performance two-place aircraft*
- *Research instrumentation / data acquisition system with "glass" cockpit display in front and aft cockpits*
- *Post-flight data download via USB port inserted "memory stick"*

UTSI Cessna Turbo-Centurion (T-210L)

- **Single Engine, High-Performance, STOL Aircraft**
  - 1 pilot and up to 3 researchers
  - Turbocharged engine, retractable landing gear
  - Very low speed capability with Robertson STOL kit
- **Sensor / Systems Installation**
  - Two (left and right) under-wing mounted pods allow “plug and play” integration
  - Main cabin area and aft cabin equipment bay
- **Instrumentation / Data Acquisition**
  - UTSI / National Instruments DAS Similar to UTSI Navajo

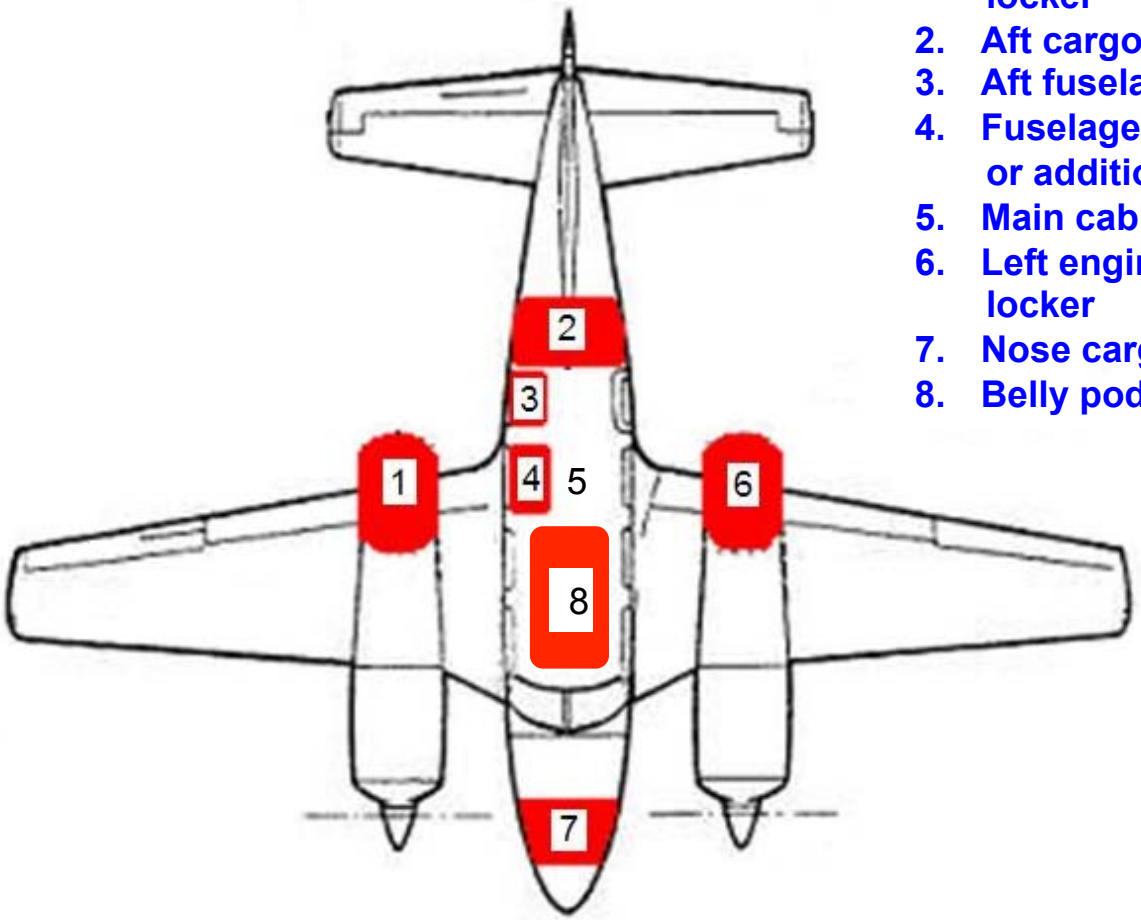
UTSI Piper Navajo (PA31-310)

- *Cabin-Class, Twin Engine Aircraft*
- *Experimenter's Handbook Available*

UTSI Navajo Performance

- Absolute Ceiling 27,300 ft
- Top Speed 260 mph
- Cruising Speed, 75% power at sea level 201 mph
- Cruising Speed, 75% power at 23,500 247 mph
- Fuel Consumption:
  - 75% power 35.6 gph
  - 65% power 27.8 gph
- Endurance (190 gals fuel):
  - 75% power 5.3 hrs
  - 45% power 6.8 hrs
- Cruising Range:
  - 75% power at 23,500 ft 1,300 mi
  - 65% power at 24,000 ft 1,560 mi
  - 45% power at 24,000 ft 1,685 mi

Equipment Integration Locations



1. Right engine nacelle wing locker
2. Aft cargo compartment
3. Aft fuselage 19-inch rack
4. Fuselage breadboard table or additional 19-inch rack
5. Main cabin area
6. Left engine nacelle wing locker
7. Nose cargo bay
8. Belly pod

Equipment Integration Locations

Nose Cargo Bay

Engine Nacelle Wing Locker

Main Cabin Area

Aft Cargo Compartment

Instrumentation Racks

Aft 19-inch Rack

Mid-Cabin 19-inch Rack

Airborne Science Sensors / Instruments

- **Currently Installed Sensors / Instruments**
  - *(All data is recorded and correlated with flight parameters, e.g. GPS position, airspeed, altitude)*
  - *Nadir Heitronics infrared pyrometer (earth surface temperature)*
  - *Nadir Omega infrared pyrometer (secondary Infrared device)*
  - *Digital video, nadir and forward-looking*
  - *Nadir Riegl laser altimeter (sub-meter accuracy up to 400 m)*
  - *Buck Research hygrometer (air dewpoint)*
  - *Outside air temperature (thermocouple) and pressure*
  - *Kipp and Zonen radiometers, nadir and zenith (incoming and reflected radiation)*
  - *Ocean Optics spectrometers, nadir and zenith (spectrum of incoming and reflected radiation)*
- **Additional Sensors / Instruments Available**
  - *Air sampling system (previously flown on NOAA missions)*

Aircraft Certification and Maintenance

- ***Airworthiness Certification***
  - ***Several aircraft have FAA Standard Category certification***
  - ***Can also operate all aircraft as Public Use***
- ***Aircraft Maintenance***
  - ***Maintenance performed by FAA certified IA and A&P Mechanics***
  - ***Follow FAA Standard Category requirements & schedules***

Experiment Integration

- **Processes**
  - Similar to NASA processes, but with less "overhead"
- **Aircraft Installations and Modifications**
  - Usually follow standards in accordance with FAA certification
- **Objectives and Requirements Document (ORD)**
  - Start of integration process
  - Experimenter defines requirements
- **Integration Controls**
  - Configuration Control Process

Flight Operations

- **Process**
  - Similar to NASA and other flight test organizations
  - UTSI fleet designated as "NASA Catalog" aircraft
- **Flight Readiness Preparations**
  - Hazard Reports
  - Flight Safety Review
  - Flight and Logistics Plan
  - Test Cards
- **Flight Research Campaigns**
  - Capability to deploy aircraft and personnel
  - (Off-site flight campaigns benefit from reduction in UTSI overhead rates.)

Aircraft Modification Capability

Transitioning MAPIR Capabilities to Applications

Hydrologic Modeling

Weather Forecasting

Flood Water Monitoring

Precipitation Validation

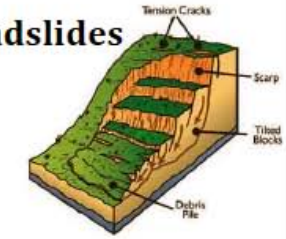
Drought Detection

Irrigation Scheduling
Agricultural Productivity

Supported NASA Missions:
SMAP
DESDynI
HyspIRI
NPOESS
GPM

Human Health & Air Quality

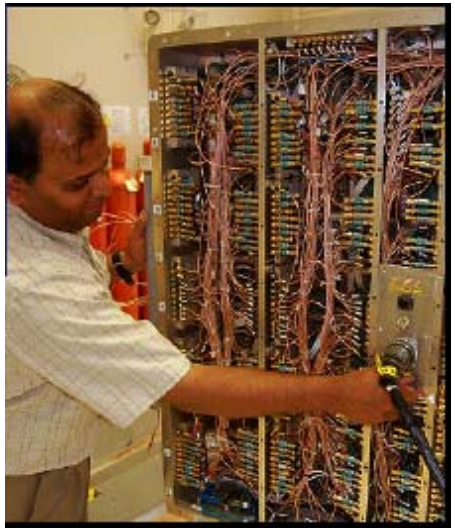
Landslides



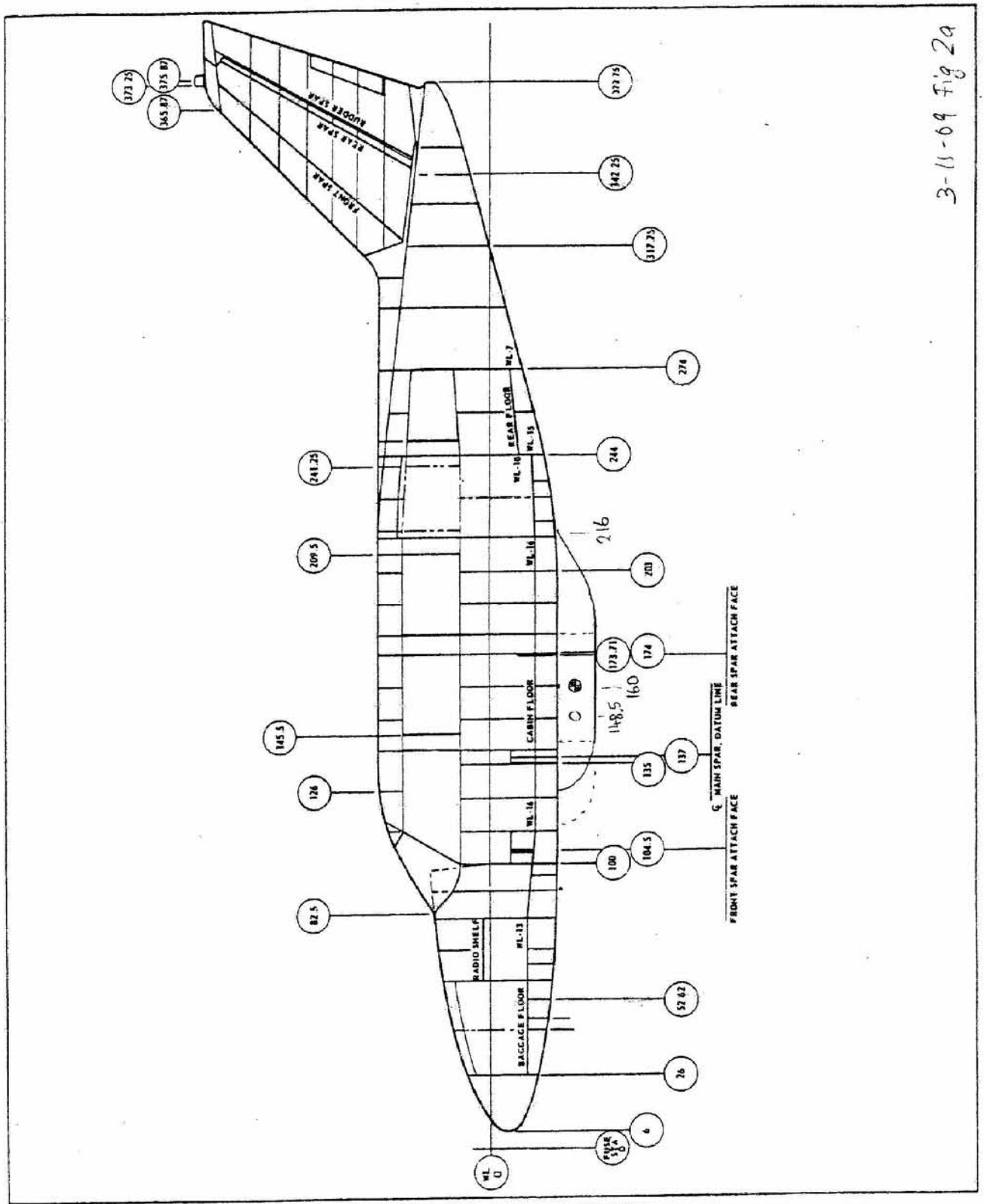
Biomass & Ecosystem Health

National Defense Applications

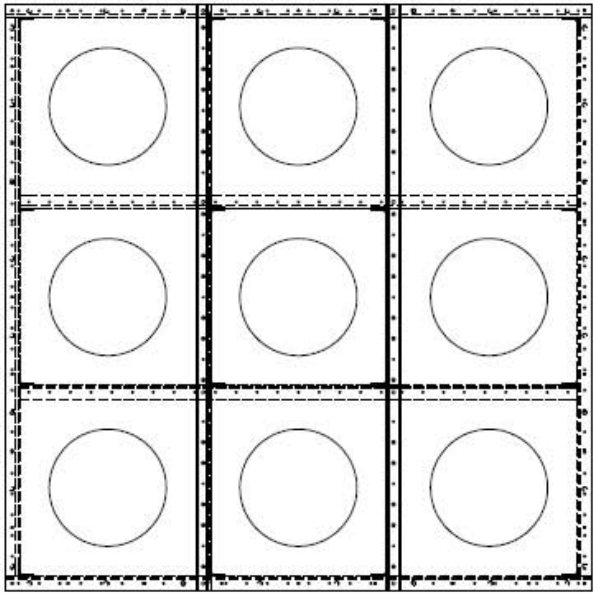
L-band RFI Surveillance

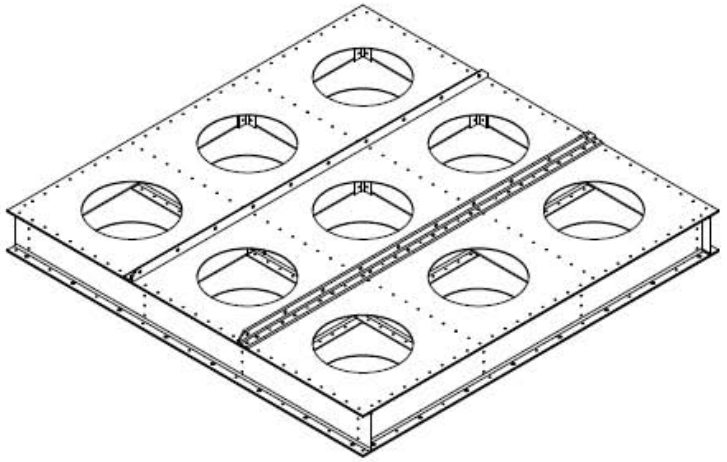


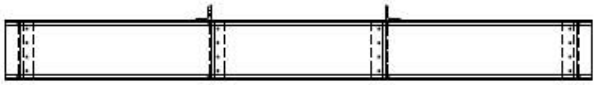
Antenna

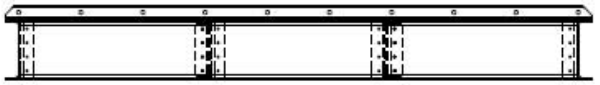


STATION REFERENCE - FUSELAGE









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			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

University of Tennessee Space Institute
AVIATION SYSTEMS

UT Space Institute

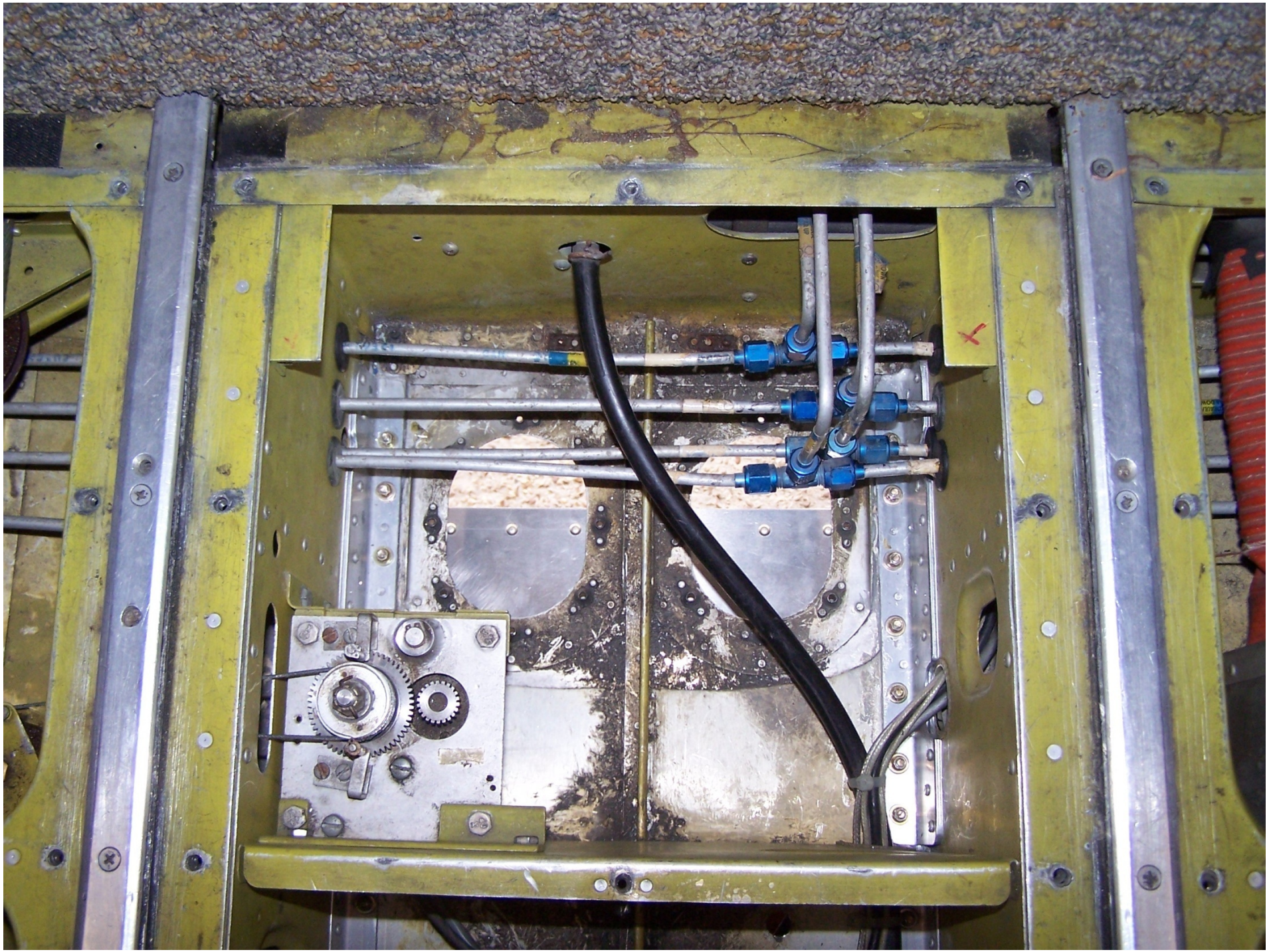
TITLE:

MAPIR INTERFACE STRUCTURE

SIZE	DWG. NO.	REV
A	IS-100	C

SCALE: 1:12 | SHEET 1 OF 2

5 4 3 2 1




WERNER


NASA

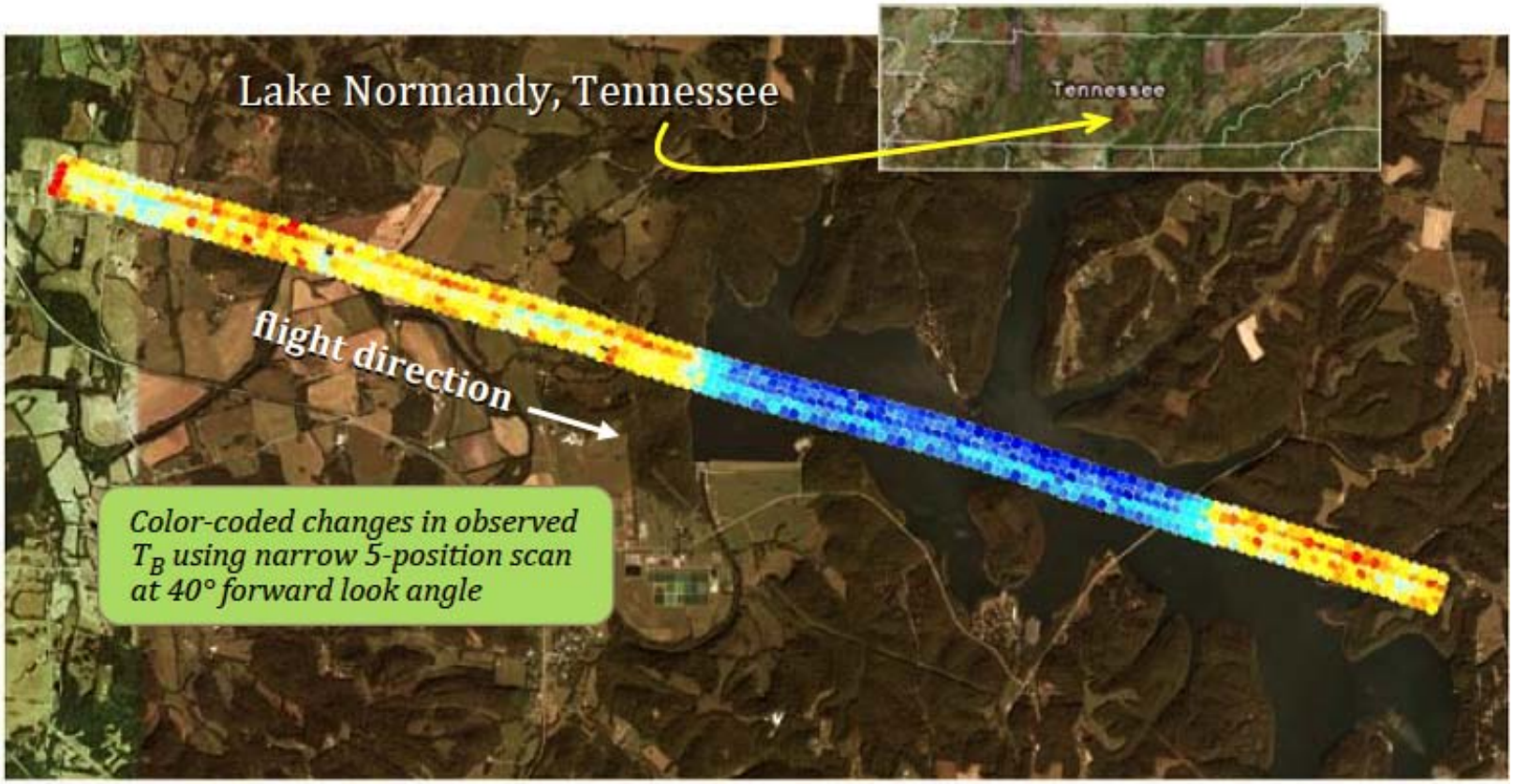
UTSI Flight Research Piper Navajo with NASA Marshal Airborne Polarimetric Imaging Radiometer (MAPIR) Under Fuselage Nacelle

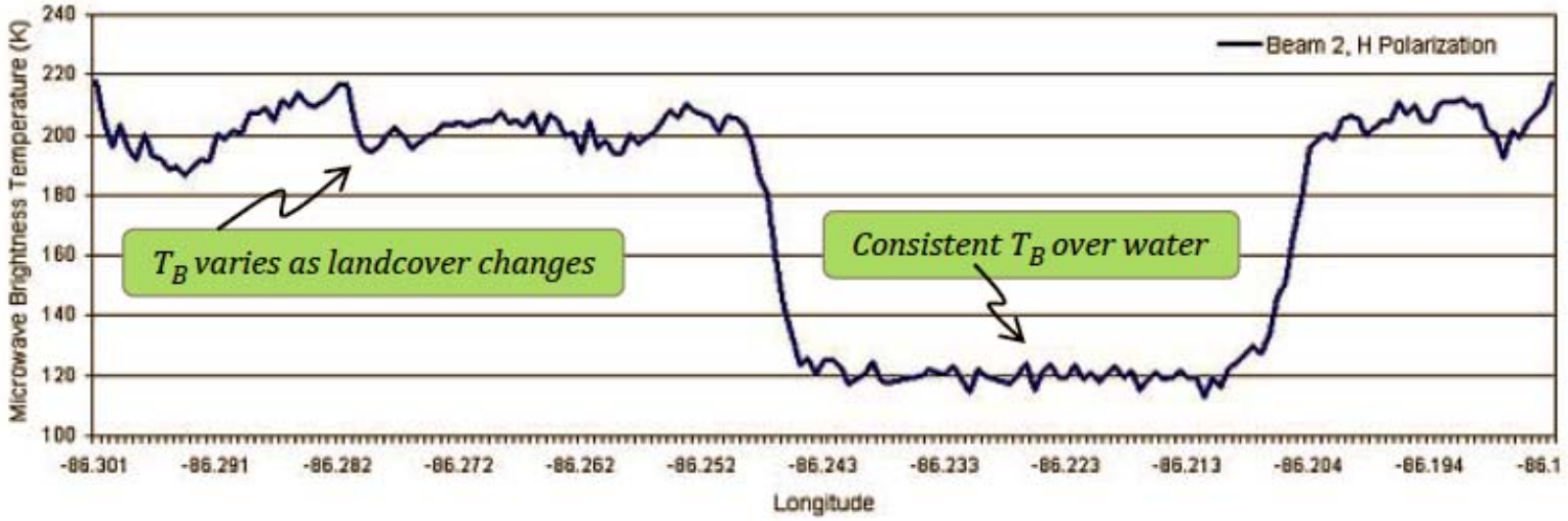
Examples of UTSI Flight Research

NASA MAPIR

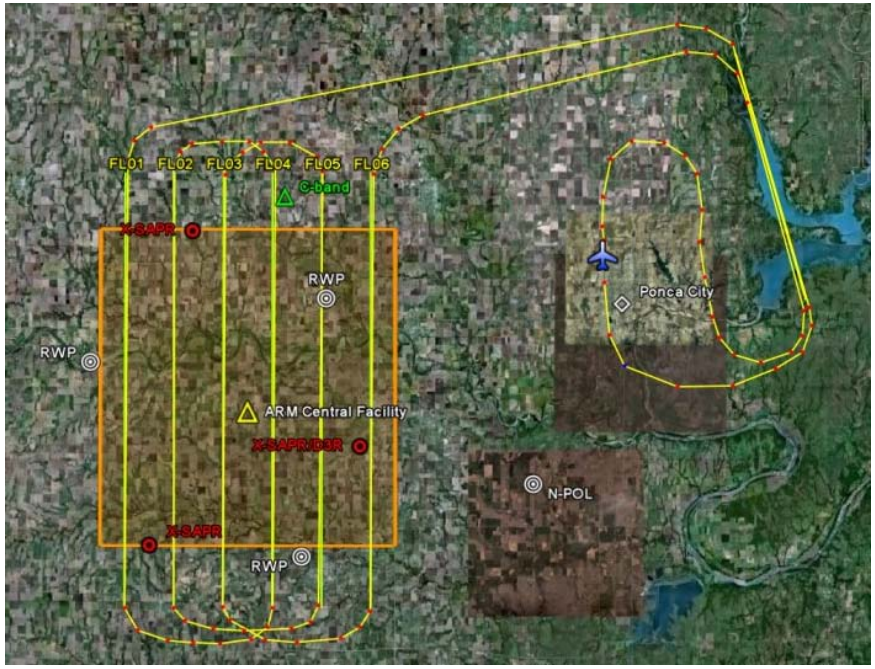
- *NASA Marshall Airborne Polarimetric Imaging Radiometer (MAPIR), novel airborne, passive L-band imaging system*
- *Flown in unique, UTSI designed and fabricated "belly" sensor pod on Piper Navajo*
- *MAPIR Flight Campaigns*
  - *Airborne measurements of nuclear power plant cooling water temperatures to improve computational models, Fall 2009*
  - *Earth surface temperature measurements around NOAA CRN sites, Spring 2010*
  - *NASA MAPIR Oklahoma (next chart)*


Recorded flight tracks using
Real Time Mission Monitor
NAVAJO


Lake Normandy, Tennessee
Tennessee
flight direction
Color-coded changes in observed T_B using narrow 5-position scan at 40° forward look angle


Beam 2, H Polarization
Microwave Brightness Temperature (K)
240
220
200
180
160
140
120
100
-86.301
-86.291
-86.282
-86.272
-86.262
-86.252
-86.243
-86.233
-86.223
-86.213
-86.204
-86.194
-86.1
Longitude
T_B varies as landcover changes
Consistent T_B over water

NASA MAPIR Oklahoma



- *NASA Marshall Airborne Polarimetric Imaging Radiometer (MAPIR), novel airborne, passive L-band imaging system*
- *Flown in unique, UTSI designed and fabricated "belly" sensor pod on Piper Navajo*
- *MAPIR Flight Campaign flown by Aviation Systems in UTSI Piper Navajo in May-June 2011 in Ponca City, Oklahoma*
- *UTSI Piper Navajo part of airborne science data collection team with NASA ER-2 and UND Cessna Citation Jet*

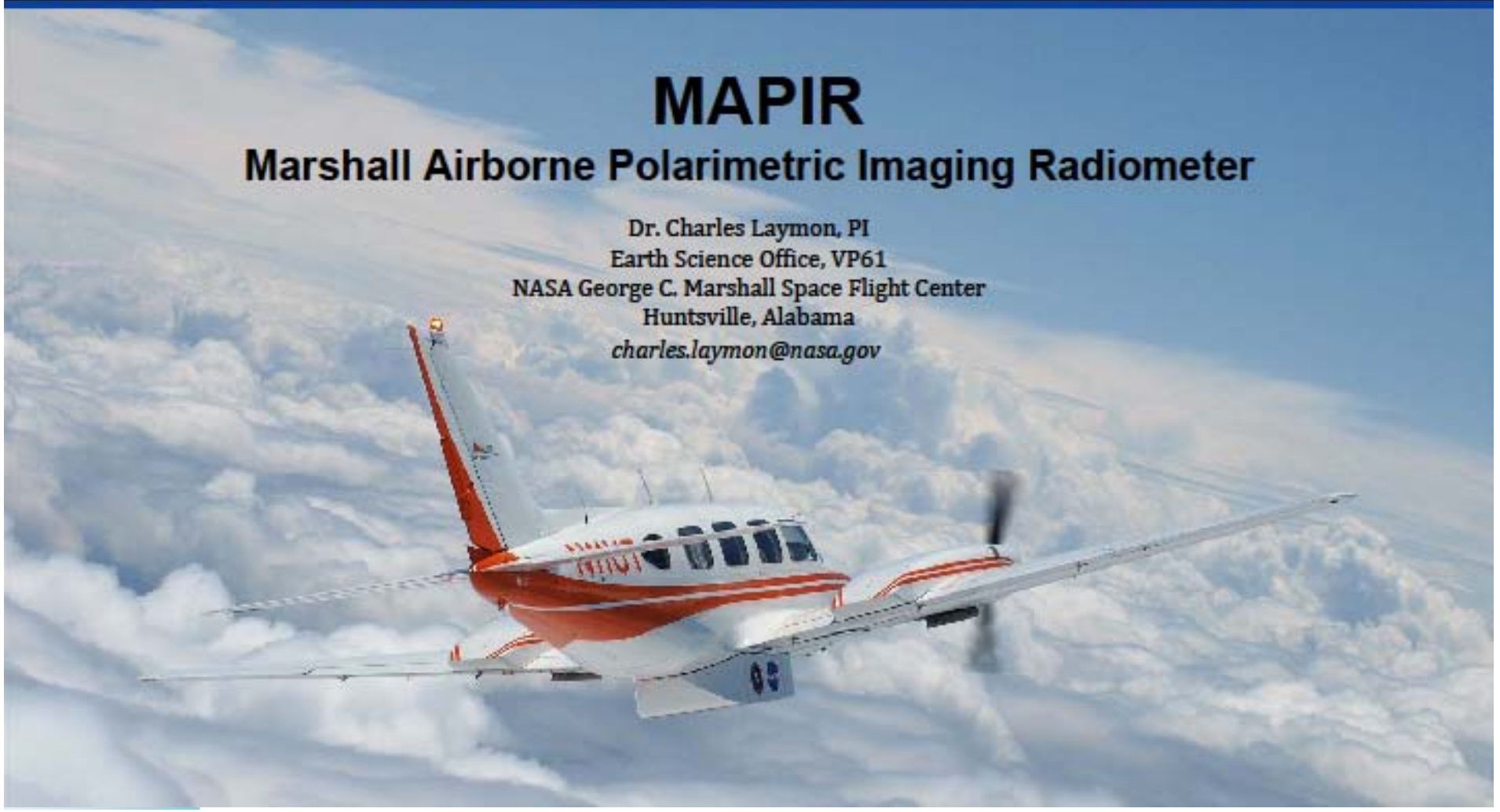
National Aeronautics and Space Administration

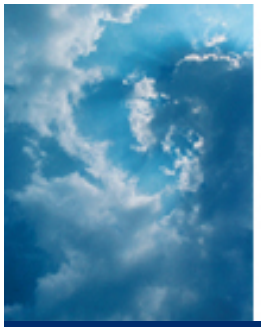
SCIENCE & MISSION SYSTEMS

MAPIR

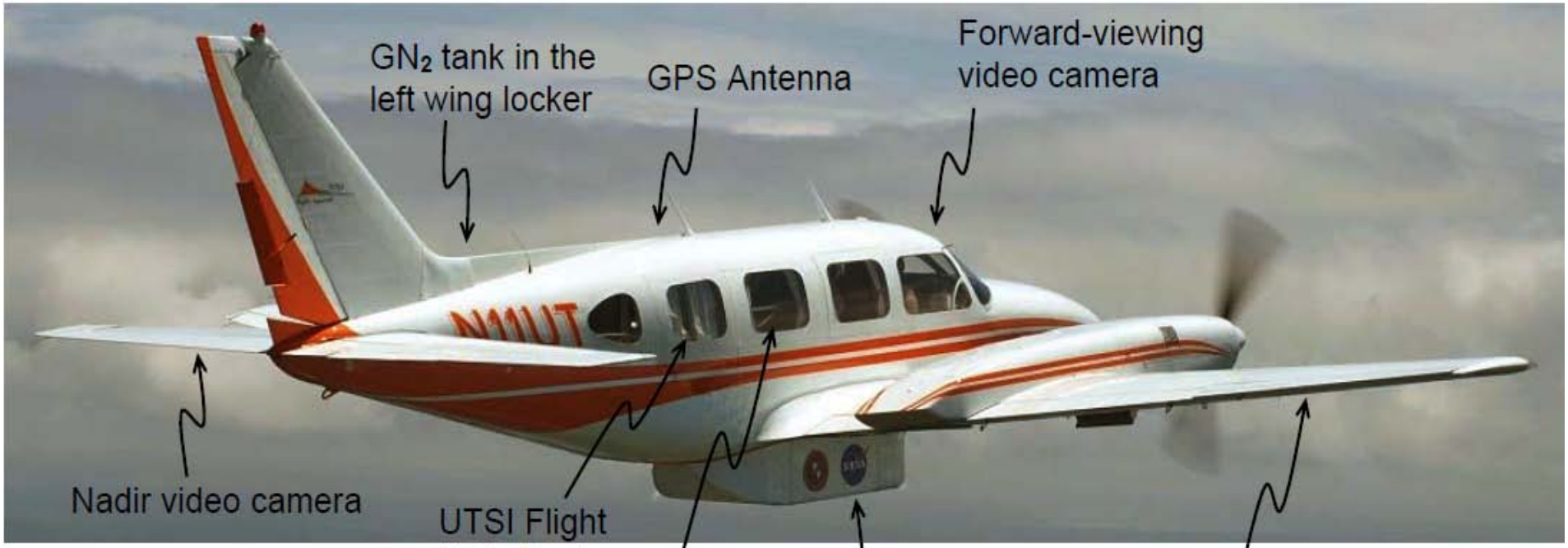
Marshall Airborne Polarimetric Imaging Radiometer

Dr. Charles Laymon, PI
Earth Science Office, VP61
NASA George C. Marshall Space Flight Center
Huntsville, Alabama
charles.laymon@nasa.gov

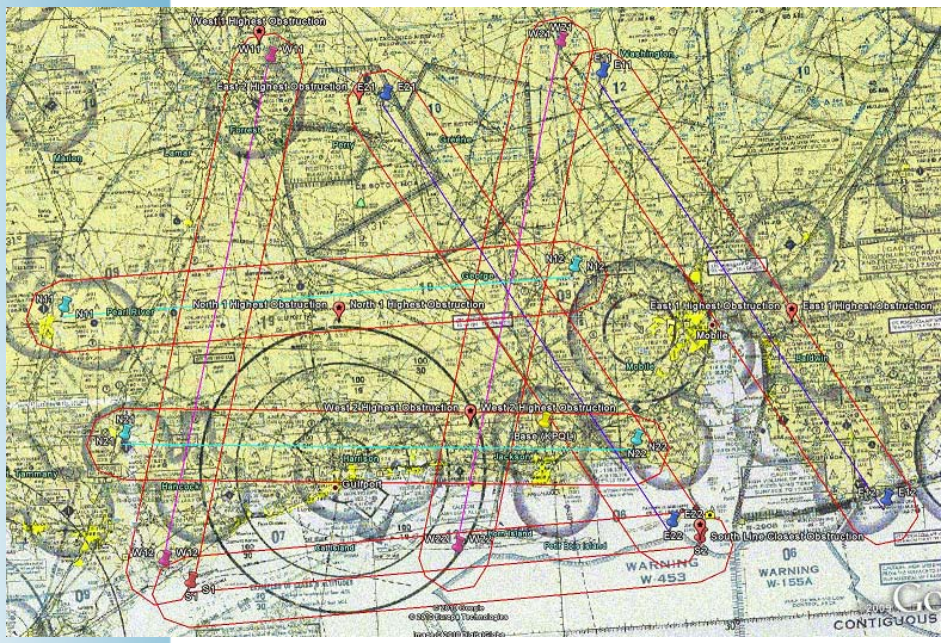




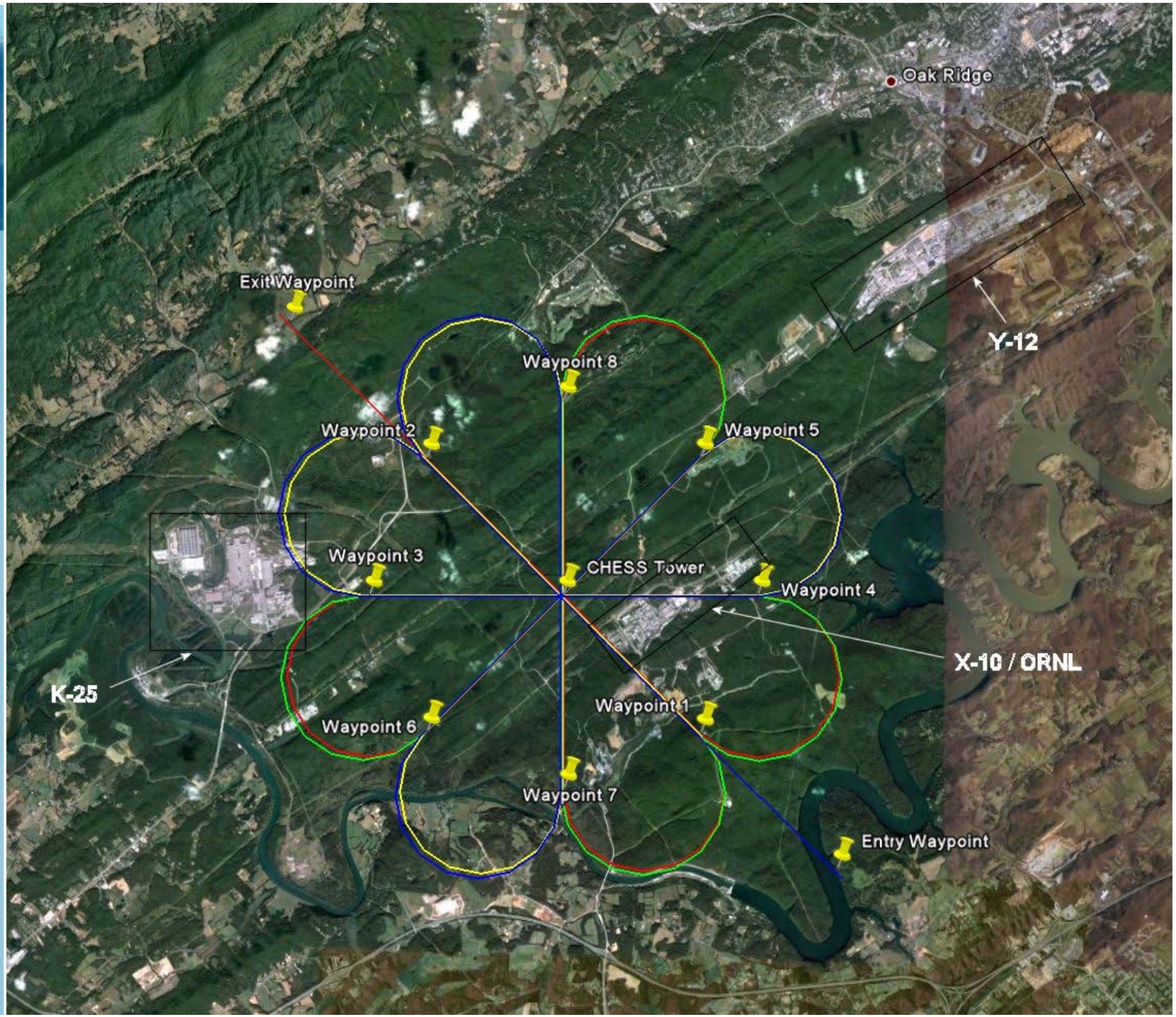
Feb. 2009	Established aircraft collaboration with University of Tennessee Space Institute
August 2009	Completed MAPIR modifications and integration into UTSI Piper Navajo
August 2009	Successful demonstration of MAPIR



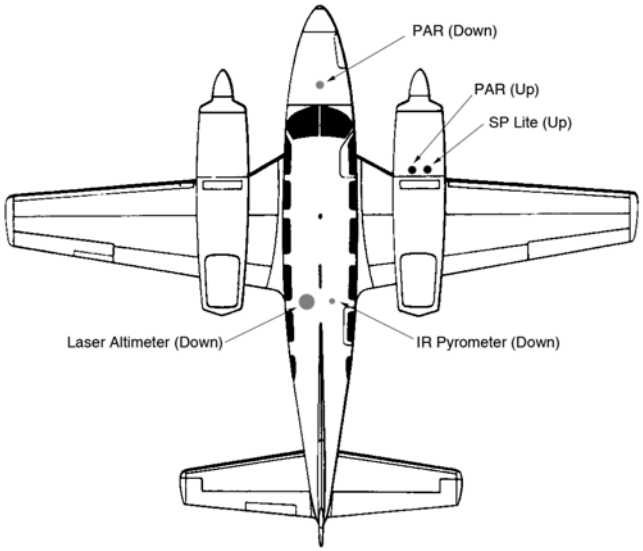
NOAA Atmospheric Mercury
2nd Flight Campaign in the Gulf of Mexico

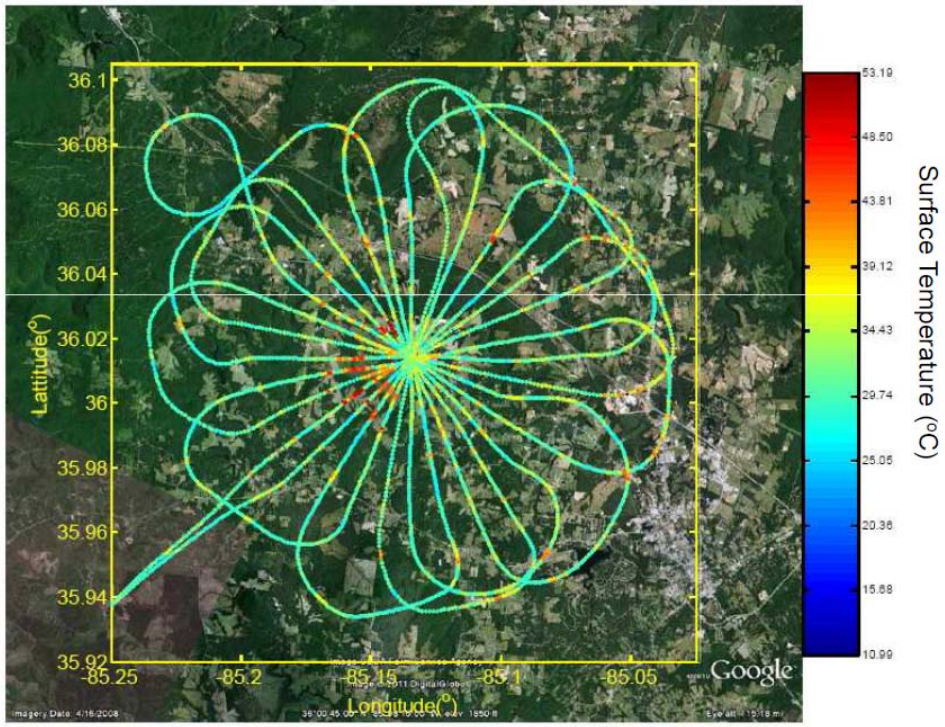


- *Supported by T. Hynes, U. Miami*
- *NOAA sponsored flight & ground research campaign in Gulf of Mexico*
- *Intensive field study to investigate the chemistry, transport, and deposition of mercury compounds in the atmosphere*
- *2nd Flight Campaign completed by Aviation Systems flying the UTSI Piper Navajo research aircraft in April-May 2011*


Oak Ridge
Exit Waypoint
Y-12
Waypoint 8
Waypoint 2
Waypoint 5
Waypoint 3
CHESS Tower
Waypoint 4
X-10 / ORNL
K-25
Waypoint 1
Waypoint 6
Waypoint 7
Entry Waypoint

NOAA Land Surface Temperature Sensing





- ***Cooperative research with NOAA Atmospheric Turbulence & Diffusion Division, Oak Ridge, Tennessee***
  - ***Characterization of spatial variability of surface temperature measurements around NOAA Climate Research Network (CRN) ground sites and improvement in accuracy of satellite-derived surface temperature data***
- ***Science flights flown over NOAA CRN sites in Tennessee and under satellite over-passes, flown in Summer and Fall 2011***

FWRI Marine Mammal Aerial Surveys

- *Partnership with Florida Fish & Wildlife Research Institute (FWRI), St. Petersburg, Florida*
- *Aerial surveys of manatees to develop improved techniques for estimating population size and distribution around warm-water aggregation sites (near power plants).*
- *First survey flights planned for February 2012*


QUESTIONS?
N55UT

Backup Slides

Space Institute

UTSI Aviation Systems and Flight Test Engineering

Aviation Systems and Flight Test Engineering Programs

- ***Master of Science (MS) degree program***
- ***Fundamentals of Flight Test Engineering education, including "hands-on" flight laboratory courses***
- ***Mix of Aerospace Engineering and Flight Sciences***
- ***Interdisciplinary "systems" philosophy***
- ***Not a Pilot Training or Test Pilot School***
- ***Graduate students with diverse undergraduate degrees***
  - ***Aerospace, Electrical, & Mechanical Engineering***
  - ***Atmospheric Science***
  - ***Oceanography***
  - ***Other***

UT Flight Research Laboratory

UT Flight Research Laboratory

Research Aircraft

UTSI Navajo Specifications

- Seating — 2 pilots + (up to) 4 PAX
- Wing Span — 40.7 ft
- Length — 32.6 ft
- Powerplant — 2 x Lycoming TIO-540-A, 310 hp ea.
- Maximum Takeoff Weight — 6,500 lbs
- Empty Weight — 4,387 lbs
- Payload (includes max fuel) — 2,113 lbs
- Maximum Fuel Load — 190 gals
- Payload (excluding max fuel) — 973 lbs

UT Flight Research Laboratory

Flight Research Instrumentation

Aircraft Instrumentation / Data Acquisition System (DAS)

- **National Instruments PXI-8104 Data Acquisition System**
  - Celeron M 1.83 GHz CPU with Windows XP and LabVIEW
  - Over 100 flight parameters, incl. aircraft GPS position, attitude, angular rates, linear accelerations, airspeed, altitude, control surface positions and forces, and engine parameters
  - Sample rate of 20 sps, logged on solid state disk, higher sps is available
  - Time base synchronized to GPS time
  - 5 UltraMobile PCs with 7 inch color touch-screens for data display using LabVIEW
- **Time stamped aircraft communications (intercom and air-to-ground) recorded onboard**
- **Digital video system, nadir and forward views**
- **Four additional USB 2.0 ports devices include**
  - RS-232 serial converter for serial data acquisition
  - NI USB 6218 data acquisition unit capable of 16 differential / 32 single ended analog measurements
  - CD / DVD writer
  - Solid state memory stick (32GB)

Dedicated Data Interface Ports for Airborne Science Instruments

- *Three RS-232 serial ports (can be expanded by eight)*
- *Four 1 GBPS power over ethernet (POE) ports (can be expanded)*
- *One GPS RF direct feed from science GPS antenna*
- *Three USB 2.0 ports (can be expanded by 8 ports)*
- *10 differential analog channels (+/-10 VDC) (can be expanded by 16 channels)*
- *5 thermocouple channels*
- *Time distributed by Network Timing Protocol (NTP) over ethernet*
- *Dedicated science voice intercomm*
- *All data acquired by aircraft flight test system broadcast in real time over aircraft ethernet (accessible to onboard scientists)*

Aircraft Power

- *24-28 VDC Aircraft Power*
  - *Electrical buses isolating research systems & instrumentation from aircraft systems & avionics*
- *Two Main Buses for Experimenter Use*
  - *Bus Shared with Flight Test Instrumentation*
    - *20A capacity at 28VDC (10A baseline load for standard equipment)*
    - *+5 VDC and +15 VDC provided by DC-DC converters*
    - *Instrumentation system programmable power supply can provide +/-15 and 0 to 6 VDC*
    - *5A AC inverter provides 120 VAC*
  - *Dedicated Experiment Bus*
    - *30A load capacity at 28VDC*
    - *7A AC inverter provides 120VAC*
    - *Load shed relay automatically sheds experimenter load if one aircraft inverter or engine is inoperative.*
- *Additional Uninterruptible Power Supply (UPS) downstream of AC inverter is available if required.*

UT Flight Research Laboratory

Experiment Integration and Flight Operations