Introduction to Gulfstream Aerospace and Acoustics Activities
Our Business and Our Strategy

*Gulfstream sets the World Standard in Business Aviation*

Over 50 years of satisfying the world’s most demanding travelers with...

- Performance & Operational Flexibility
- Comfort & In-Flight Productivity
- Safety & Security
- Reliability & Exceptional Quality
- Unmatched Product Support
Gulfstream Expanded Product Line

- **G150**: 3,000 nm (5,556 km) at M0.75
- **G200**: 3,400 nm (6,297 km) at M0.75
- **G250**: 3,400 nm (6,297 km) at M0.80
- **G350**
  - G350: 3,800 nm (7,038 km) at M0.80
- **G450**
  - G450: 4,350 nm (8,056 km) at M0.80
- **G500**
  - G500: 5,800 nm (10,742 km) at M0.80
- **G550**
  - G550: 6,750 nm (12,501 km) at M0.80
- **G650**: 7,000 nm (12,964 km) at M0.85

G150, G200, G250 range with 4 passengers / G350 – G650 range with 8 passengers

G150 shown with optional Enhanced Vision System (EVS)
The New Super Midsize Gulfstream G250

The G250 establishes leadership in the super midsize market segment with the largest cabin, the best performance and the most advanced systems.

- Best performance in class
  - 3,400 nm (6,300 km) at Mach 0.80 / short takeoff distances - 4,960 ft (1,511 m)

- Largest, most comfortable cabin in class
  - Longer and more spacious cabin with in-flight access to baggage
  - Best overall cabin environment

- Most advanced cockpit and systems
  - PlaneView250™ flight deck with optional EVS II, HUD II and SV-PFD
  - Standard auto-throttles and auto-braking
New Gulfstream Flagship - The Gulfstream G650

• Longest range and fastest speeds
  – 7,000 NM (12,964 km) at Mach 0.85 / 5,000 NM (9,260 km) at Mach 0.90

• Largest, most comfortable cabin in class
  – Widest purpose built business jet
  – New, larger cabin windows & lowest cabin altitude

• Most advanced cockpit and systems
  – PlaneView® II, EVS II, SV-PFD
  – Fly-by-wire flight control system / New Rolls Royce BR 725 engines
Completion Research & Development

**Advanced Styling & Design Mockups**
- Cabin design efforts to improve comfort and productivity
- Used for initial development of G250 and G650

**Acoustic Test Facility (ATF)**
- Advanced acoustic chambers for testing materials, systems and methods to minimize cabin noise
- In operation since 2006

**Advanced Cabin System Laboratories**
- Cabin Sound Lab, Altitude Chamber, Electromagnetic Interference Chamber (EMI), Cabin Systems Lab
Gulfstream Acoustic Test Facility

- The Acoustic Test Facility (ATF) consists of a Hemi-Anechoic Room (215 m$^3$) and a Reverberation Chamber (252 m$^3$)
Gulfstream Acoustic Test Facility

Specific Types of Measurements Include:

• Sound Transmission Loss Testing
  • Including Fuselage and buildup to decorative closeout
  • *Measure Transmission Loss up to 120dB*

• Sound Power Level and Noise Emission

• Vibration Testing

• Random Incidence Sound Absorption

• Cold Temperature TL Testing
Gulfstream Acoustic Test Facility
Transmission Loss Testing – Test Methods

• SAE J1400
  • 9 Microphone Array Measurement in Hemi-Anechoic Chamber
  • Good for Fast and Qualitative Measurements

• ASTM E2249
  • Sound Intensity Measurement in Hemi-Anechoic Chamber
  • More Accurate, Less Sensitive to Flanking
  • Captures Energy at Coincidence Frequencies
ATF Test Data

![Graph showing sound transmission loss versus frequency with experimental data and mass law line.](image)
Level of Sound Source

Sound Source 50% Humidity
9dB/Octave

Sound Pressure Level (dB re 20uPa)
Frequency (Hz)
Acoustics Lab Material Testing

Characterizing Absorptivity

Better Material Properties for Improved Modeling
Testing - Isolator Characterization

- Classical Method
  - Massless – neglects internal resonances

- Four-Pole Method
  - Better characterization of the isolators

\[
\begin{align*}
\begin{bmatrix} A_1 \\ F_1 \end{bmatrix} &= \begin{bmatrix} T_{11} & T_{12} \\ T_{21} & T_{22} \end{bmatrix} \begin{bmatrix} A_2 \\ F_2 \end{bmatrix} \\
\begin{bmatrix} F_1 \\ F_2 \end{bmatrix} &= \begin{bmatrix} D_{11} & D_{12} \\ D_{21} & D_{22} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix}
\end{align*}
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Statistical Energy Analysis Modeling
SEA Modeling - Overview

• Complete SEA model for several complete aircraft
  – Including G150, G250, G550/G450, G650, others
• Each model includes a full representation of entire aircraft, including:
  – Geometry
    • CAD Models
  – Materials
    • Transmission Loss, Absorption and Vibration Testing
  – Loading
    • Analytical and Experimental
    – Includes both Structureborne and Acoustic Paths
    – Correlated with Test Data
• Use SEA Model to Predict Interior Cabin Noise
• Provide Trade Studies
  – Evaluate Design Improvements
  – Optimization
  – Weight Savings
Typical SEA Aero-Acoustic Details

- Fuselage Skin
- Skin Damping Foam
- Thermal Layer
- Acoustic Blanket
- Finish Closeout

Typical Acoustic Cross Section

- Carpet
- Carpet Pad
- Damping Foam

Typical Flooring Cross Section

- Finish Closeouts Include added damping on Headliner, Sidewalls and Dado Panels
- Turbulent Boundary Layer (TBL) Noise
- Engine Noise and Vibration

Typical Cabin Cross Section

- ECS Ducting
- ECS Noise
SEA-Experimental Correlation: Aircraft Cabin Noise

- Geometry — CAD Models
- Material — Characterized with test data
- Loading — Analytical prediction & testing
Exterior Noise Concerns

• Aircraft Community Noise
  – Noise Certification Compliance
  – Airport Community Noise
  – Focus on Reducing Exterior Noise from Engines/Airframe
    • Utilize Computational Aeroacoustics and Windtunnel Testing
  – Increase Gulfstream Aircraft Access to Noise Sensitive Airports
  – Continuous Improvement

• APU Ramp Noise
  – 20 meter Perimeter
  – Ground Service Locations
Emerging Airframe Noise Situation

Significant improvements in Engine Noise

Main sources of airframe noise: Flap Side-edge and Landing Gear
Exterior Noise – APU Ramp Noise

• Many Airports have APU operational restrictions – Noise & Emissions

• APU Specification
  – Requirement to meet guidelines of ICAO Annex 16, Volume 1, Attachment C

• Development
  – APU Noise Specification
  – Test uninstalled APU
  – Installation of acoustic liners
  – Manage noise issues (Surge bleed, etc.)

• Noise Test on complete aircraft
  – Compliance with ICAO guidelines for APU Noise Certification
  – Provide operational information for operators and airports
  – Noise exposure for ground crews
  – Noise exposure for passenger entry and exit
APU Ramp Noise Contours – dB(A)

  - Chapter 9: Installed APU Standards are not yet developed
  - Attachment C provides Recommended Guidelines for Noise certification of APUs
  - Testing is compliant with Attachment C

Noise Guidelines:
- 20 meter rectangular boundary
  - 90dB(A) maximum APU level
- Ground service locations and Main Entry Door (MED)
  - 85dB(A)
Supersonics Research - Indoor

Supersonics-related Indoor Acoustics Efforts

- Diffraction Physics
- Transmission Loss
- Rattle
  - Instability Threshold Testing
  - Analysis using Predicted Waveforms
- Human Subject Testing

- Low Booms Still Induce Rattle
- Human Response to Sonic Booms
Supersonics Research - Outdoor

Supersonics-related Outdoor Acoustics Efforts

- **Sonic Boom Occurrences**
  - Geographic Extent
  - Effected Population

- **Nonlinear Lossy Propagation**
  - N-wave vs. Low-boom waveforms
  - Standard & non-standard atmospheric conditions

- **Sonic Boom Focusing**
  - Caustic Cusp
  - Fold Caustic
Questions?