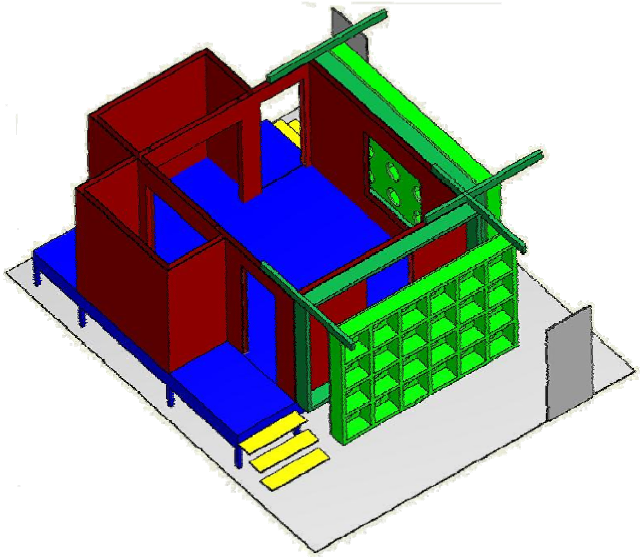
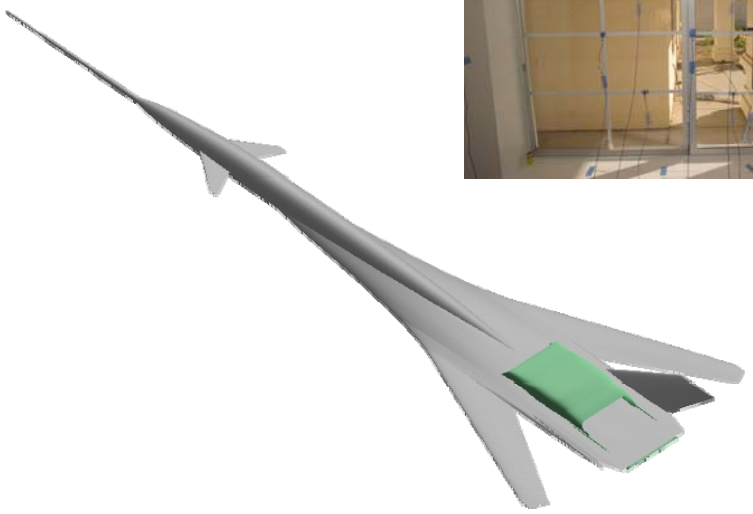
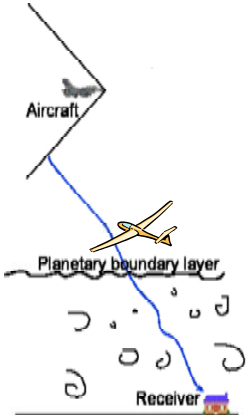
Sonic Boom Modeling Technical Challenge

- *Brenda M. Sullivan*
- *Fundamental Aeronautics 2007 Annual Meeting*
- New Orleans, LA
- Oct 31, 2007







Presentation Outline

- Technical Challenge Overview
- Status & Highlights
- Future Work

Sonic Boom Modeling Technical Challenge

Develop knowledge, capabilities and technologies to enable overland supersonic flight

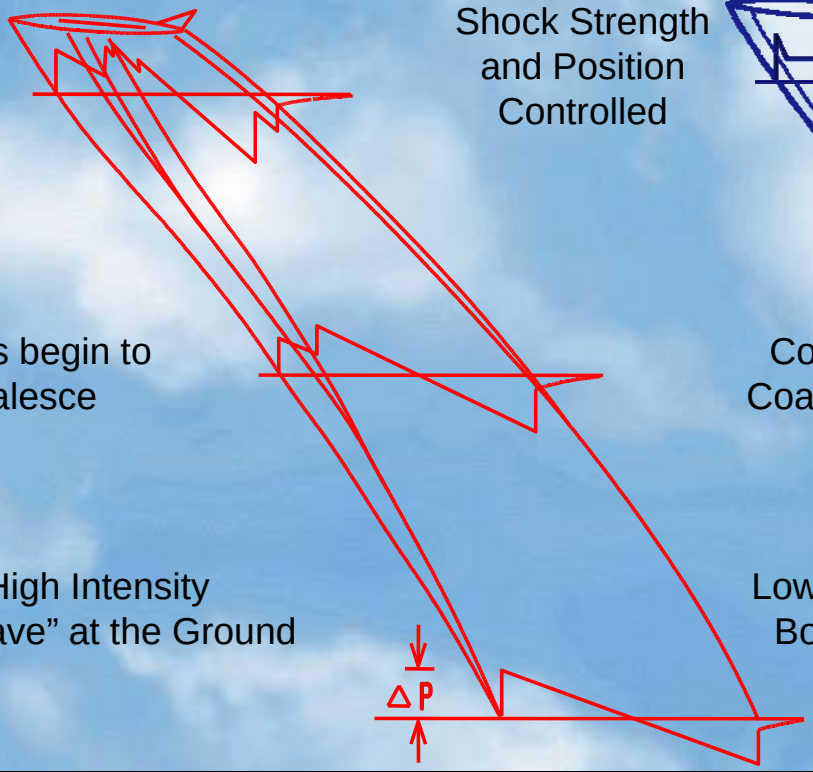
Sonic Boom Features

Conventional

Multiple Shocks of Differing Strengths

Shocks begin to Coalesce

High Intensity "N-wave" at the Ground

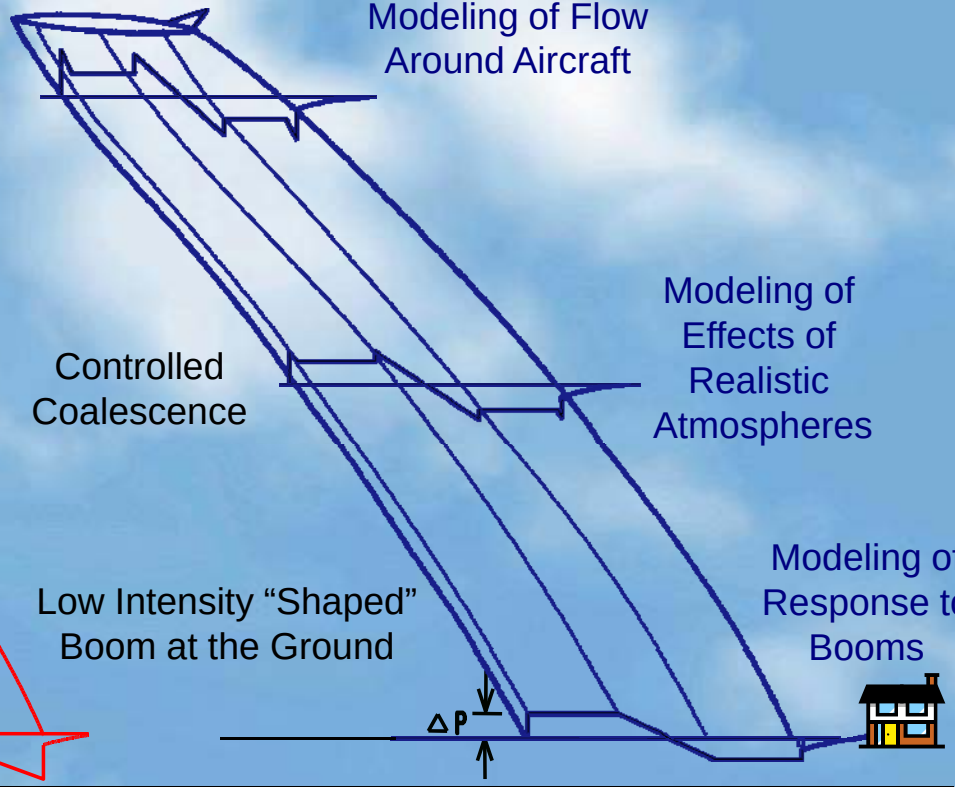


Low Boom

Shock Strength and Position Controlled

Controlled Coalescence

Low Intensity "Shaped" Boom at the Ground



NASA Program Elements

Modeling of Flow Around Aircraft

Modeling of Effects of Realistic Atmospheres

Modeling of Response to Booms

Sonic Boom Modeling

Objectives

- Develop and validate sonic boom propagation model through realistic atmospheres, including effects of turbulence
- Develop methods enabling prediction of response of and acoustic transmission into structures impacted by sonic booms
- Develop and validate psychoacoustic model of human response to sonic booms under both indoor and outdoor listening conditions, using simulators

Technical Challenge Elements

- NRA contracts/cooperative agreements
- Atmospheric Propagation
- Structural Response and Modeling
- Human Response and Modeling

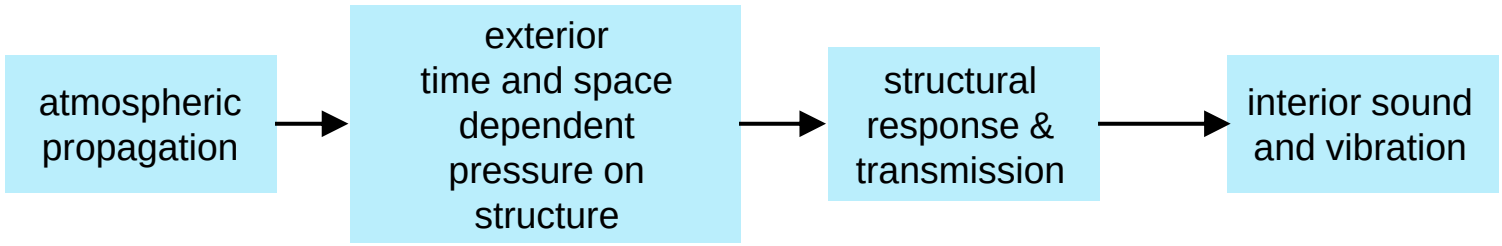
FY07 Highlights

- 2007 flight test for atmospheric propagation and structural response measurements completed
  - Significant contributions from Gulfstream, Penn State U., Purdue.
  - Visitors from FAA and other members of the FAA PARTNER Center Of Excellence
- Conceptual design for indoor sonic boom simulator completed
  - risk reduction experiments being performed
  - preliminary design in progress.
- 5 NRA Proposals funded

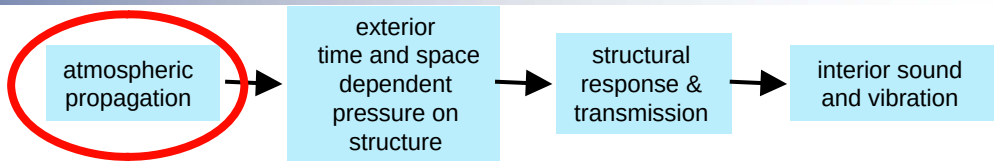
NRA Awards

Topics :

- Modeling and analysis for atmospheric sound propagation
- Diffraction around individual and aggregated building structures
- Transmission of sonic booms into building structures (2 awards)
- Modeling of rattle and other contact induced noise



NRA Awards - Propagation



Modeling and Analysis for Atmospheric Sound Propagation

Objective:

Develop efficient and robust models to predict outdoor sonic boom exposure under realistic atmospheric conditions and for all flight conditions

Award:

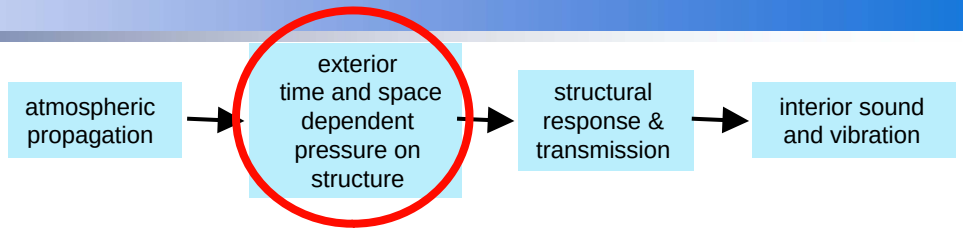
Atmospheric sonic boom prediction model (Wyle Labs)

Principal Investigator: Juliet Page

Two Year Program: 9/07 – 8/09

- Investigate near field prediction to far-field 3-D pressure field transition
- Improve propagation capability to more accurately predict boom shape
- Include turbulence modeling

NRA Awards - Diffraction



Diffraction of Sonic Booms around Building Structures

Objective:

Predict pressure loads (temporal and spatial) on building

Award:

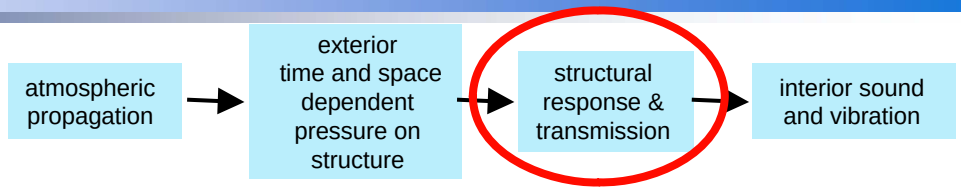
Low-boom sonic boom coupled diffraction around individual and aggregated building structures (Penn. State University)

Principal Investigator: Vic Sparrow

Two Year Program: 8/07 – 7/10

- Develop computer codes to quantify temporally and spatially dependent forces on buildings due to low booms
- Use NASA field test data to validate models for single dwellings
- Expand to multiple structure – “urban canyons”

NRA Awards - Transmission



Transmission of Sonic Booms into Building Structures

Objective:

Develop models to predict the structural acoustic response of building interiors due to exposure to sonic booms of arbitrary wave shape

Awards:

Development of a model for predicting the transmission of sonic booms into buildings (Virginia Polytechnic Institute & State University)

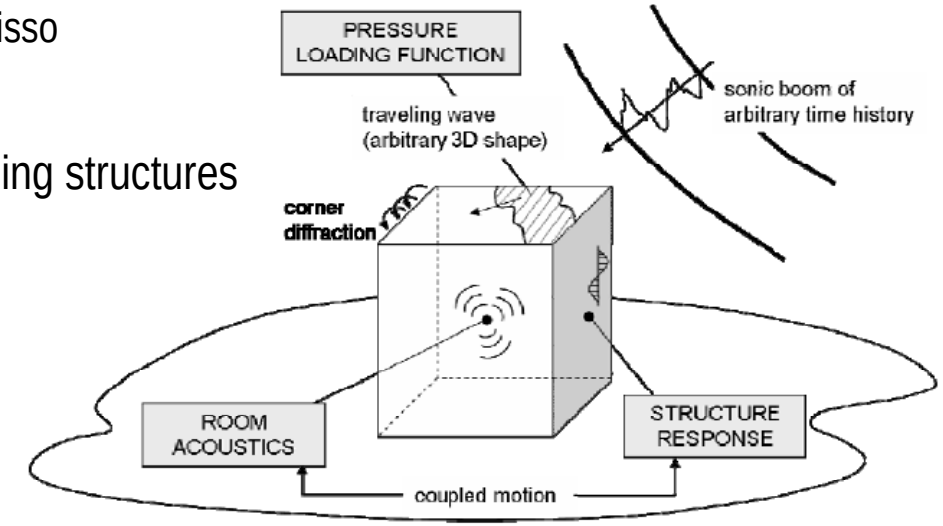
Principal Investigator: Ricardo Burdisso

Two Year Program: 9/07 – 8/09

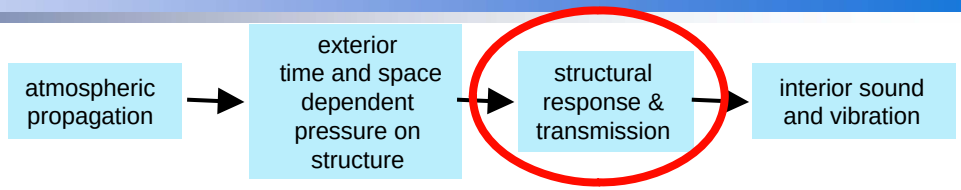
Transmission of sonic boom into building structures (Wyle Labs)

Principal Investigator: Natalia Sizov

Two Year Program: 9/07 – 8/09



NRA Awards - Rattle



Modeling of Rattle and Other Contact Induced Noise

Objective:

Develop models to predict interior noise levels from window rattle and other contact induced acoustic sources subjected to sonic boom excitation

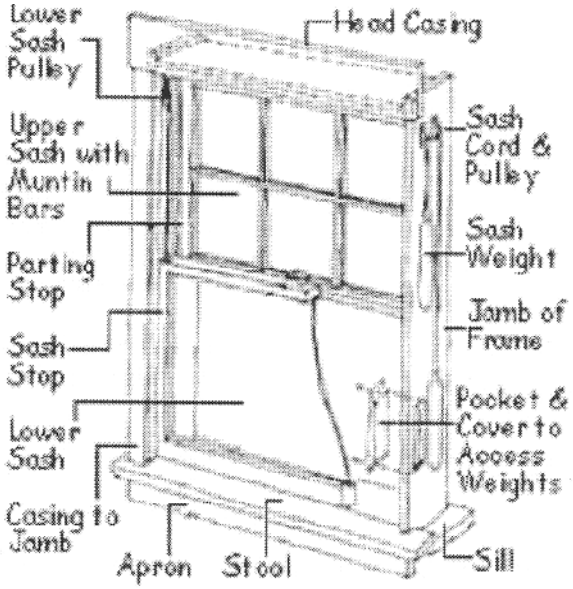
Award:

Modeling of rattle and other contact induced noise (Wyle Labs).

Principal Investigator: Natalia Sizov

Two Year Program: 9/07 – 8/09

- Measure window rattle in situ
- Study selected windows under controlled conditions in laboratory tests
- Develop and validate model



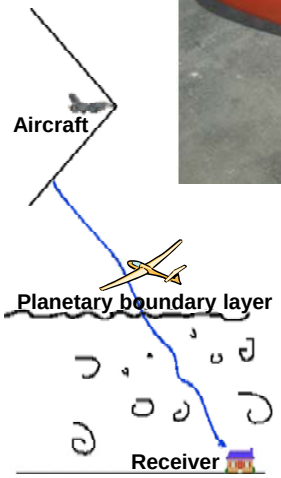
In House Research

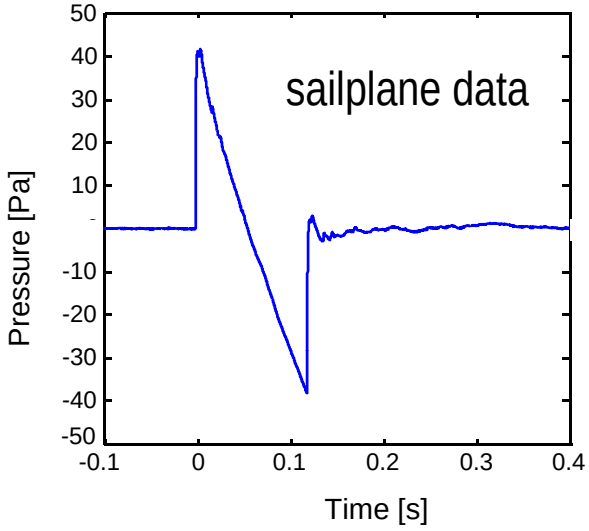
- Atmospheric Propagation
- Structural Response and Modeling
- Human Response and Modeling

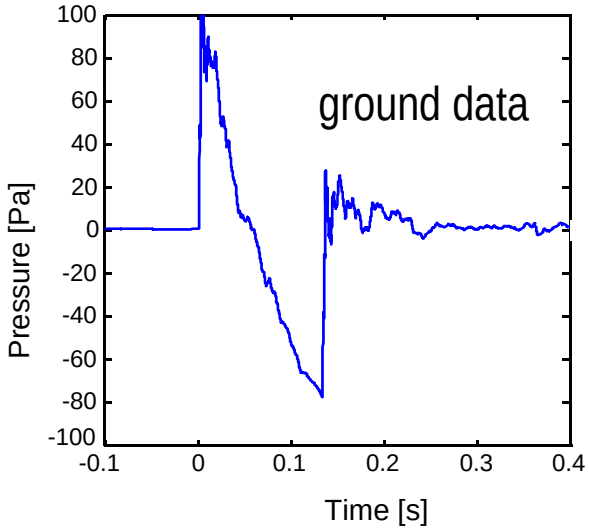
Atmospheric Propagation

Propagation data acquired in conjunction with structural response field test

- 17 low-intensity and 10 conventional sonic booms recorded by sailplane at altitude
- recordings above the Planetary Boundary Layer to be compared to recordings of same booms on ground
- 35-ft tower populated with microphones to investigate terrain and atmosphere effects



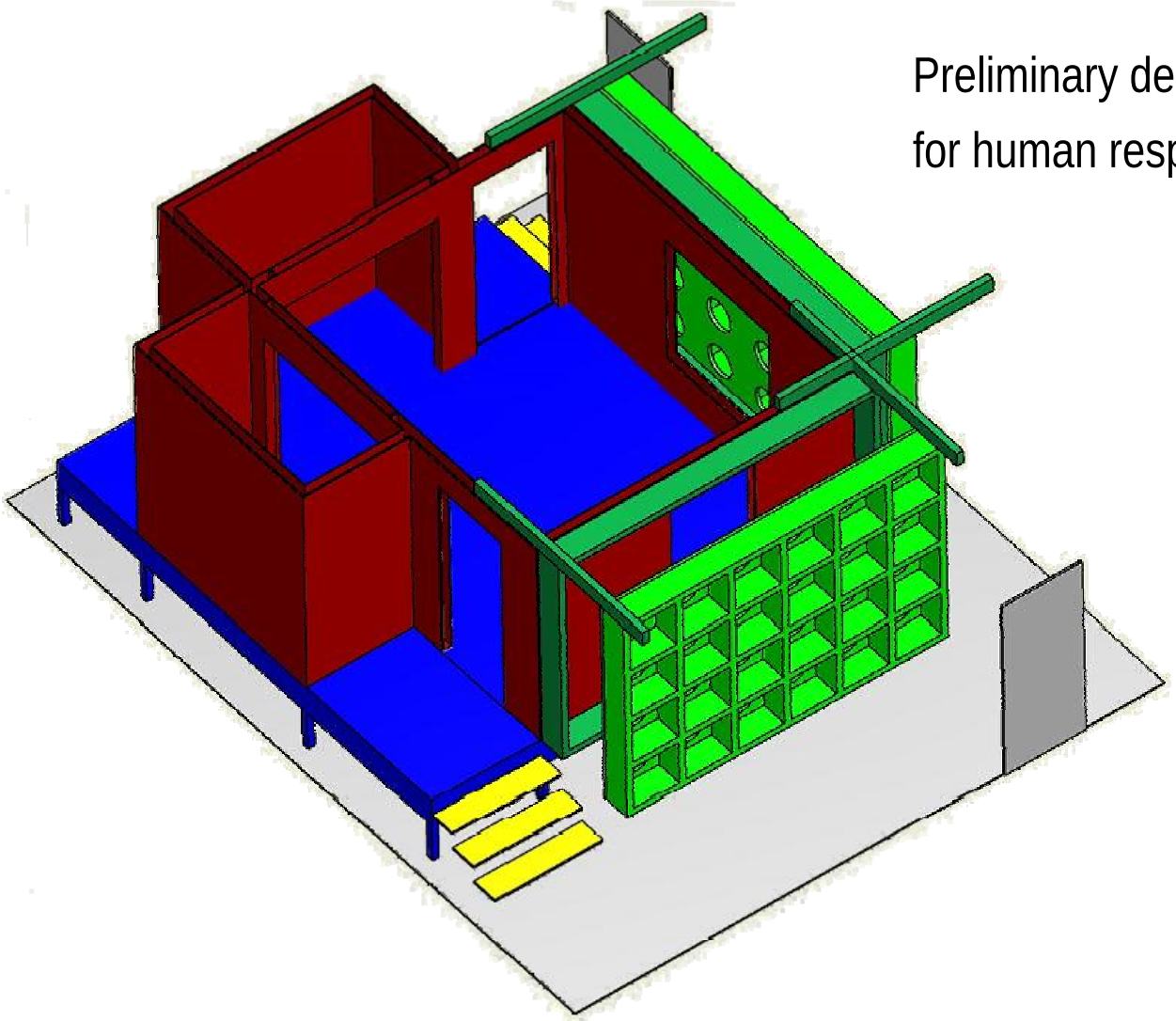




Structural Response and Modeling

July 2007 structural response / transmission field test completed

Human Response and Modeling



Preliminary design of interior simulator for human response to sonic boom

Future Work

Plans for FY2008

- Continuing work with NRA award recipients
- Complete design and construction of indoor sonic boom simulator
- Develop high frequency structural acoustic transmission models
- Design Over-the-Top sonic boom flight test