PYROTECHNIC SHOCK SIMULATION

DESIGN REVIEW II INTERIM PRESENTATION

3/17/16

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Instructors: Dr. Gupta & Dr. Shih

Team 12 Members: Max Mecabe, Tiffany Shaw, Justin Vigo, Sarah Wyper, Luis Lopez

PROJECT BACKGROUND

- Pyrotechnics are used for tasks such as rocket separation, pilot ejection, airbag inflation, and payload deployment
- Can be damaging to sensitive electronic hardware
- Important to simulate in order to make sure other components are not damaged.
- Not easy to simulate
  - High Frequency
  - High Acceleration
  - Short Duration
  - Transient Response

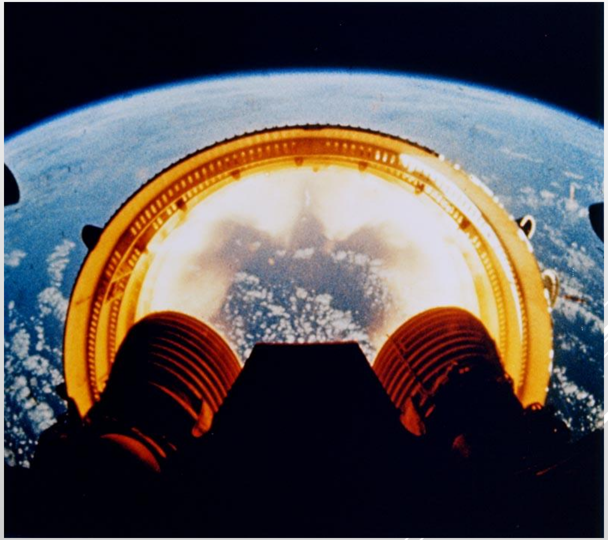


Figure 1: Rocket Separation

PROJECT BACKGROUND

- Actual pyrotechnics are not required to simulate similar shock responses
- Shock response is difficult to analyze in the time domain
- Shock Response Spectrum (SRS): Describes the shock response in the frequency domain

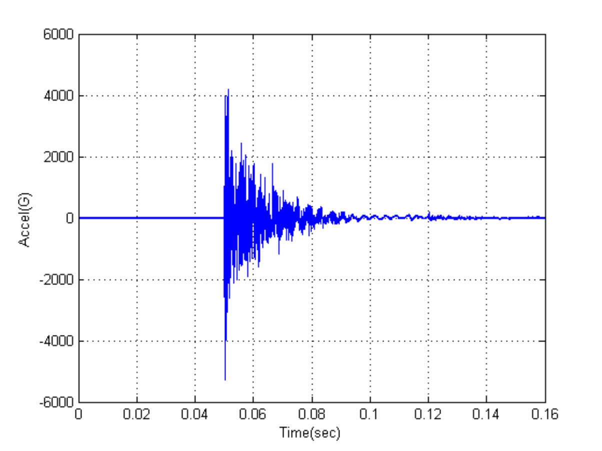


Figure 2: Example shock response in the time domain

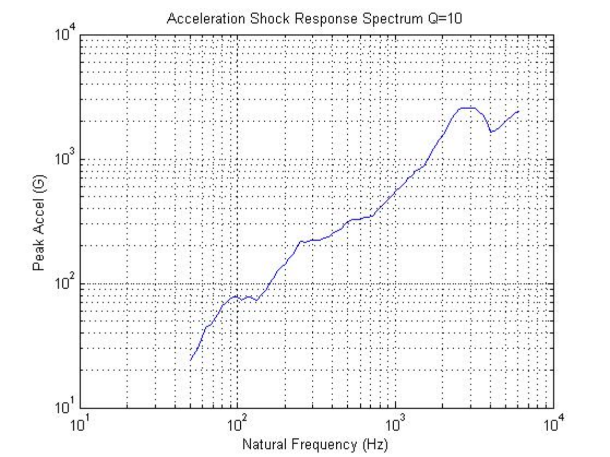


Figure 3: Example SRS curve in the frequency domain

PROJECT BACKGROUND

- SRS curves are generated from the acceleration time history of the shock response
- Models the system as an array of single-degree-of-freedom (SDOF) systems
- The maximum acceleration is mapped to each frequency, yielding the SRS curve

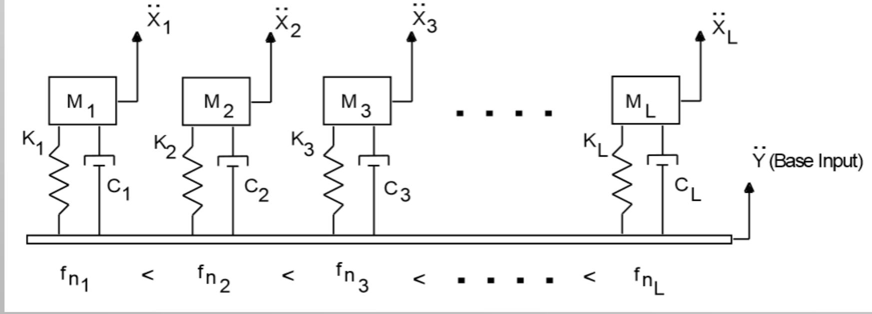


Figure 4: Array of SDOF systems with every possible natural frequency

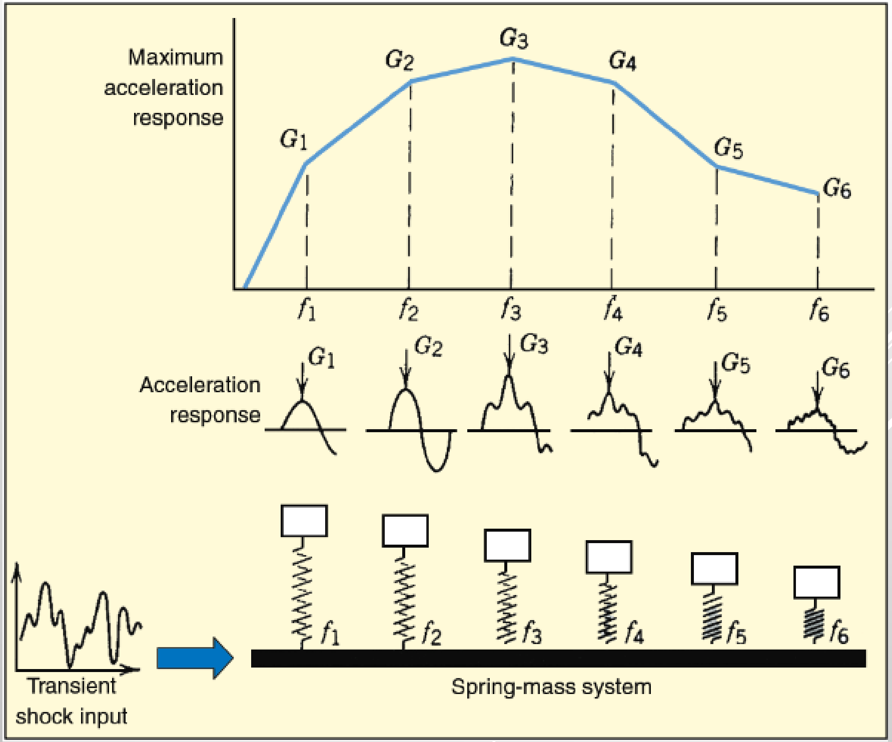


Figure 5: How SRS curves are generated

PROJECT SCOPE

What does Harris want?

- Harris simulates pyrotechnic shock, but they don't have time to manipulate variables to find the desired result.
- Want understanding of how different variables affect SRS in order to predict results.

How to accomplish this?

- Build device to simulate pyrotechnic shock.
- Run tests to correlate variables with changes in SRS curve.

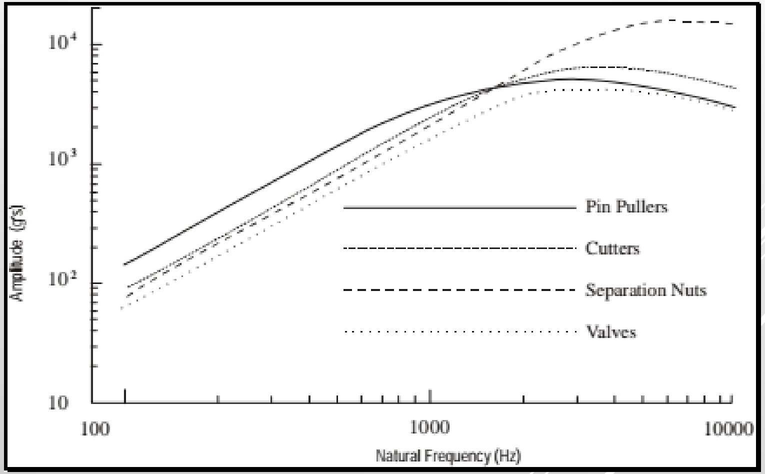


Figure 6: Harris SRS curves for different pyrotechnics

PROJECT SCOPE

- Two Year Project
  - Year 1 – Design and build test rig and data acquisition system.
  - Year 2 – Implement design changes to create repeatability and collect data for variable pyroshock simulation.
- Need Statement

  Collect data that demonstrates correlation between variables and SRS curve output
- Project Goals
  - Modify design to create repeatability in results
  - Design experiments to test variables and resulting curves
  - Possibly improve efficiency of data acquisition process

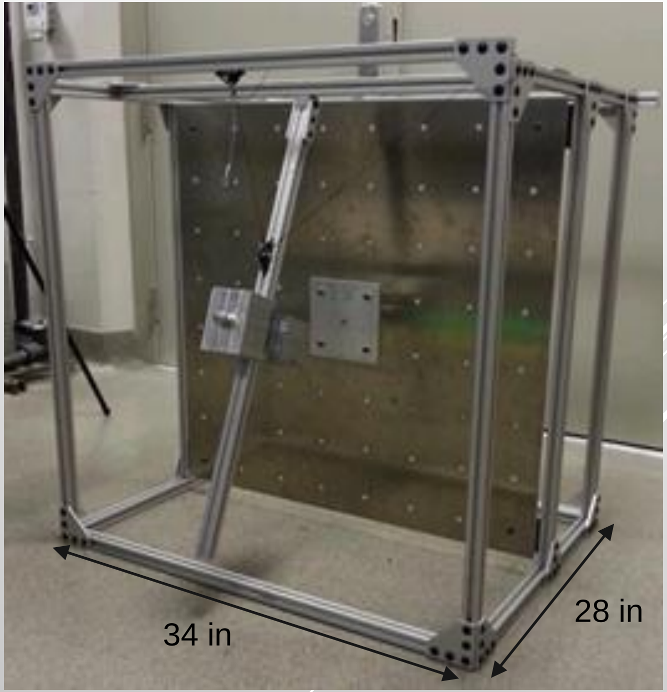


Figure 7: Testing Apparatus

REPEATABILITY

- -3dB to +6dB over minimum 90% of SRS Curves
- Remaining 10% within -6dB to +9dB

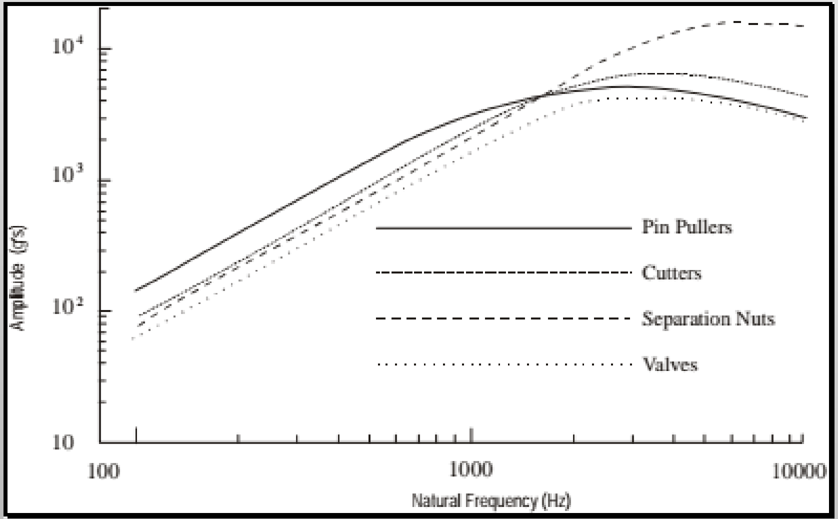


Figure 8: Harris Theoretical SRS Data

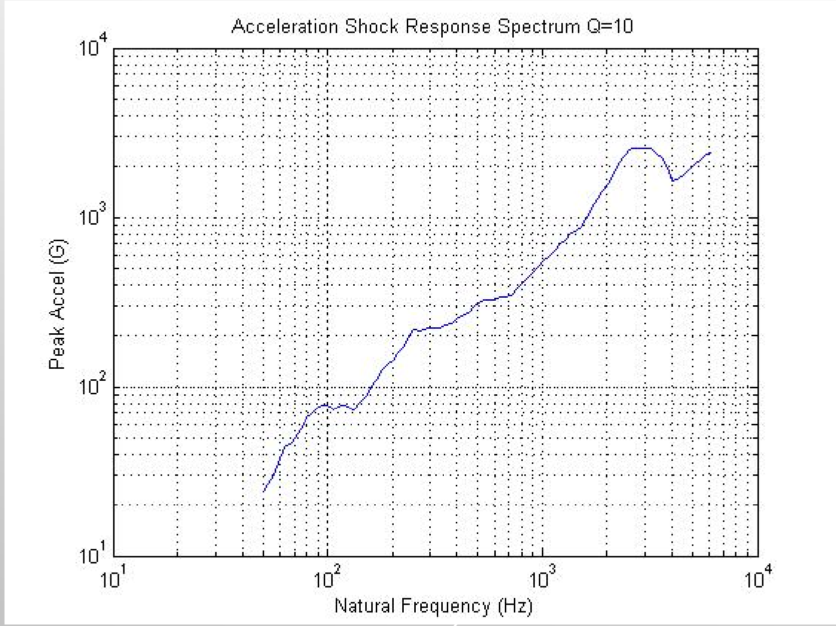


Figure 9: Experimental Results

DESIGN IMPLEMENTATIONS

Things to be changed in order to create repeatable data:

- Anchor
- Change Pivot
- Decouple from frame
- ~~Sacrificial plate adjustment~~
- Nut and bolt torque consistency

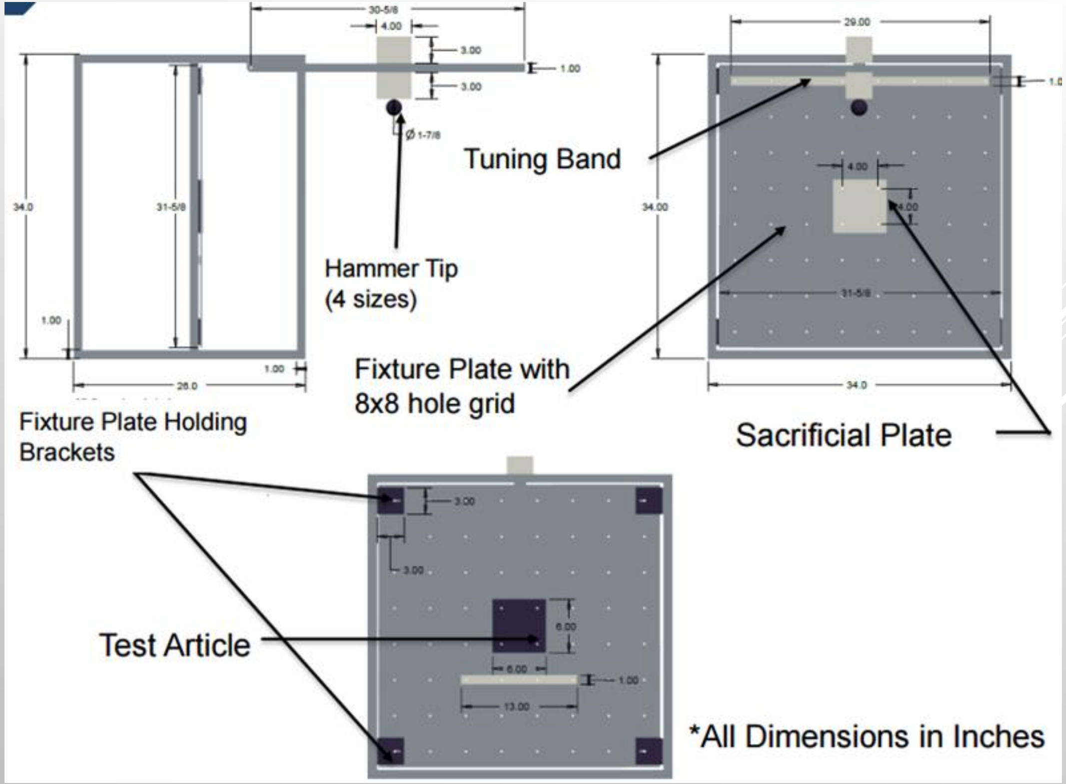


Figure 10: Apparatus Dimensions

ANCHORING

- Newport series instrumentation table
- 528lb
- Aluminum two hole strap
- Foam for equivalent force distribution.

Figure 11: Simulation Table and Mounts

ANCHORING

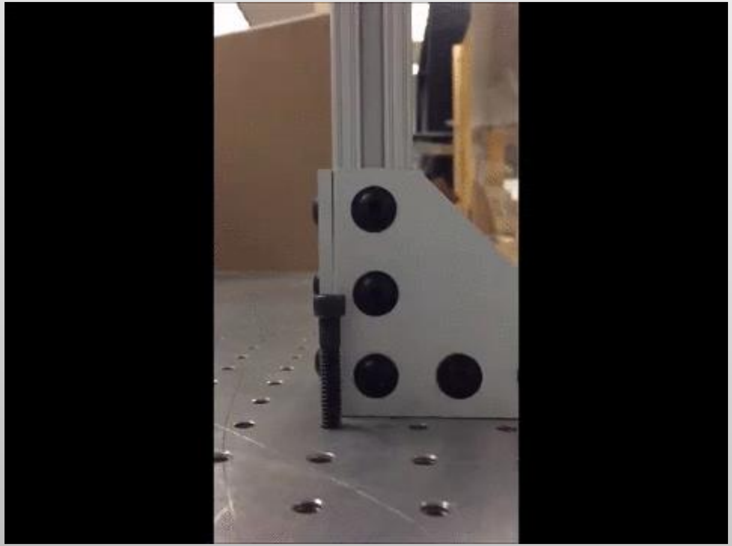


Figure 12: Un-anchored Test

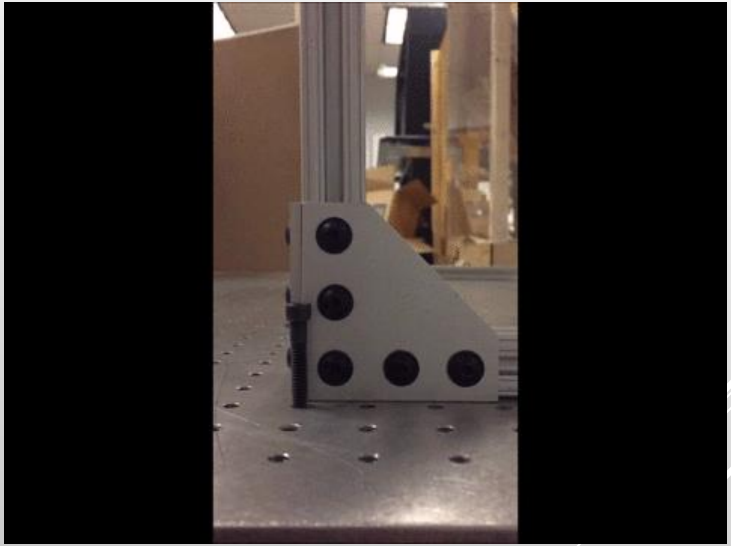


Figure 13: Anchored Test

PIVOT REPLACEMENT

- Previous pivot was a static pivot mount
  - This caused wear and unwanted side to side motion.
- New pivot is a dynamic pivot with lubricated bronze bushings

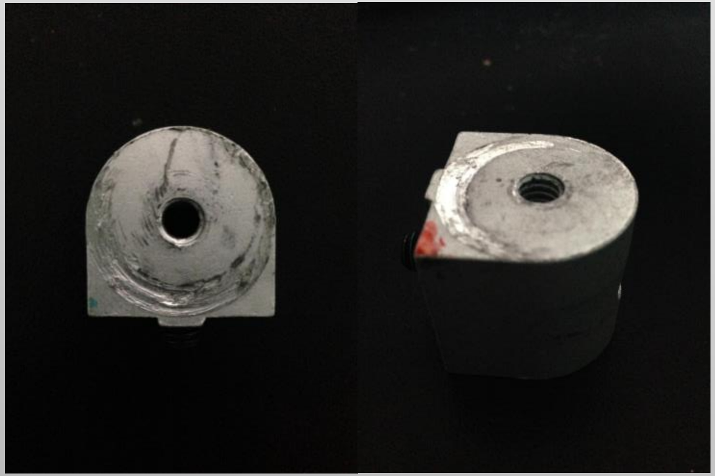


Figure 14: Wear Static Pivot

Figure 15: Dynamic Pivot

CURRENT SETUP

- National Instruments DAQ (USB - 6211)
  - 16 Bit
  - Max Frequency - 80 MHz
- PCB Signal Conditioner (model 485A21)
- Dytran Current Limiting Power Source (model 4110C)
- Dytran Accelerometer (model 3086A4T)

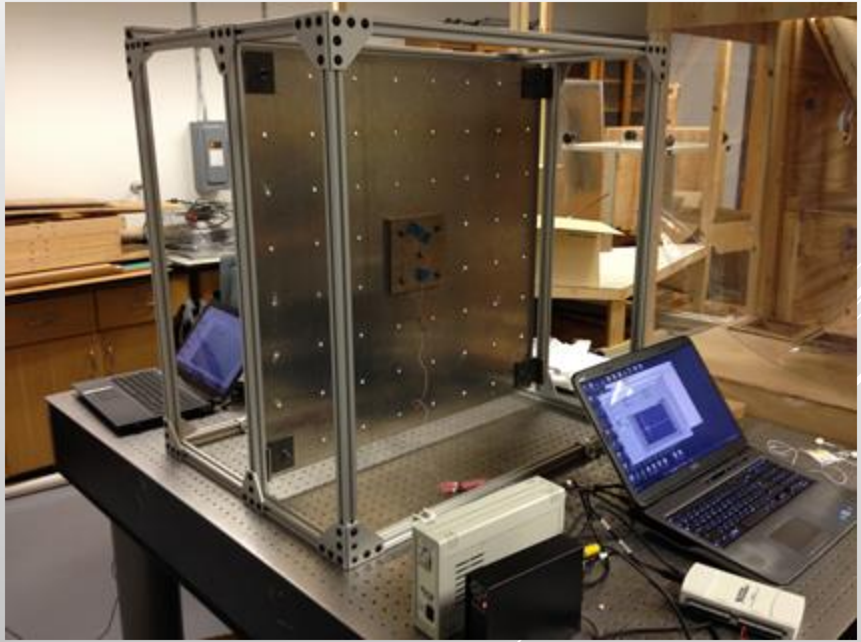


Figure 16: Test Apparatus and Equipment

DECOUPLING PROPOSALS

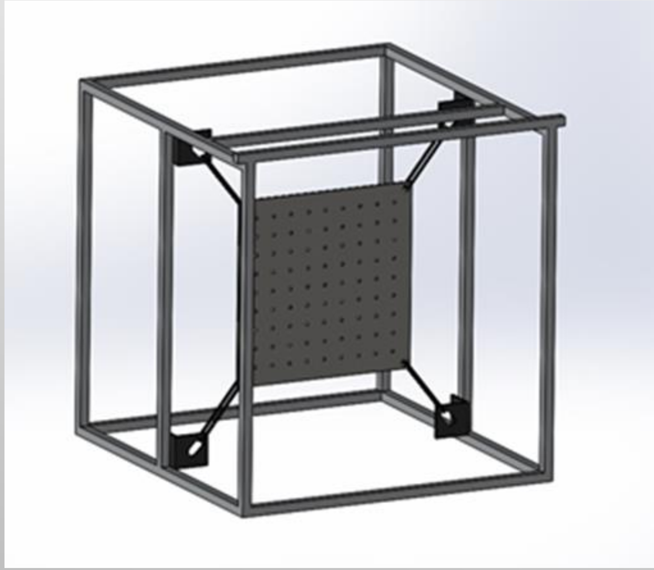


Figure 17: Tethered Suspension Design

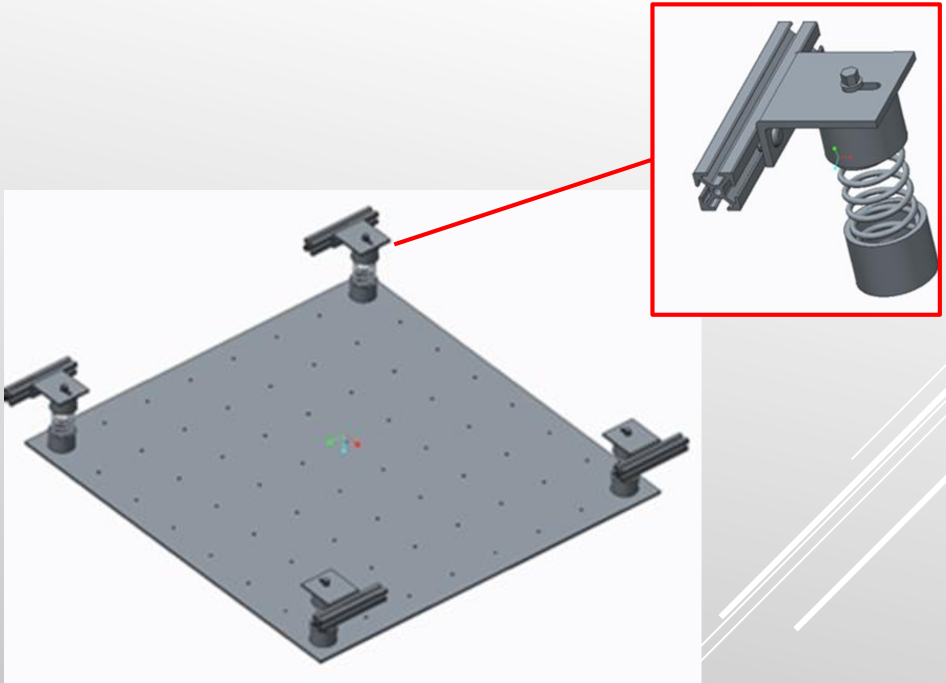


Figure 18: Spring Suspension Design

DATA COLLECTION

- Initial runs more successful than anticipated
- Repeatability good enough to reconsider decoupling

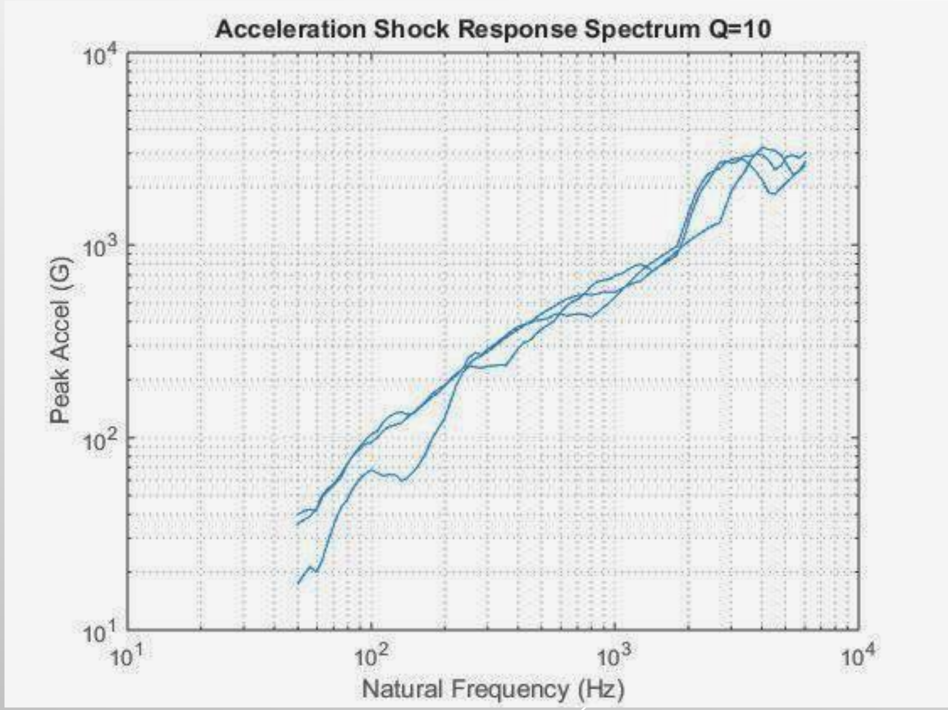


Figure 19: Initial Test Runs

DECOUPLING

- Rubber pads between plate and L bracket improve repeatability.

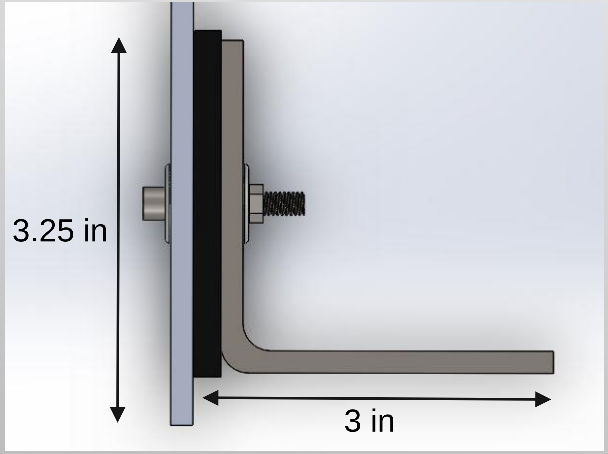


Figure 20: Simple CAD Model of Rubber Dampening

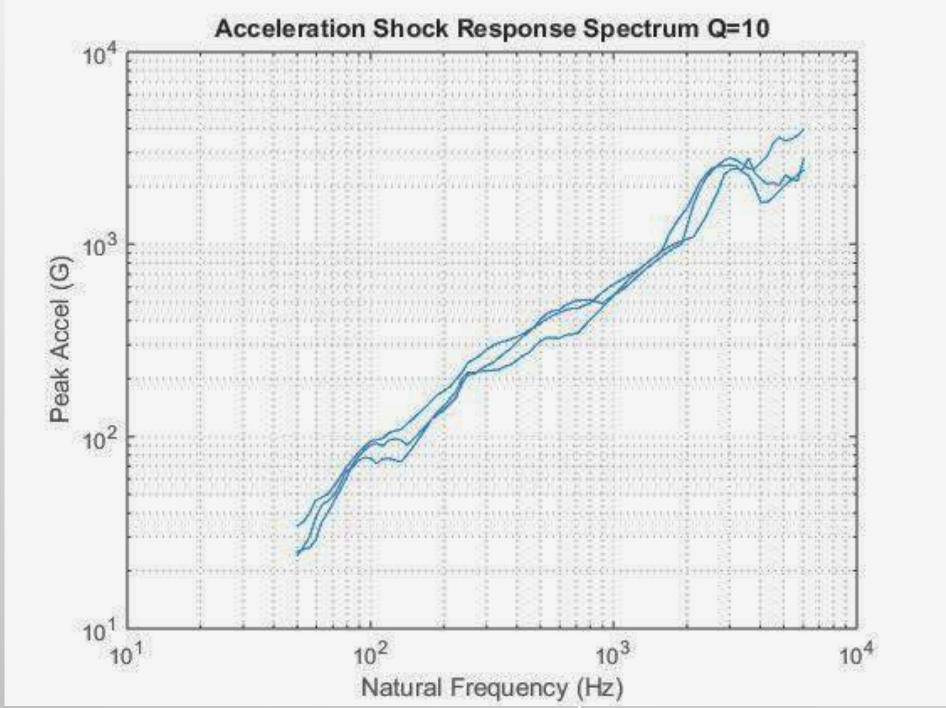


Figure 21: Damping Test Runs

DATA COLLECTION

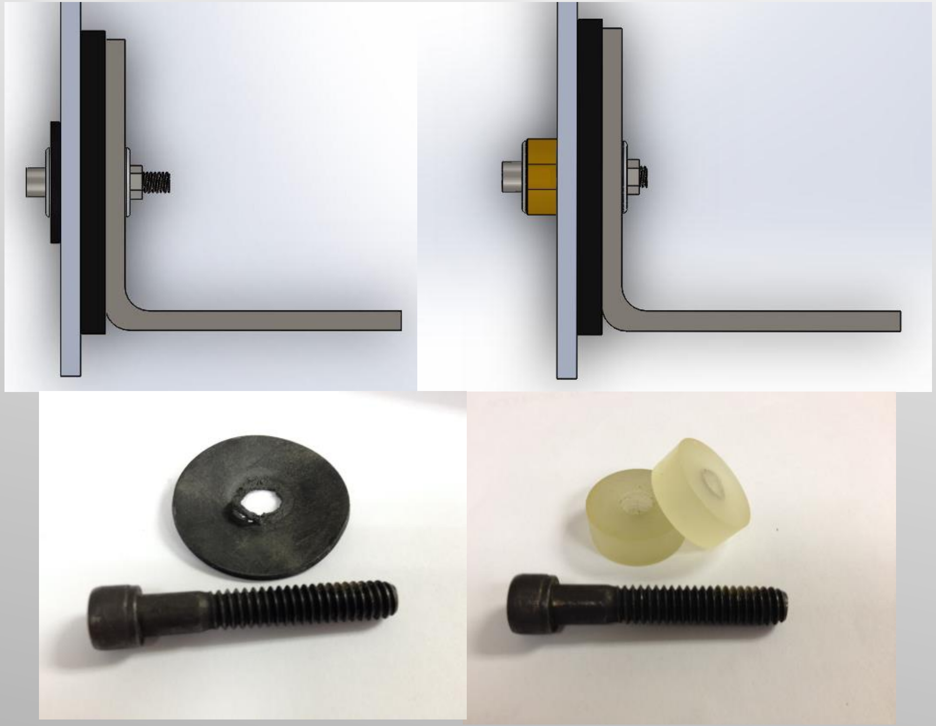


Figure 22: Rubber Dampers

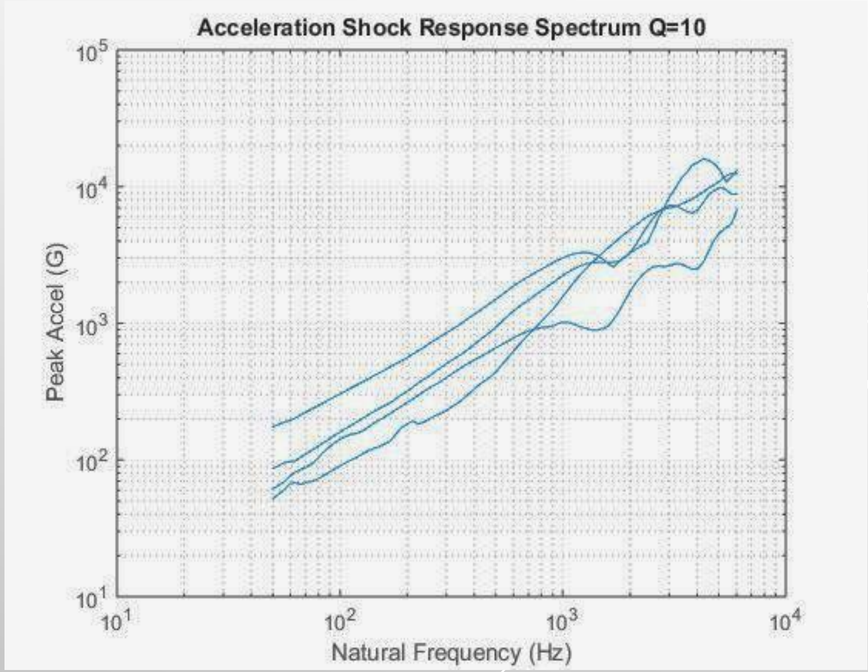


Figure 23: Damping Test Runs

DATA COLLECTION

- Getting second disturbance which we would like to eliminate
- Most likely caused by the sacrificial plate rebounding

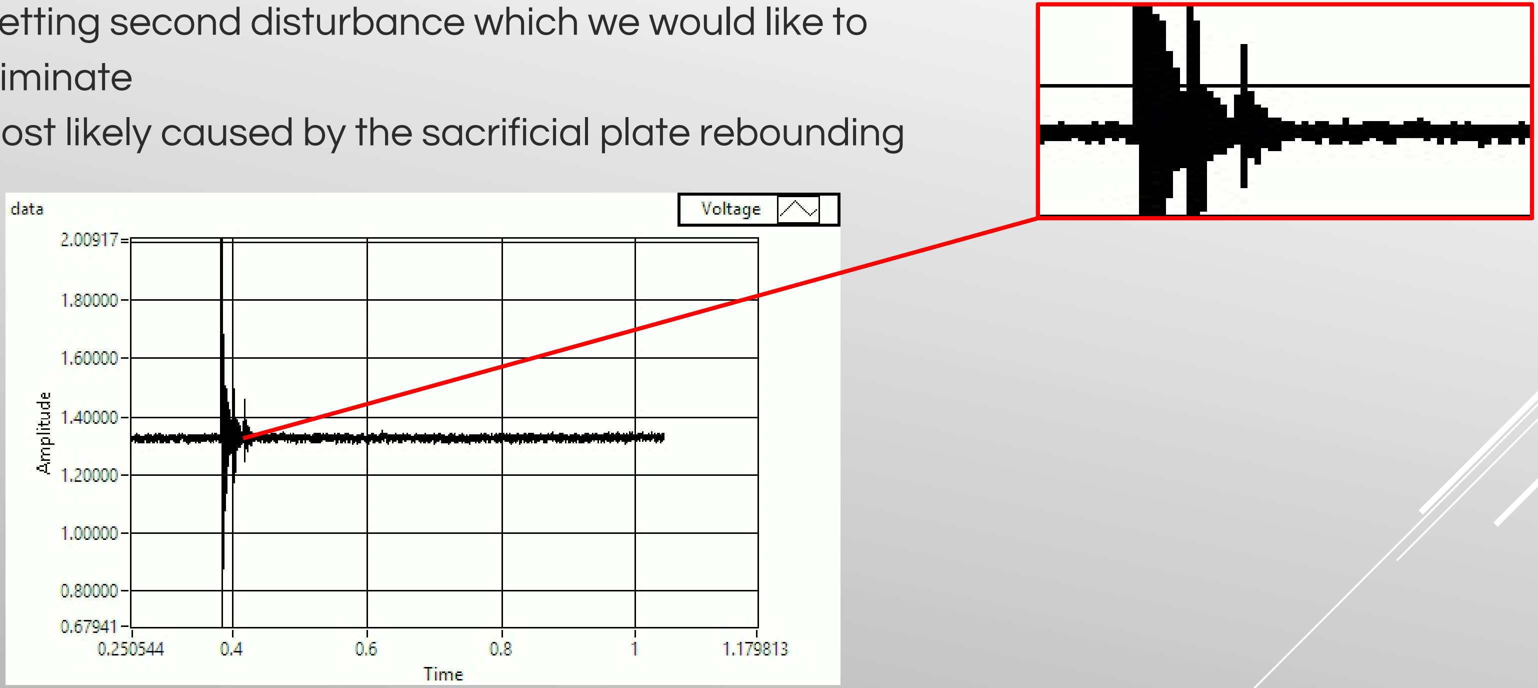


Figure 24: Raw Data with Disturbance

DATA COLLECTION

- Began testing different lubricants (Oil, Grease, Vaseline). Amplitude and shape of SRS changed.
- Very messy and time consuming process.
- Ran test without sacrificial plate and secondary spike still occurred.
- Unknown source that does not affect SRS directly.

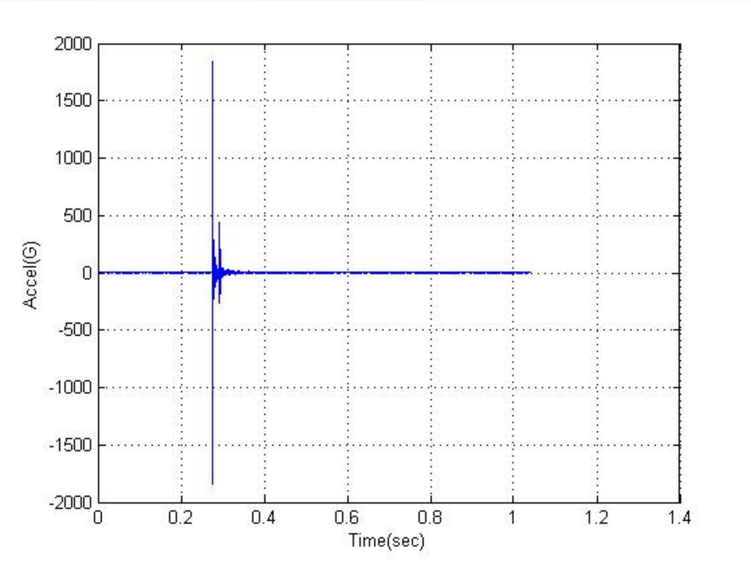


Figure 25: Disturbance without Sacrificial Plate

DATA COLLECTION

- Variability source - mounting bolts of plates and frame
- Removed all remnants of lubricants
- Conducted group of experiments in which every nut and bolt was tightened between each run

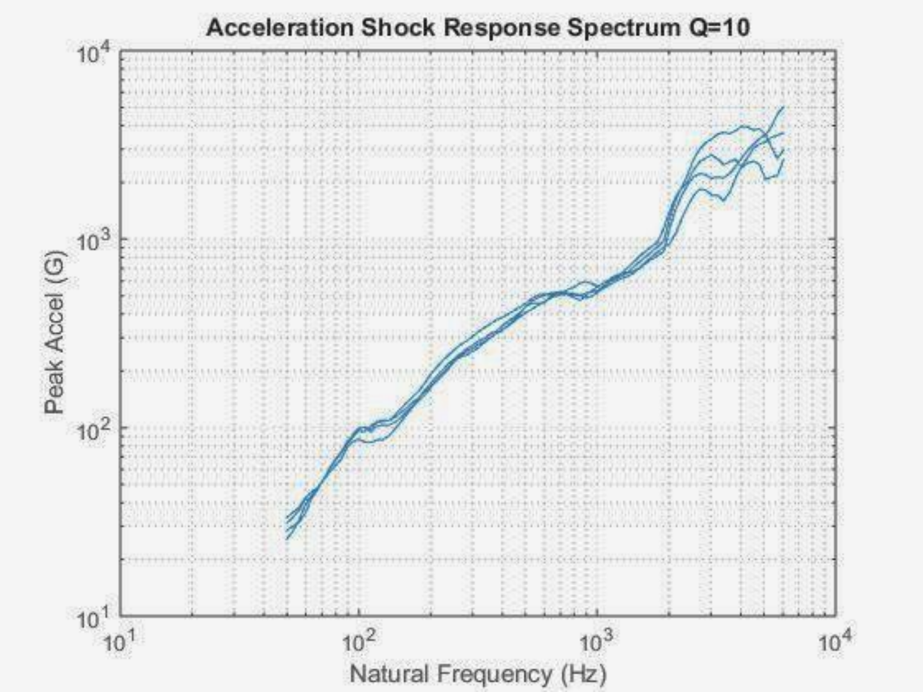


Figure 26: Bolt Adjustment Test Runs

HARRIS®

FUTURE PLANNING

- A torque wrench has been purchased in order to ensure consistency in mounting bolts.
- Quick release planned to be replaced by electromagnetic to ensure consistency in release.

Figure 27: Torque Wrench and Electromagnet

PLANS FOR THE FUTURE

- Design of Experiments to understand what variables affect specific parts of SRS curves

Variables	Locations	Trial Count
Strike Location	9	5 per location
Sensor Location	9	5 per location

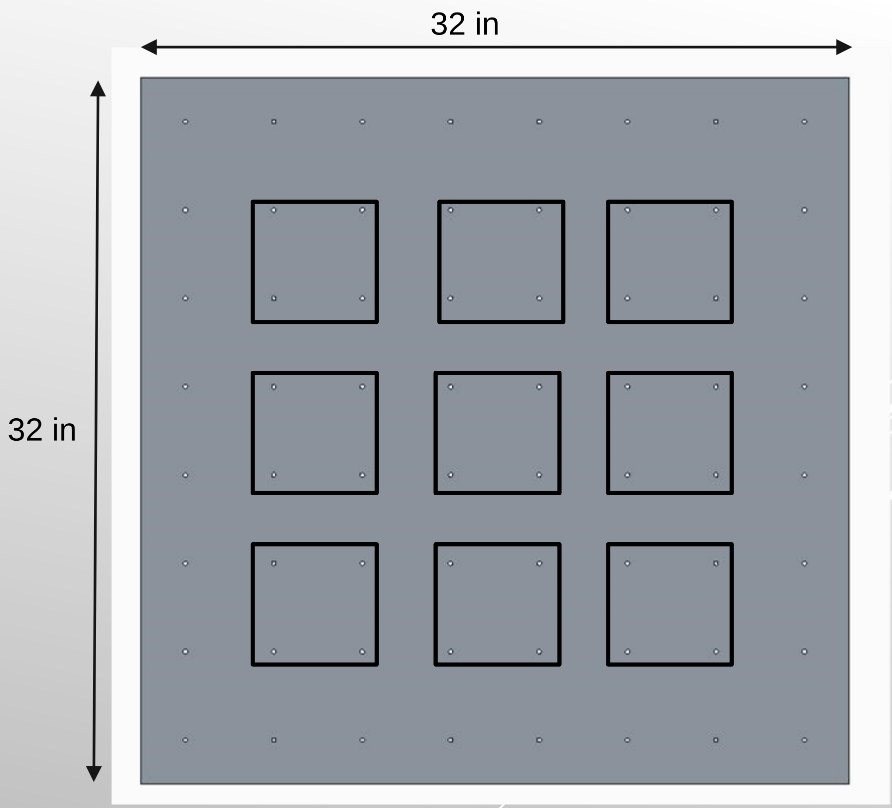


Figure 28: Test Plate Showing Variable Locations

PLANS FOR THE FUTURE

- Individual testing of each variable to determine effects of each variable on curves
- Analyze trends in data
- Repeat tests with both variables changing locations based on concluded trends

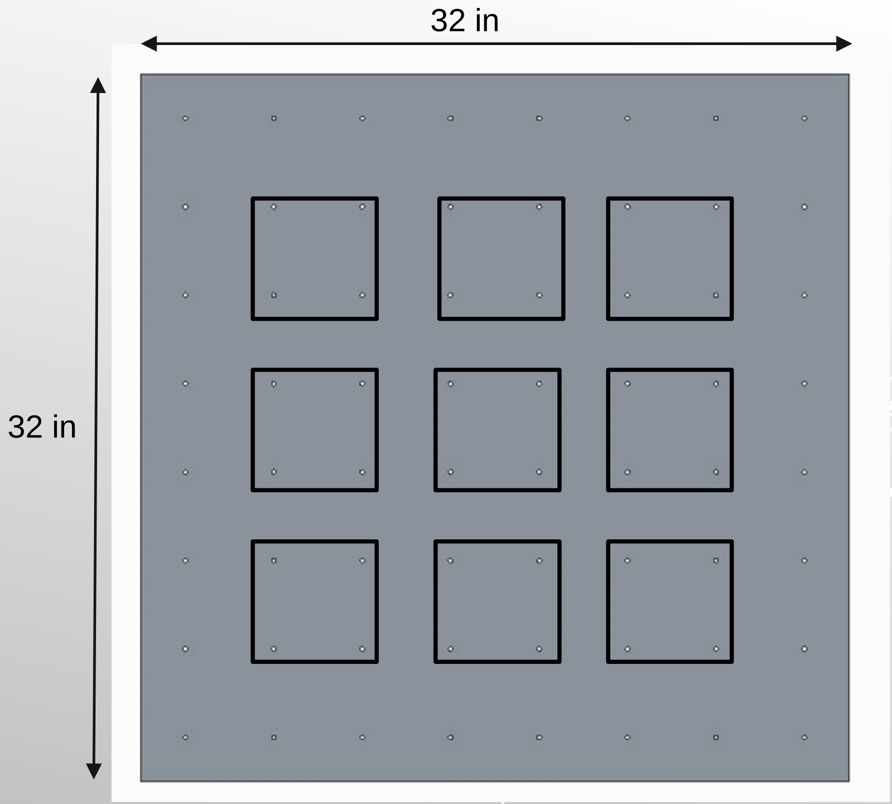
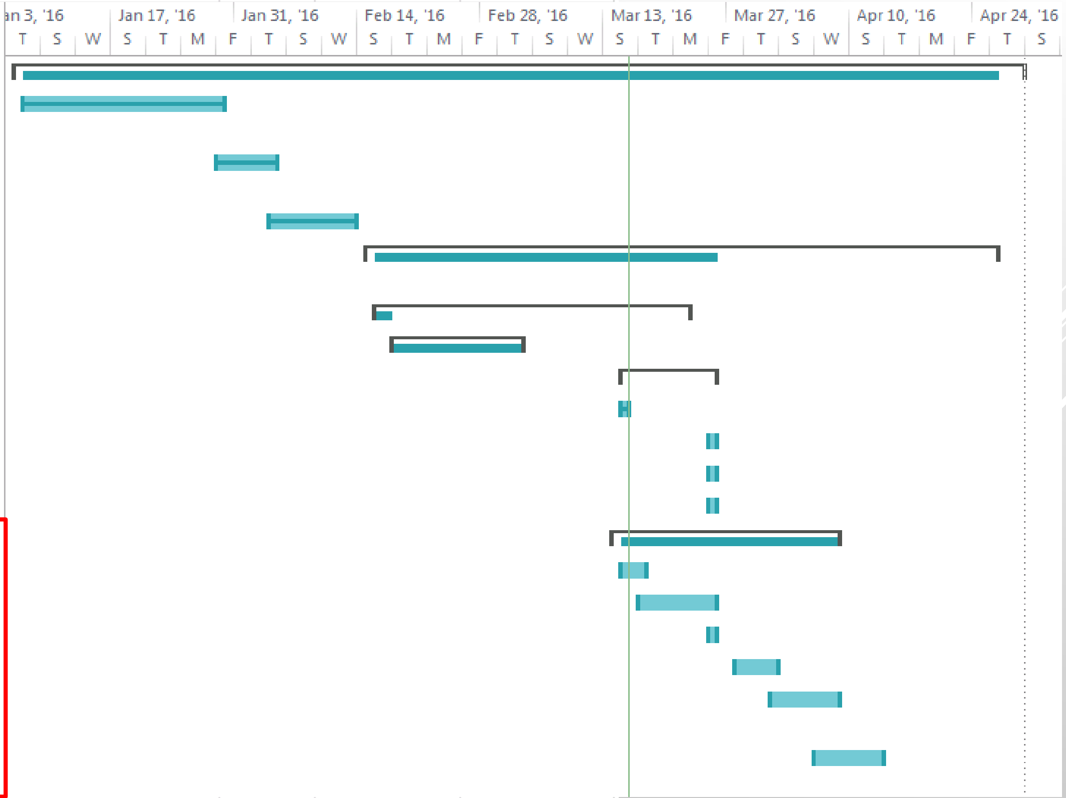


Figure 29: Test Plate Showing Variable Locations

GANTT CHART

Task Mode	Name	Duration	Start	Finish
	Fall Semester	**74 days**	**Tue 9/1/15**	**Fri 12/11/15**
✓	Background Research	29 days	Tue 9/1/15	Fri 10/9/15
✓	**Initial Repeatability Improvements**	**41 days**	**Fri 10/9/15**	**Fri 12/4/15**
✓	Anchored Testing- no data	4 days	Mon 11/16/15	Thu 11/19/15
✓	New Pivot Testing- no data	3 days	Thu 11/19/15	Sat 11/21/15

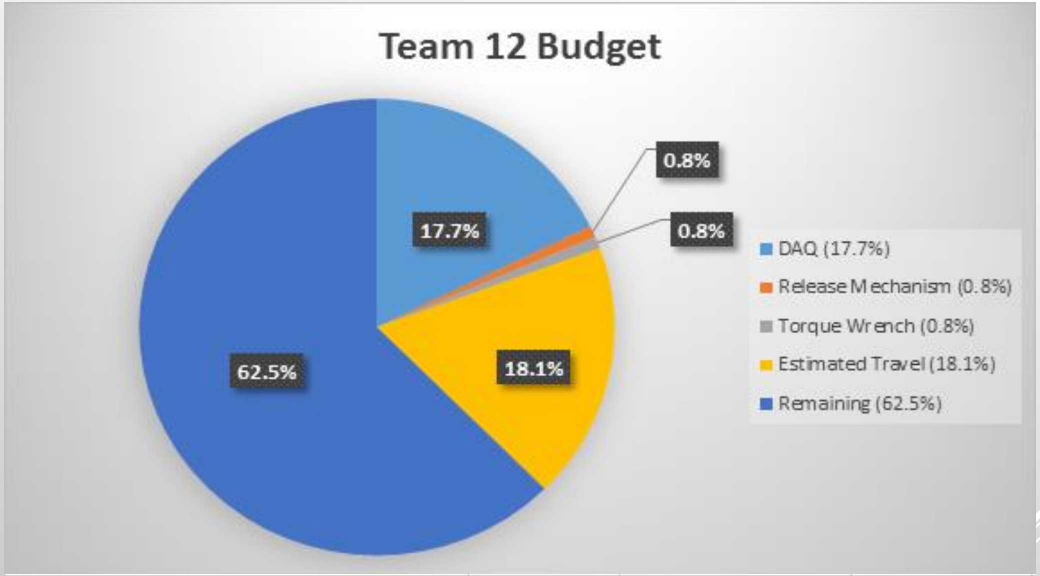
	Task Name	Duration	Start	Finish
	Spring Semester	**83 days**	**Wed 1/6/16**	**Fri 4/29/16**
✓	SRS and Analysis- Baseline	17 days	Thu 1/7/16	Fri 1/29/16
✓	Brainstorming Noise in Data	5 days	Fri 1/29/16	Thu 2/4/16
✓	Eliminate Noise	8 days	Thu 2/4/16	Sat 2/13/16
	Secondary Changes- Repeatability	**52 days**	**Mon 2/15/16**	**Tue 4/26/16**
✓	**Decoupling**	**26 days**	**Tue 2/16/16**	**Tue 3/22/16**
✓	**Sacrificial Plate**	**11 days**	**Thu 2/18/16**	**Thu 3/3/16**
	Release Mechanism	**9 days**	**Tue 3/15/16**	**Fri 3/25/16**
✓	Order Parts	1 day	Tue 3/15/16	Tue 3/15/16
	Assemble	1 day	Fri 3/25/16	Fri 3/25/16
	Testing	1 day	Fri 3/25/16	Fri 3/25/16
	SRS and Analysis	1 day	Fri 3/25/16	Fri 3/25/16
	Design of Experiments	**20 days**	**Mon 3/14/1€**	**Fri 4/8/16**
	Design and Confirm	3 days	Tue 3/15/16	Thu 3/17/16
	Run Experiments	7 days	Thu 3/17/16	Fri 3/25/16
	SRS and Analysis	1 day	Fri 3/25/16	Fri 3/25/16
	Draw Conclusions	5 days	Mon 3/28/1€	Fri 4/1/16
	Changes/Reruns (if necessary)	6 days	Fri 4/1/16	Fri 4/8/16
	Finalize/Document all Conclusions	6 days	Wed 4/6/16	Wed 4/13/16



	Draw Conclusions	5 days	Mon 3/28/16	Fri 4/1/16
	Changes/Reruns (if necessary)	6 days	Fri 4/1/16	Fri 4/8/16
	Finalize/Document all Conclusions	6 days	Wed 4/6/16	Wed 4/13/16

FINANCES

- Well within budget provided for this project



Initial Budget (AME): $5000			
Items	**Cost**		**Remaining**
DAQ	$880.00	*bought*	$4,120.00
Quick release (& supplies)	$40.00	*bought*	$4,080.00
Torque Wrench	$42.00	*bought*	$4,038.00
Travel to Harris	$900.00	*estimated*	**$3,138.00**

Figure 30: Budget Breakdown

QUESTIONS?

REFERENCES

"Pyro Shock Testing." Pyroshock Testing Simulation & Techniques. National Technical Systems, Inc., 2015. Web. 27 Oct. 2015. <https://www.nts.com/services/dynamics/shock/pyro_shock>.

DeMartino, Charles, Nathan Crisler, Chase Mitchell, and Chad Harrell. Pyrotechnic Shock Test Development - Midterm II Presentation Tech. no. 1. Tallahassee: FAMU-FSU College of Engineering, 2014.

Wells, Robert. "Conference Call with Mr. Wells, Mrs. Cooper, and Mr Cornejo." Teleconference interview. 12 Nov. 2015.