# Ground Vibration Testing (GVT) at NASA Armstrong



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# **Ground Vibration Test**





What boundary conditions will the system have for GVT?  $\Rightarrow$  Greatly affects results

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# GVT's Goals, Objectives & Challenges

- **GVT Goal**: Gather modal data to validate and/or correlate the finite element model (FEM) which will later be used in the flutter analysis to grant airworthiness
- GVT Objective: Measure & characterize the structural frequencies, mode shapes & damping
- GVT Challenge: Obtaining test boundary conditions (BCs) which are comparable to FEM BCs
  - Frequencies & mode shapes heavily depends on the BCs
  - FEM modal analysis often use rigid or free-free BCs
  - Rigid BCs ⇒ Very difficult to obtain in ground test... Nothing is completely *rigid*
  - Free-free BCs  $\Rightarrow$  Challenging, but obtainable in ground test
    - Need to simulate the aircraft flying (landing gear up, no constraints)
    - Soft Support System (SSS) minimize structural coupling by isolating rigid-body modes from aircraft's elastic modes, thus simulating as close as possible the free-flight conditions the aircraft will experience
      - SSS typically have a natural frequency below the first natural frequency of the test article & allows for a "floating" type effect
      - If designed efficiently, SSS should have no effect on the test article mass, stiffness or damping
      - SSS examples: Bungee cords or air bag systems



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# GVT Boundary Condition: Self-Jack Soft Support System

- 60k lbs Self-Jacking Soft Support System
  - 3 canisters interface at aircraft jacking locations
    - Canisters filled with Nitrogen
  - Each soft support is rated for 20,000lbs (9,070kg)
  - SSS has  $\approx$  1 Hz natural frequency
    - Allows for a "floating" type effect
  - · Self-Jacking allows landing gear to be retracted

### Self-Jack Soft Support Canister











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# GVT Boundary Condition: Overhead Soft Support System

- Overhead Soft Support Systems
  - MIL spec bungees or custom build bungees
  - SSS can be custom designed based on aircraft pick-up locations and desired SSS frequency (typical ≈ 1 Hz)
    - As wings are becoming more flexible, SSS designs are becoming more difficult

### Ikhana GVT using Overhead Bungees





### Phantom Eye GVT with Custom Build Overhead SSS





### MIL-C-5651B, Type II Bungees



# GVT Boundary Condition: Soft Tires

- Sometime soft (partially deflated) tires are used as a soft support system
  - Used for ease of use
  - GVT data will have landing gear affects
  - Can be acceptable BCs for small test article on larger aircraft (i.e. F-15 centerline experiments)

F-15 on *Soft* Tires for Centerline Experiment GVTs



Swept Wing Laminar Flow (SWLF)



Supersonic Boundary Layer Transition (SBLT) II

# C-20 on *Soft* Tires with Generation Orbit's Inert Test Article GVT







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## GVT Boundary Condition: Strongback (Rigid)

- FLL Strongback is used to mount test articles to for some GVTs
  - Weighs 7,000lbs (3,175kg)
  - Fixed with 8-bolted ground points to FLL floor tracks
  - Laterally flexible
  - Strongback can couple with test article's modes of interest

### X-56 Wing GVT Mounted on Strongback

# <image>



**FLL Strongback & FEM** 

### Strongback Mode Shape – Laterally Flexible







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