Non-Intrusive Shock Measurements using Laser Doppler Vibrometers

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Outline

- Background
- Shock Simulation Tests
- Results Summary
- Future Work

Shock Testing Practices

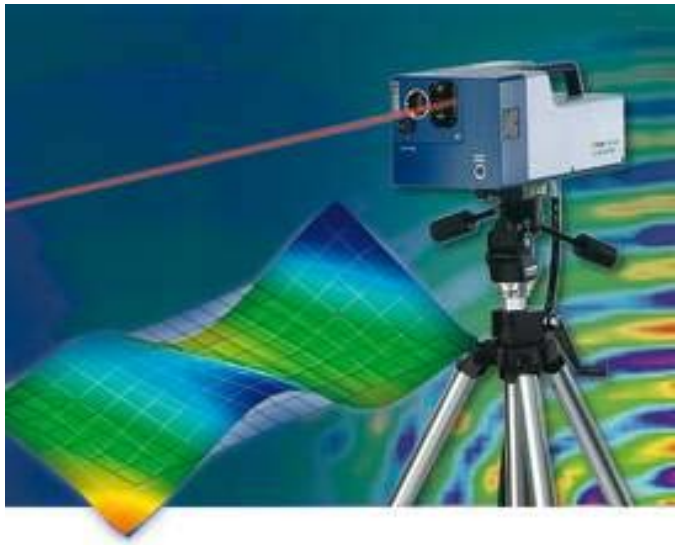
- Critical step in qualifying flight hardware
- Use accelerometers on or near the hardware
- Limitations to surface mounted accelerometers:
  - Stud mounted accelerometers interfere with high-frequency shock wave and distort signature
  - Calibration limitations above 20 kHz
  - Sensitive surfaces or small devices
- Explore alternative sensors for shock testing

www.pcb.com

Laser Doppler Vibrometers

- Interferometer
  - Measure velocity of moving object along line-of-sight

$$\Delta f_D = \frac{2v}{\lambda}$$



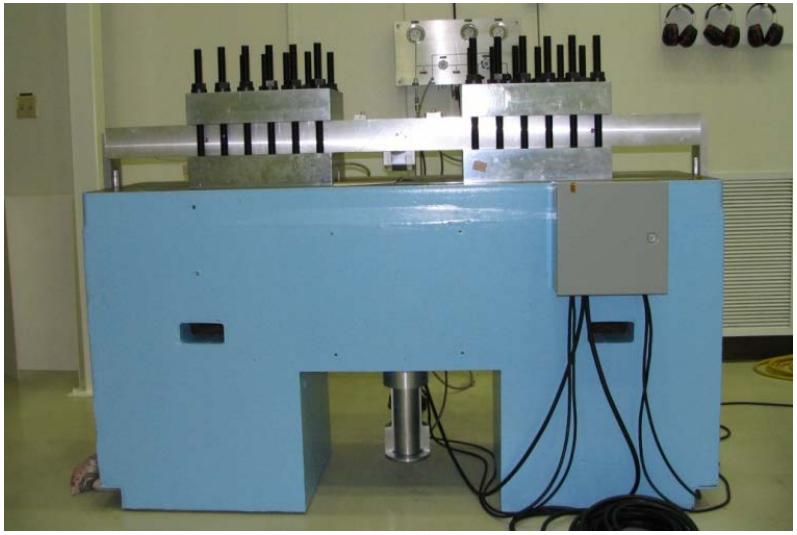
www.polytec.com

- Non-intrusive sensor
- Opportunities in shock testing
  - Do not disturb shock wave
  - Measurement capabilities beyond accelerometers

www.metrolaserinc.com

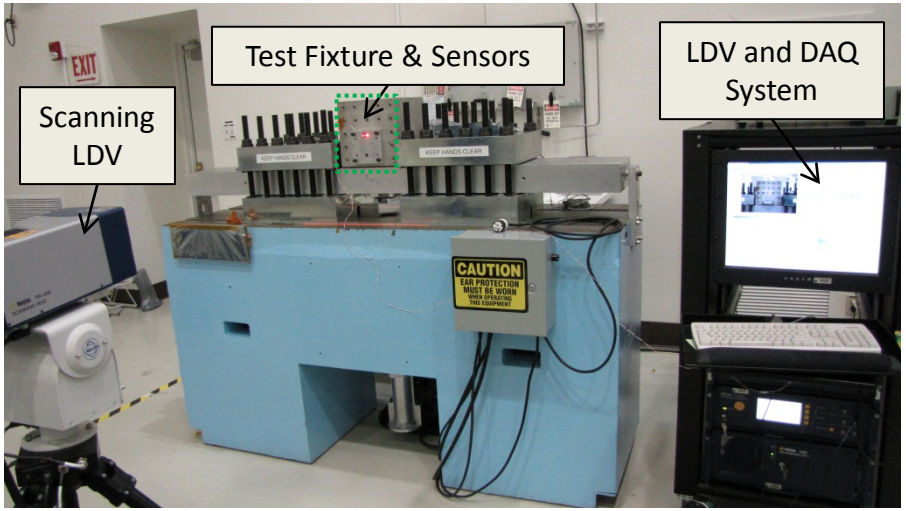
Shock Simulation Tests at JPL

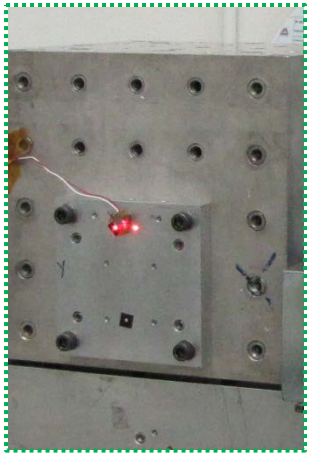
- Two shock test demonstrations using LDVs
- Simulated pyroshock testing at JPL ETL using a tunable resonant beam shock apparatus



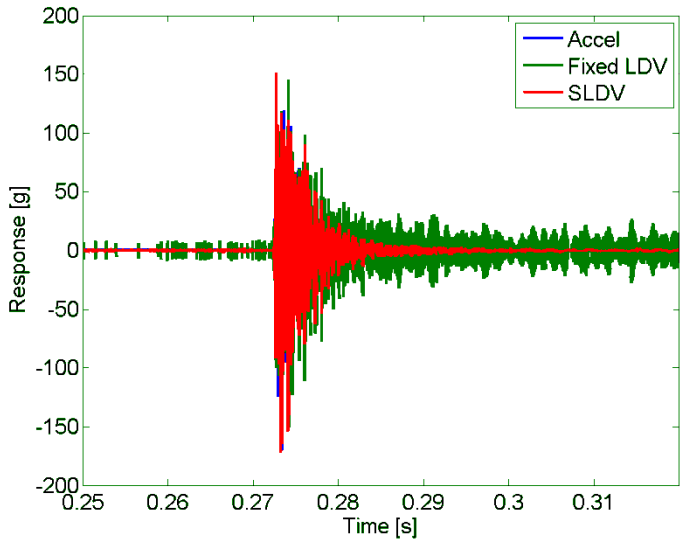
Shock Simulation Test #1

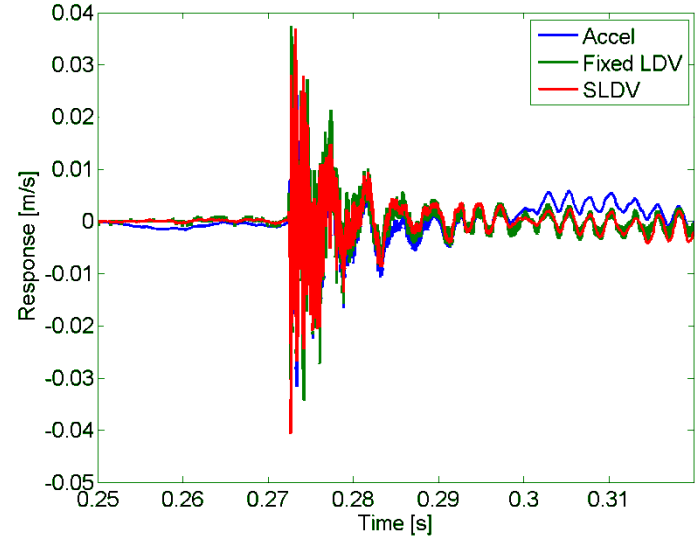
- Date: March 2011
- Test Article:
  - Aluminum plate
- Instrumentation:
  1. Accelerometer
  2. Fixed LDV
  3. Scanning LDV
- Tests:
  - Two shock runs at 50 psi
  - Sensors at approximately same location

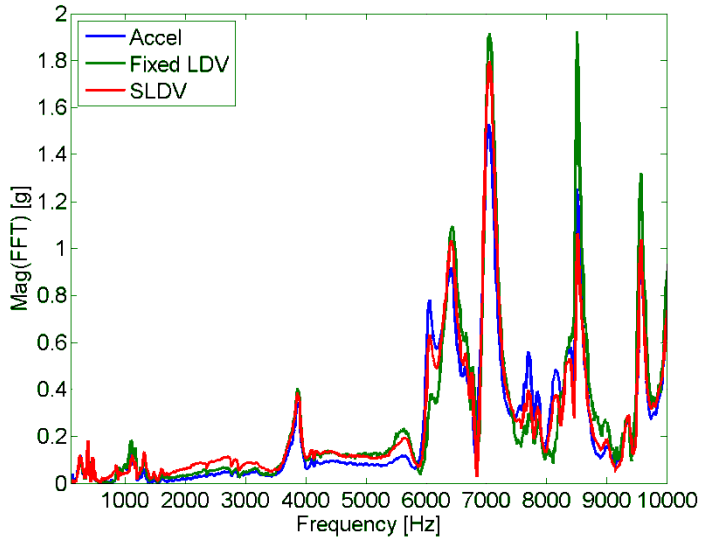


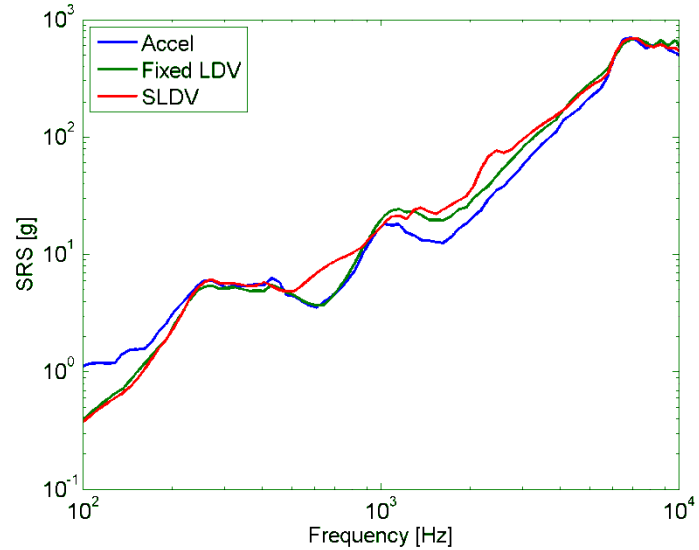


Results from Shock Simulation Test #1



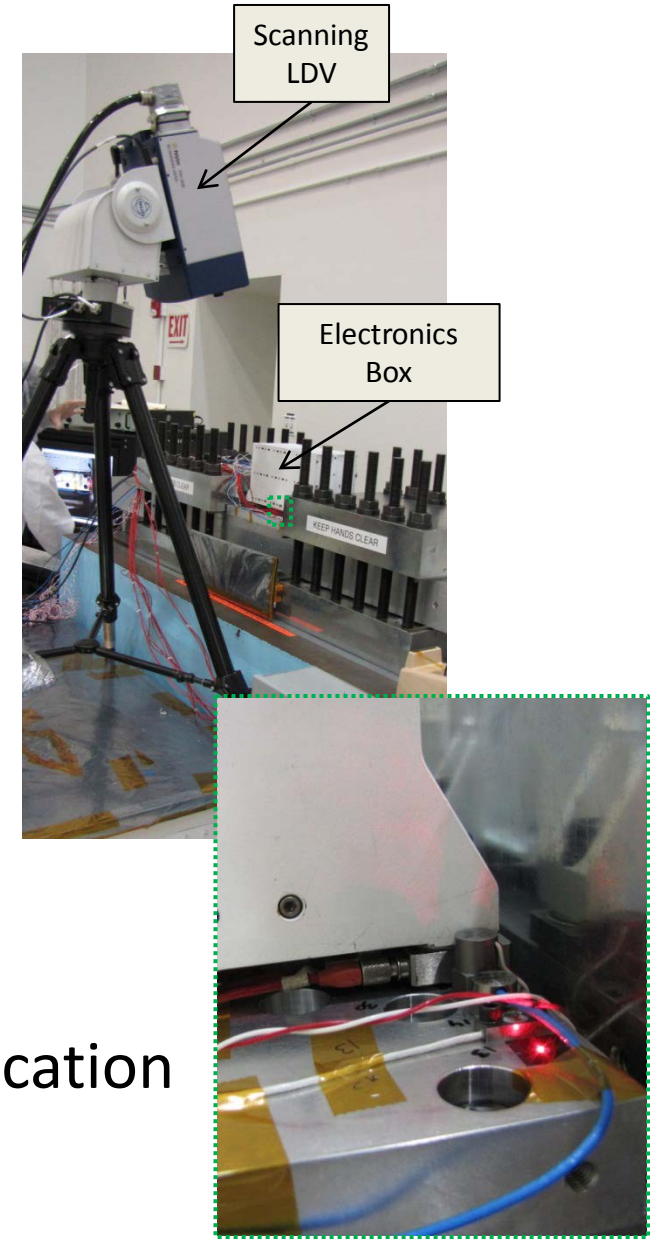




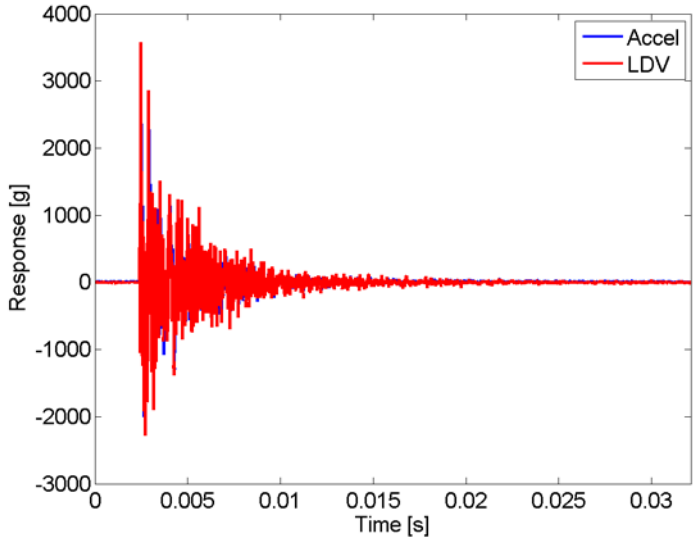


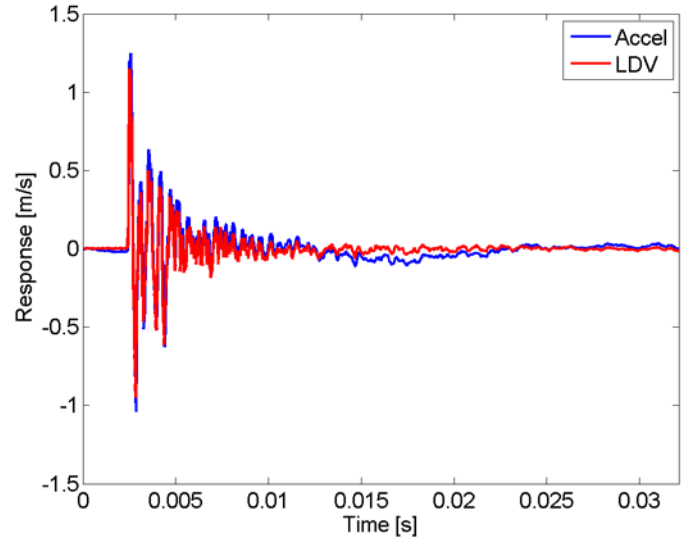
Shock Simulation Test #2

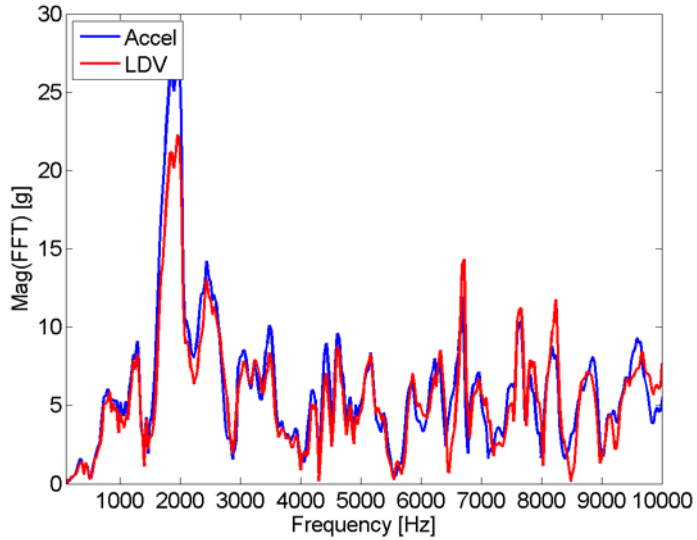
- Collaborative test with ULA
- Date: April 2011
- Test Article:
  - “Obsolete” electronics box
- Instrumentation:
  1. Accelerometer
  2. Scanning LDV
- Tests:
  - Seven runs (100-150 psi)
  - Sensors at approximately same location

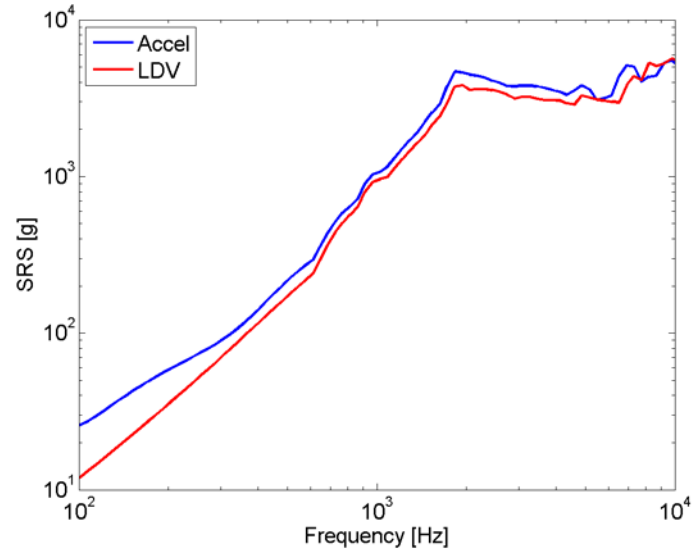


Results from Shock Test #2 (100 psi)

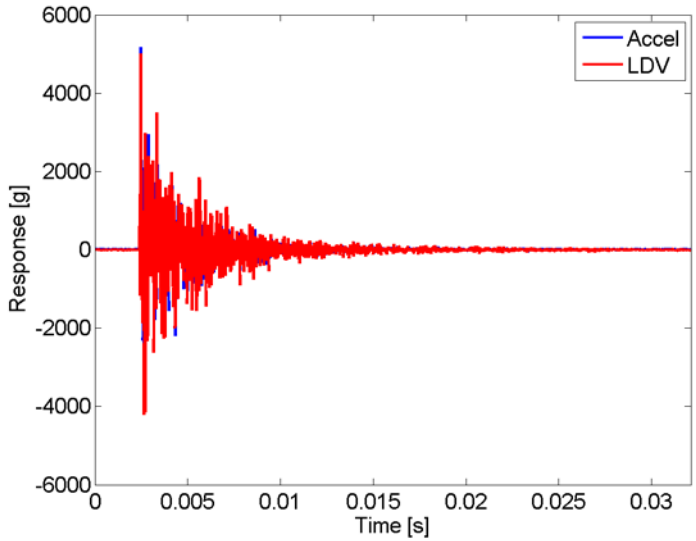


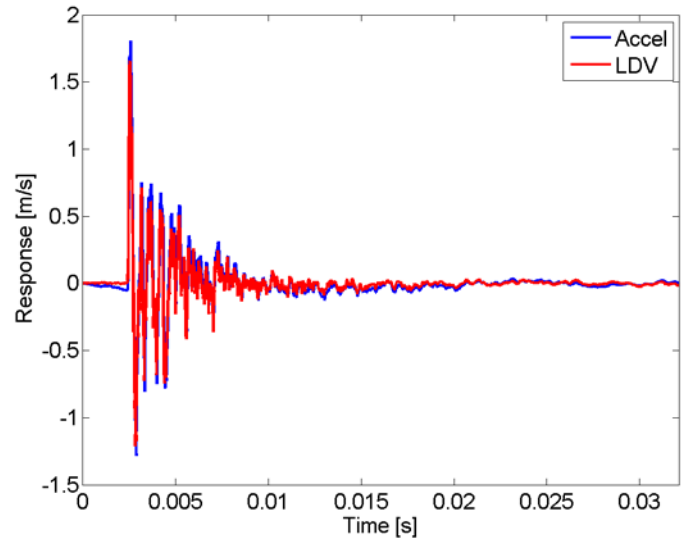


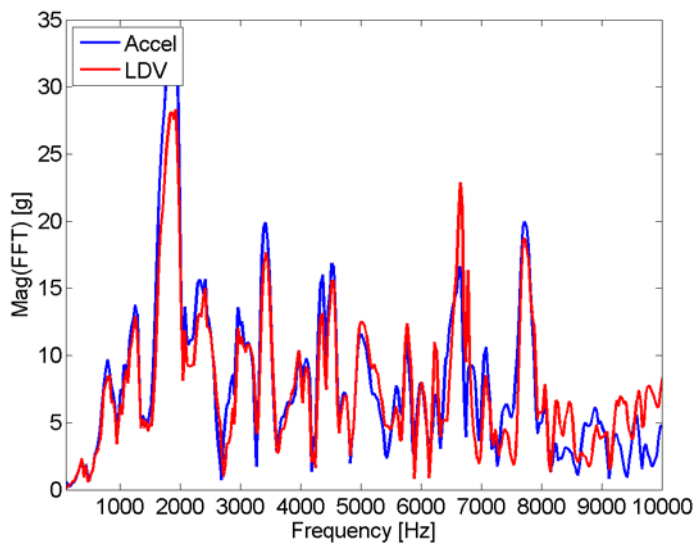


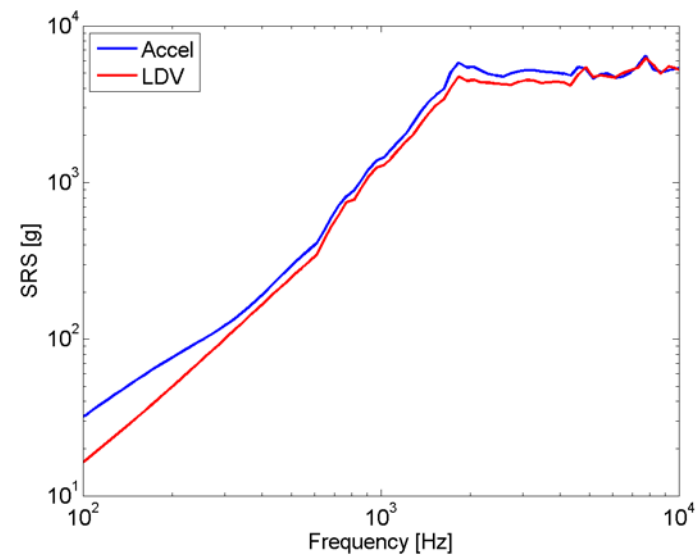


Results from Shock Test #2 (150 psi)



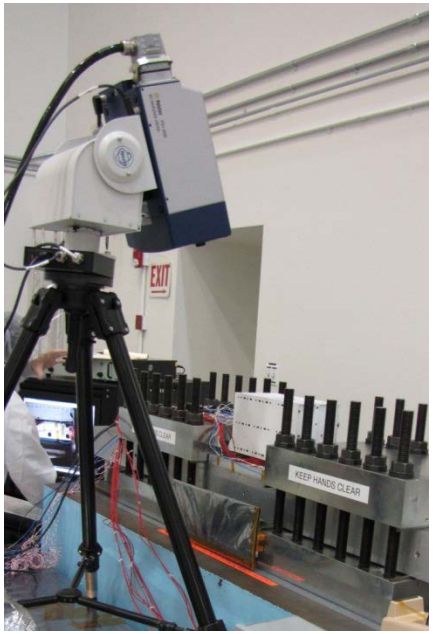






Results Summary

- Measured responses from accelerometers and LDVs are comparable
- Differences in measured responses attributed to variances in:
  - Sensor locations
  - Test article
  - Test setup
  - SLDV positioning
  - Load levels



Conclusions

- Two shock simulation demonstrations completed using LDVs
- Good correlation between accelerometers and LDVs
- Advantages to LDVs include:
  - Non-intrusive measurement
  - No distortion in shock wave and acquired signature
  - Measure sensitive surfaces and small instruments
- Disadvantages to LDVs include:
  - Portability
  - Setup difficulties
  - Measurement location must be optically visible

Future Work

- Complete shock simulation tests for:
  1. One test article
  2. Multiple pressure levels
  3. Three dimensions
- Better define feasibility of using LDVs in shock and other environmental tests

Acknowledgements

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