Multiple-Input Multiple-Output Shaker Shock Testing

Seth Havens ECET, Jesse Gloria ME, Jose Estrada ME, Jacob Ritzke MAE

Sandia National Laboratories (SNL)

Mission/SOW

Sandia National Labs requested the research, Design, and development of a test article to advance MIMO Shaker Shock Testing at their labs.

The following parameters must be met:

- **Design a tunable structure that meets**
  - **6DOF/IMMAT compatibility**
  - **50-2000 Hz natural frequencies**
  - **<50 lbs weight**
- **Build durable prototype**
  - **Structurally Sound**
- **Conduct Validation Testing**
  - **Shock and vibration loads**
  - **Gather, compile, and analyze data**

Our team worked diligently to deliver a structurally sound, tunable test article that meets these requirements.

Research

- **Single-Axis Testing (SISO): Traditional method where vibrations are applied one direction at a time. It is widely used but fails to replicate real-world multi-directional forces.**
- **Multi-Axis Testing (MIMO): Simultaneously excites a test article in multiple directions (X, Y, Z), improving accuracy and reducing test time.**
- **Advantages of MIMO:**
  - **Identifies failure points missed in SISO tests.**
  - **Provides a more realistic field environment.**
  - **Reduces overall test duration.**

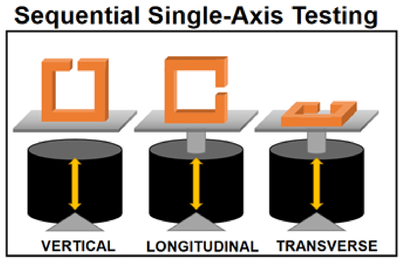


Figure 3. Example of SISO testing.

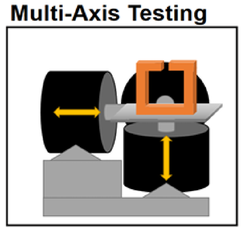
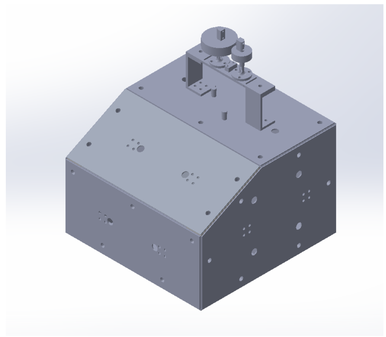
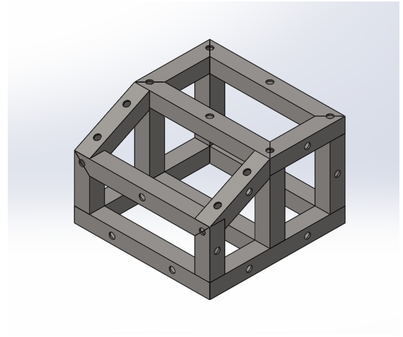


Figure 2. Example of multi-axis testing.

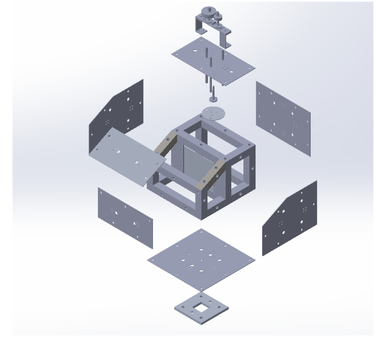
Final Design



Isometric view of wedge frame assembly.



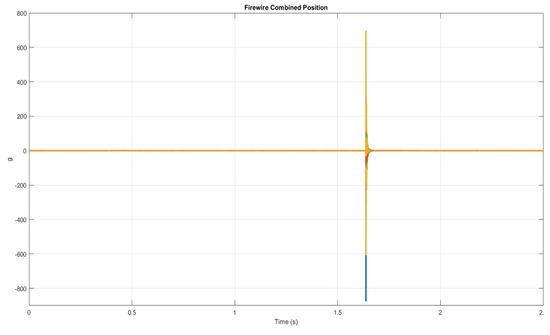
Isometric view of wedge frame.



Exploded view of wedge frame assembly.

Shock Testing

Firewire charge detonation

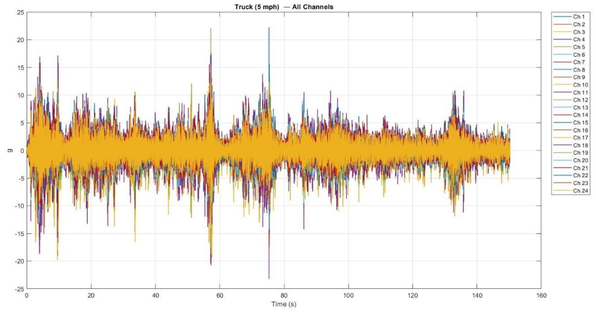


Fire Wire All Positions Test Run Results

- **Total of ten tests performed**
  - **Three different positions on test article**
    - **Three tests for each position**
- **Final test involved fire wire ignited at all positions**

Vibration Testing

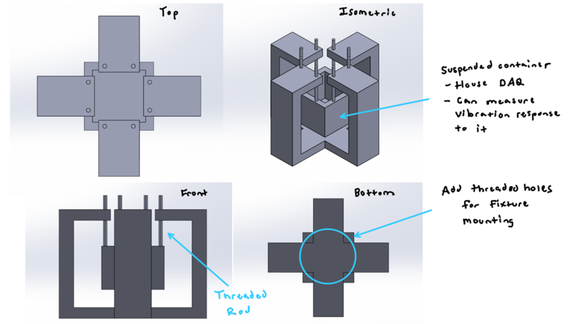
Test article secured to pallet fastened onto flatbed of truck via tow straps.



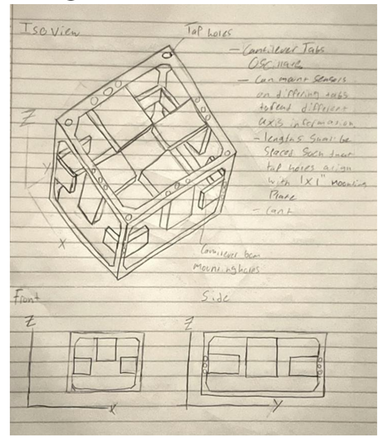
Truck Test 5 mph Results

- **Total of three tests performed**
  - **5 mph, 10 mph, 12 mph**
- **Consistent vibration response obtained in all data sets**
- **G levels increased in increasing speed**

Concept Development



- **Two-body system: Consists of a main outer body and a suspended inner container.**
- **Vibration measurement: The suspended container's vibration response can be measured.**
- **Suspension method: Container is hung within the frame using materials like threaded rods.**



- **Simple frame structure with tapped holes**
- **Designed for mounting cantilever beams**
- **Sensors can be mounted on either the beams or the frame**
- **Allows for interchangeable cantilever beam configurations**
- **Supports testing for different oscillation responses through varied beam setups**

References

- Danforth, S., Johnson, S., Fenstermacher, K., Ramirez, A., Sedillo, H., Schultze, J., Ferguson, E., (Sept 2024). Developing Methods for Single-Axis Base Excitation Vibration Testing with Additional Distributed Shakers. Los Alamos National Laboratory. Provided by SNL
- Soine, D., Schoenherr, T., Heister, J. Evaluation of a Multiaxis Shoxk Fixture Concept. Albuquerque, NM. Sandia National Laboratories. Provided by SNL.
- Harvey, D., Cramer, E., Zhang, R. (n.d). Rapid, Approximate Multi-Axis Vibration Testing. Los Alamos National Laboratory. https://doi.org/10.2172/1983835
- Babuška, V., Sisemore, C., Booher, J. (n.d). On the Sensitivity of Energy Metrics to Failure in a Complex Structure. Albuquerque, NM. Sandia National Laboratories. Provided by SNL