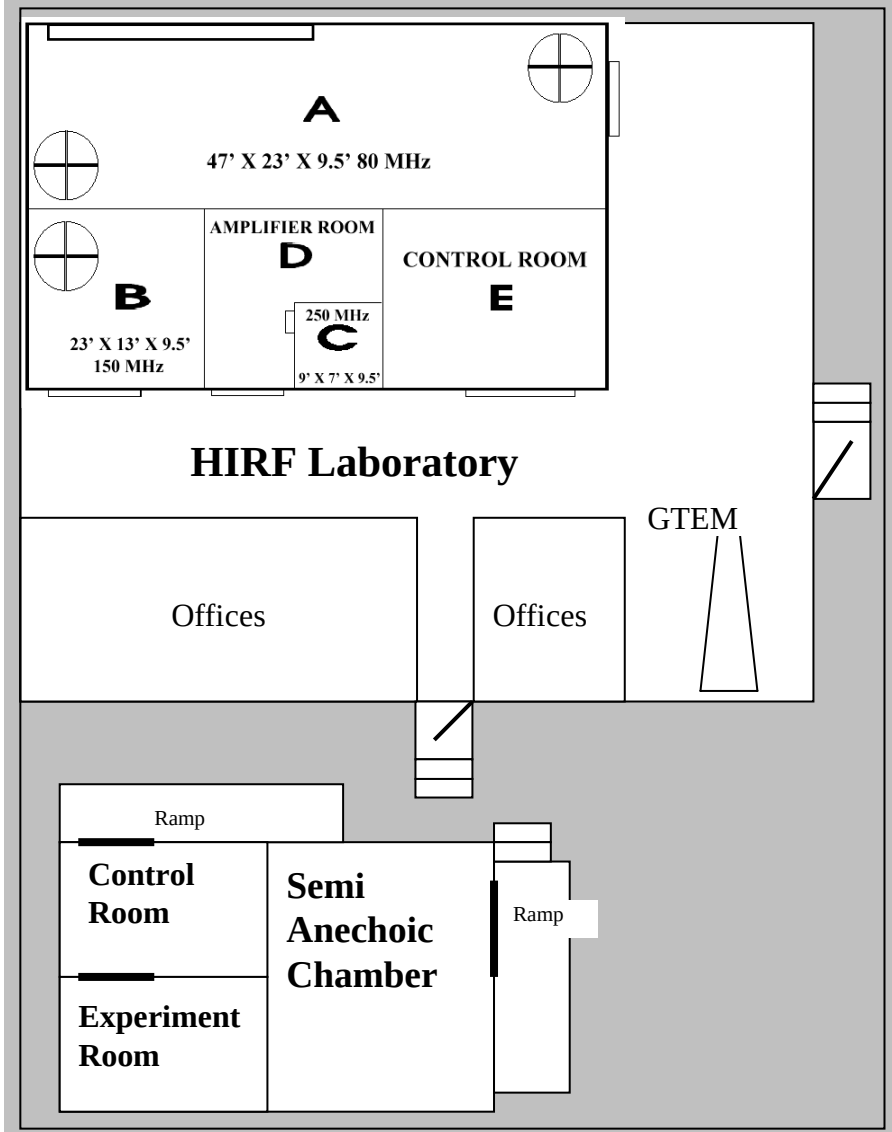
The NASA High Intensity Radiated Fields (HIRF) Laboratory

The HIRF Laboratory is a state of the art facility for generating radiated electromagnetic environments for testing the EM susceptibility, immunity and compatibility of flight critical avionics. It is located at NASA Langley Research Center in Building 1220. The test data acquired are used to study avionic-upset and to characterize fault-tolerant systems. In addition, the facility is used to measure radiated emissions from wireless devices such as cell phones, wireless LANs, and RFID tags. The lab includes three reverberation chambers, TEM cells, high power amplifiers, source generators, indirect lightning waveform and impulse generators, and measurement equipment. In 1995 it was certified by NIST to have a field uniformity of +/- 2 dB with exceptional performance. The lab has expertise in reverberation chamber theory and operation, evaluation of portable electronic device (PED) compatibility with aircraft systems, aircraft coupling measurements and RF propagation, flight spectrum measurements and EMI assessments, and EMI/EMC testing. It has contributed to NTSB accident investigations, spectrum policy studies, and development of aeronautical certification documents relating to the use of PEDs on airplanes and HIRF. The lab is currently supporting research in the Aviation Safety's Integrated Vehicle Health Management program, particularly HIRF and lightning effects on metal and composite aircraft and wireless sensor technologies.

Description

- HIRF Lab is located at NASA Langley Research Center in Building 1220, Room 144
- Consists of one large shielded enclosure divided into 5 subclosures
  - 3 separate and co-located Reverberation Chambers A, B, C
  - Control Room
  - Amplifier Room
- Access to semi-anechoic facility

Description – Floor Plan & Stats



Chamber Statistics

Chmbr	Length (ft.)	Width (ft.)	Height (ft.)	Lowest Usable Frequency (MHz)
A	47	23	9.5	80
B	23	13	9.5	150
C	9	7	9.5	250

Description - Facility

Chamber A

Chamber B

Chamber C

Amplifier Room

Control Room

GTEM Cell

HIRF Lab Capabilities and Resources

- Primarily a research facility
- Radiated Susceptibility and Emissions Testing
- Facility includes
  - Reverberation Chambers/Mode-Stirred and Mode-Tuned Chambers
  - Gigahertz Transverse Electromagnetic (GTEM) Cell
  - TEM Cells
  - Access to semi-anechoic chamber
- Field Uniformity of +/- 2 dB in chambers
- 120 dB shielding in chambers
- Consultation on HIRF, Reverberation Chambers, PEDS, Spectrum, Indirect Lightning Effects
- True Distributed Testing using Multiple chambers – simultaneous testing different components of a system with three different environments
- Achievable field strength 1500 - 3000 V/m
- Lab Frequency Range - DC to 18 GHz
- DO-160D & F HIRF Susceptibility Tests, DO-160F Field Probe Chamber Calibration, MILSTD-461 Test, DO160 Indirect Lightning Effects Tests, Radio Emission Measurements, Interference Path Loss Msmts, Flight Spectrum Surveys.

HIRF Lab Capabilities and Resources

- **RF Instrumentation and Equipment - Spectrum Analyzers, Network Analyzers, Signal Generators, Power Meters and Sensors (CW and Peak), Power Supply, High Power CW and Pulsed Amplifiers, Arbitrary Waveform Synthesizers, Isotropic Field Sensors, Wireless Test Set, Lightning Indirect Effects Test Set, Antennas, Safety RF Monitors, Oscilloscopes, Sources, Cables, Attenuators, filters**
- **Lightning Indirect Effects Test Equipment**
- **Airframe shielding effectiveness measurement**
- **Customized Radiated Emissions and Susceptibility Tests per customer requirements (hardware and software)**
- **Software Controlled and Automated Susceptibility and Emissions Testing based on DO160F guidelines**
- **20 ft. door in Chamber A to accommodate large test articles (UAV, GA Aircraft, Flight Deck)**
- **Field testing – aircraft, airports, flight tests**
- **Bulkhead panel between Chambers A & B suitable for shielding effective tests (composite materials)**
- **Chamber cameras - video and audio recording system**
- **Numerous NASA and conference publications**
- **Personnel (5 FTEs, 1 PBC) functions :**
  - **Research Engineers, Test Engineers, Engineering Technician, Software Engineer, Lab Manager, Program Manager, Computer Engineer**
  - **George Szatkowski, Sandra Koppen, Jay Ely, Truong Nguyen, Laura Smith, John Mielnik**

HIRF Lab Equipment and Instrumentation

- Agilent E4407B portable spectrum analyzers (9 kHz – 26 GHz)
- Anritsu portable spectrum analyzer
- Tektronix real-time SA (DC – 8 GHz)
- Agilent 70000 series - 4 channels
- Lightning indirect effects test equipment
- Wireless base station simulator
- RF Power amplifiers include:
  - 10 kHz – 250 MHz : 2000W CW, 4000W Pulse
  - 0.1 – 1 GHz: 1000W CW/Pulse
  - 1 - 4 GHz: 200W CW (2 each)
  - 4 – 18 GHz: 200W CW
  - 1 - 18 GHz: 1000W Pulse
- Agilent E8257D PSG Analog Signal Generator
- Gigatronics 8542C Power Meter, CW & Peak Probes

Immunity Testing: HIRF

- Radiated Susceptibility Test of Aircraft Avionics
  - Aircraft Actuators - AFRL
  - Flight Control Computers – AvSP
  - Flight Management Systems – NASA/Honeywell RCS (AvSP)
  - Engine Data Processors – Boeing
  - Data Communication System – AvSP
  - RF Interference Path Loss (IPL) Measurements (AvSSP)
- Ultrawideband EMI Assessment (NASA HQ)
- RF coupling msmts on composite aircraft - Hostile Electromagnetic Interference on Aircraft Radios (HEAR) Experiment (AvSSP)
- NTSB TWA Flight 800 EME Investigation (AvSP)
- Lightning Technologies, Inc. - Mooney GA Aircraft shielding effectiveness investigation

Lightning Indirect Effects Capabilities

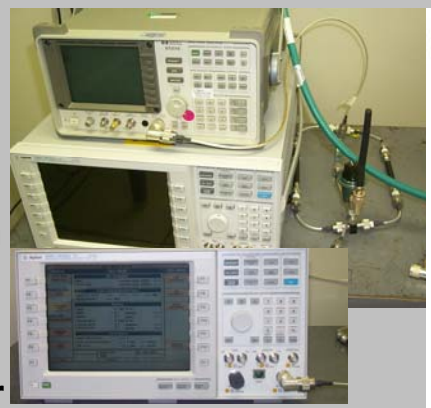
- Lightning indirect effects (induced)
  - Single stroke, multiple strokes, multiple bursts
  - DO-160 test levels, waveforms and patterns
  - Programmable to produce Boeing & Airbus patterns
  - Software automation and remote control
  - COTS – Easy to maintain
  - Very few test set worldwide. Used by Boeing and Airbus
- Induced surface current measurement capabilities
  - Low frequency network/spectrum/impedance analyzer
  - Surface current probes
  - Capability developed for measuring surface current on composite materials

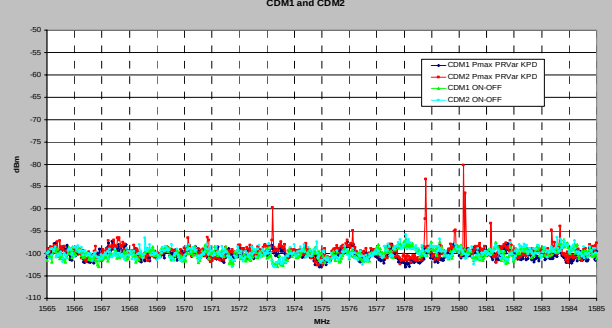
Single and Multiple Strokes

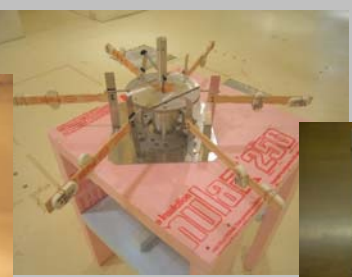
Multiple Bursts

Emissions Testing: Portable Electronic Devices

- Radiated Emissions Measurement
- Reimbursable FAA Interagency Agreement DFTA03-96-X-90001, Single Aircraft Accident Prevention Project (SAAP)
- Objective: To develop a radiated emission measurement process for PEDs and to provide a preliminary risk assessment of unintentional interference to aircraft radio receivers.
- Cell Phones
  - 2002: CDMA & GSM Mobile Phones
  - 2004: PCS and 3G Mobile Phones
- 2003: Wireless LANs (802.11a/b, Bluetooth, FRS/GMRS radios)
- 2005: RFID Tags - Active







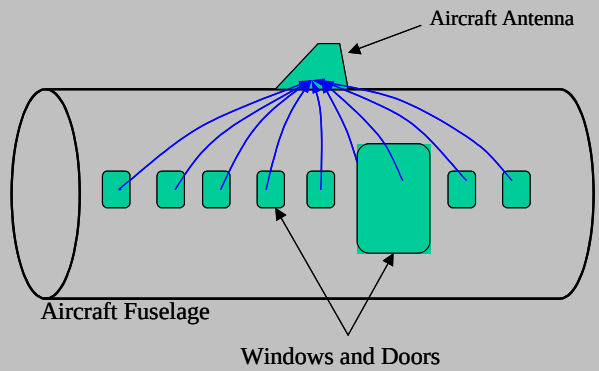
Interference Path Loss Measurements

- Cooperative effort with United Airlines and Eagles Wings, Inc.
- United Airlines provided six B737-400 and four B747-400 aircraft and engineering support
- Measurements were taken during three 1-week trips to Southern California Aviation in Victorville, CA
  - Four B747-400: LOC/VOR, VHF-1 Comm, GS, TCAS-Top, GPS, Satcom
  - Six B737-200: LOC/VOR, VHF-1 Comm, GS, TCAS-Top, GPS
- Measurements on Com/Nav systems of Ten general aviation aircraft at Norfolk Airport
- NASA provided:
  - Instrumentation
  - Data acquisition software and support
  - Manpower, data analysis
- IPL results were summarized and compared with other existing path loss data

Portable Electronic Devices Aircraft Risk Assessment

Source Emissions
(Wireless Devices)

Interference Path Loss
(Aircraft Fuselage)



Victim Interference Threshold
(Nav. & Com. Radio Receivers)

Safety_Margin = Threshold – (Emission – IPL)

Industry, University, Government Relationships

- NASA Aviation Safety Program
- Phase II SBIR – NanoTech Labs
- NRA – ODU
- NASA Aging Aircraft and Durability (AAD) community
- NASA Glenn consultations on lightning protection and waveforms
- FAA (2001 – 2007)
- DHS
- Lightning Technologies, Inc. (LTI)
- Delta Airlines
- United Airlines
- Eagles Wings, Inc.
- Air Force Research Lab
- Boeing Commercial Airplane Group
- NIST
- Ohio State University, University of Oklahoma, U of Florida
- Naval Surface Warfare Center, Dahlgren
- National Transportation and Safety Board (NTSB)
- Certification committees – RTCA DO160, SAE, SC202
- Support of NASA Reliable Systems Research:
    - Provide electromagnetic environment for assessing Bendix Flight Control Computer digital upset and recovery, as is processes dynamic flight data.
    - Provide electromagnetic environment for assessing Honeywell Recoverable Computer digital upset and recovery, as is processes data.
    - Provide electromagnetic environment for characterization of Scalable Processor Independent Design for Extended Reliability (SPIDER) architecture