PYROTECHNIC SHOCK SIMULATION

MIDTERM II PRESENTATION

11/19/15

Sponsored by: Robert Wells, Harris Corporation

Advisor: Dr. Kumar

Instructors: Dr. Gupta & Dr. Shih

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

PRESENTATION OVERVIEW

- Project Background
- Project Scope
- Previous Year's Results
- Goals
- Progress
- Immediate Plans for the Future
- Long Term Plans for the Future
- Conclusion
- References

PROJECT BACKGROUND

- Pyrotechnics are used for tasks such as rocket separation, pilot ejection, airbag inflation, and payload deployment
- Can be damaging to electronic hardware
- Not easy to simulate
    - High Frequency
    - High Acceleration
    - Short Duration
    - Transient Response
- Difficult to computationally model
- Discrepancies in drop tests (tendency to overestimate damage)

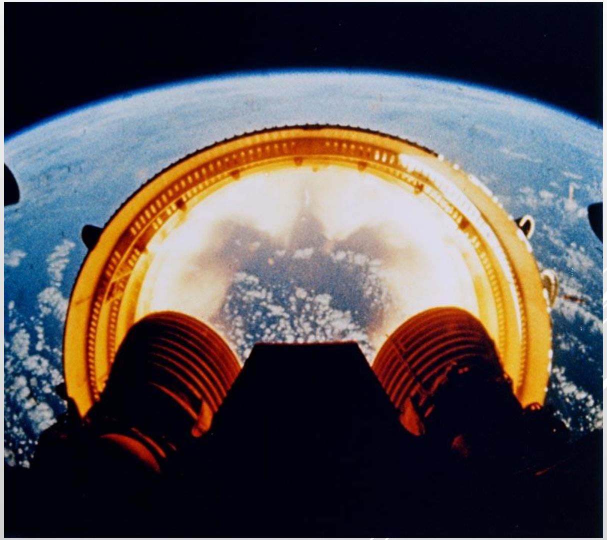


Figure 1: Rocket Separation

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

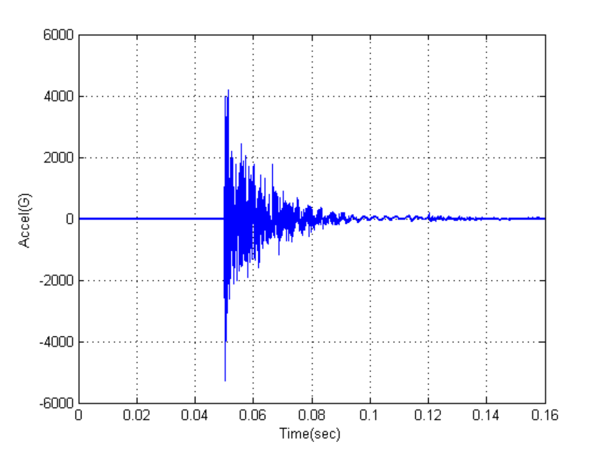


Figure 2: Example shock response curve in the time domain

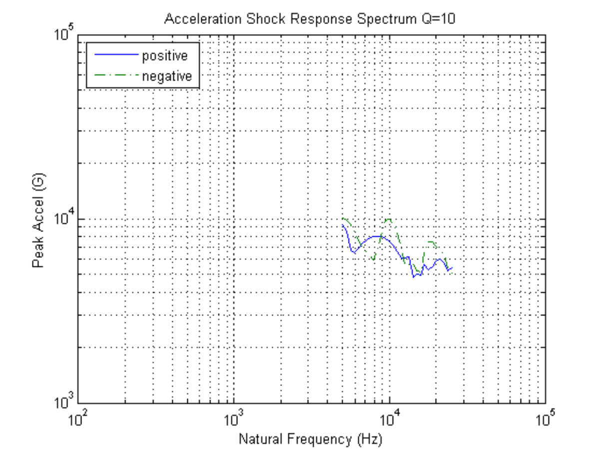


Figure 3: Example SRS curve in the frequency domain

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

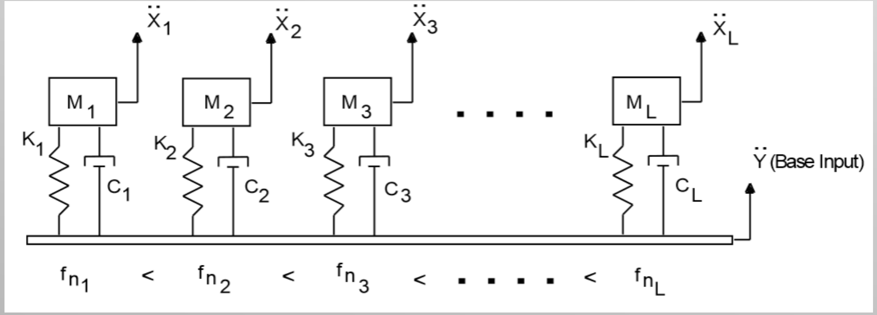


Figure 4: Array of SDOF systems with every possible natural frequency

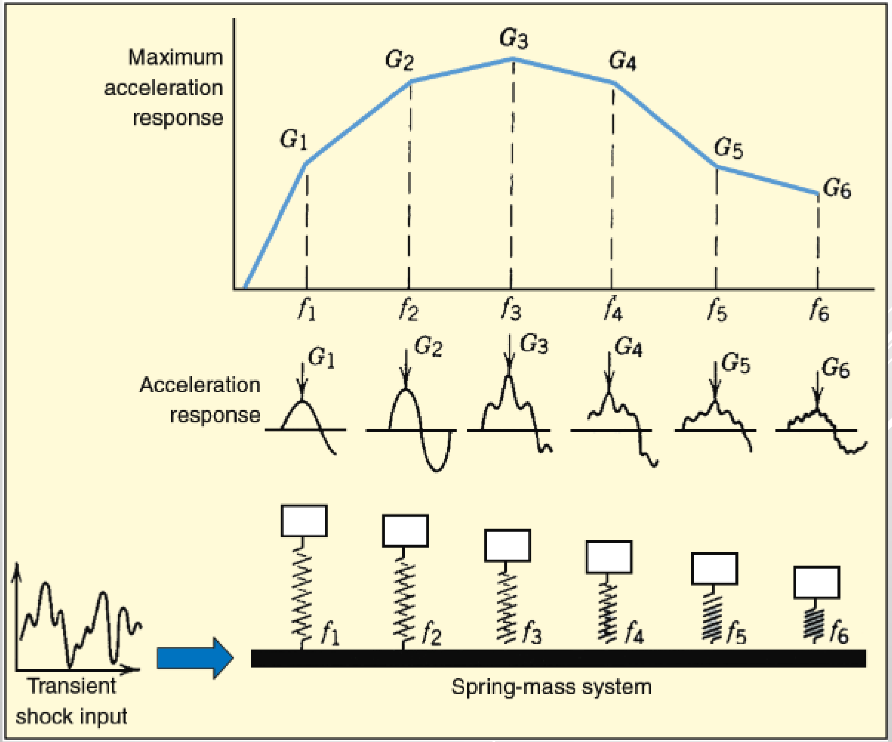


Figure 5: How SRS curves are generated

PROJECT BACKGROUND

Figure 6: Complex physical systems undergoing pyroshock; interests lies in understanding how electronics and their housings respond to high-acceleration, low-duration shock

- The short duration of pyrotechnique shock allows one to characterize the shock by the maximum response on the SDOF systems
- This allows researchers to design housings for sensitive electronics that can mitigate the shock response at various frequencies
- In simulating pyroshock, developing relationships between various system parameters (e.g. material, stiffening rods, etc.) to the system’s SRS curves remains an active area of research

PROJECT SCOPE

What does Harris want?

- Currently simulate pyrotechnic shock
- Long, time consuming process
- Aren’t able to change a lot of variables
- Want understanding of how different variables affect SRS

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

  Optimize the test device's stability and repeatability and in turn develop better understanding of relations between various test fixture parameters and resulting SRS curves.
- Project Goals
  - Modify design to create repeatability in results
  - Systemize and correlate variables to specific SRS curve outputs
  - Possibly improve efficiency of data acquisition process

PREVIOUS YEAR'S RESULTS

Designed and Built Test Rig

Figure 7: Test Rig

Designed Data Acquisition System

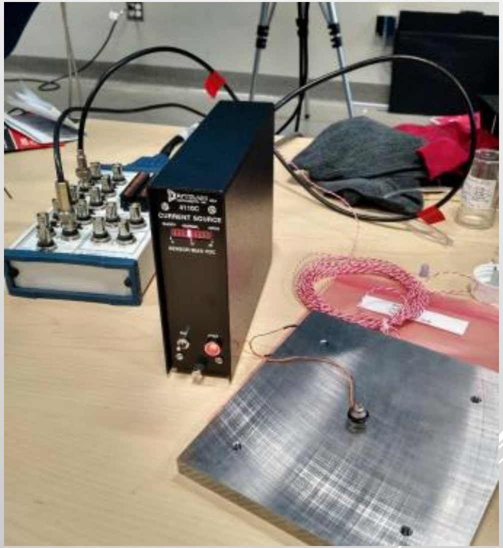
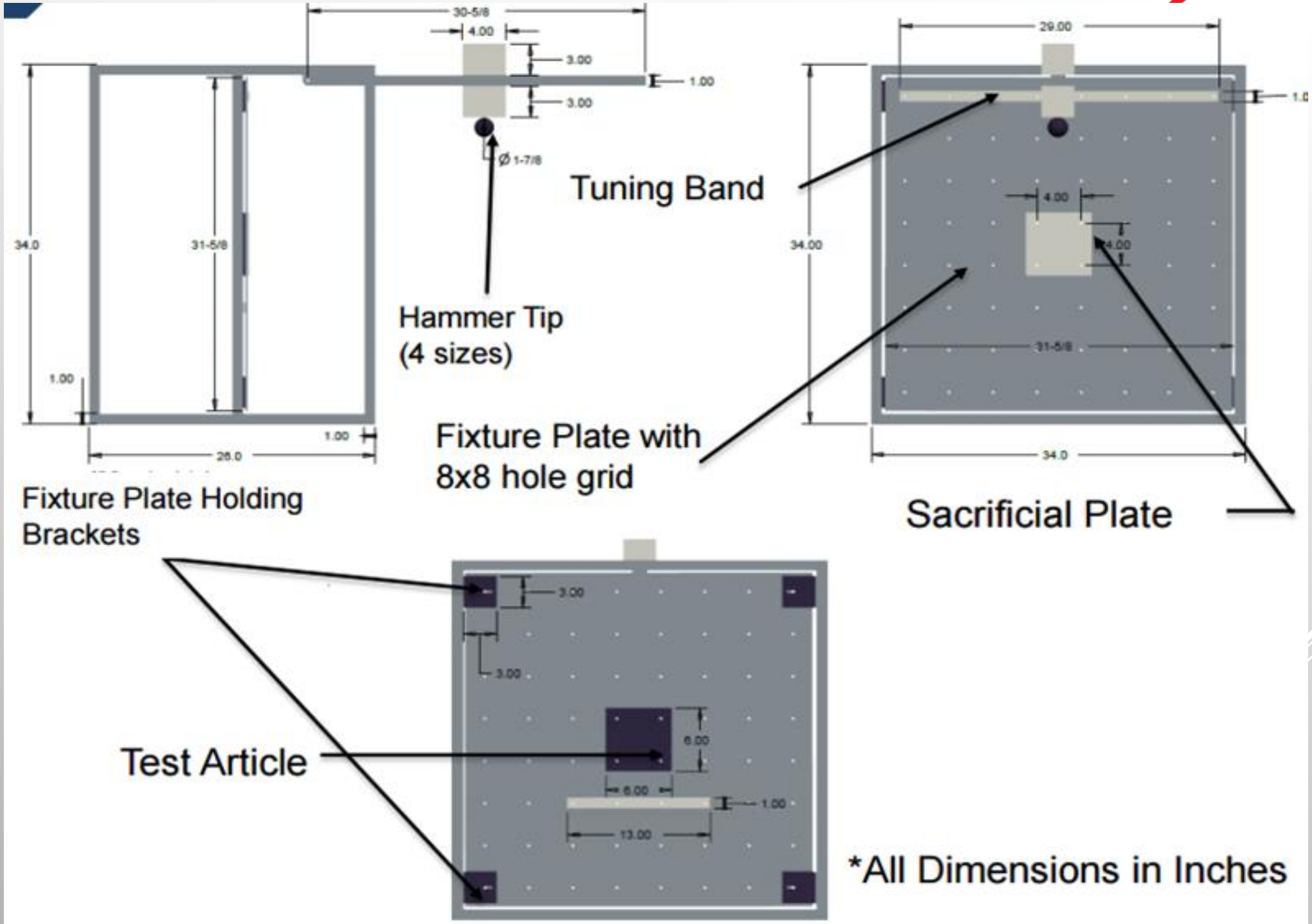


Figure 8: Data Acquisition System

Previous year's device is unable to produce repeatable results!


30-5/8
4.00
3.00
1.00
3.00
Ø 1-7/8
34.0
31-5/8
1.00
1.00
26.0
Tuning Band
Hammer Tip
(4 sizes)
Fixture Plate with
8x8 hole grid
Fixture Plate Holding
Brackets
29.00
34.00
4.00
4.00
31-5/8
34.0
Sacrificial Plate
3.00
3.00
6.00
6.00
1.00
13.00
Test Article
*All Dimensions in Inches

DESIGN IMPLEMENTATIONS

Things to be changed in order to create repeatable data:

- Anchor
- Change pivot
- Decouple from frame
- Sacrificial plate adjustment

PROGRESS - ANCHORING

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

Figure 10: Simulation Table and Mounts

PROGRESS - ANCHORING

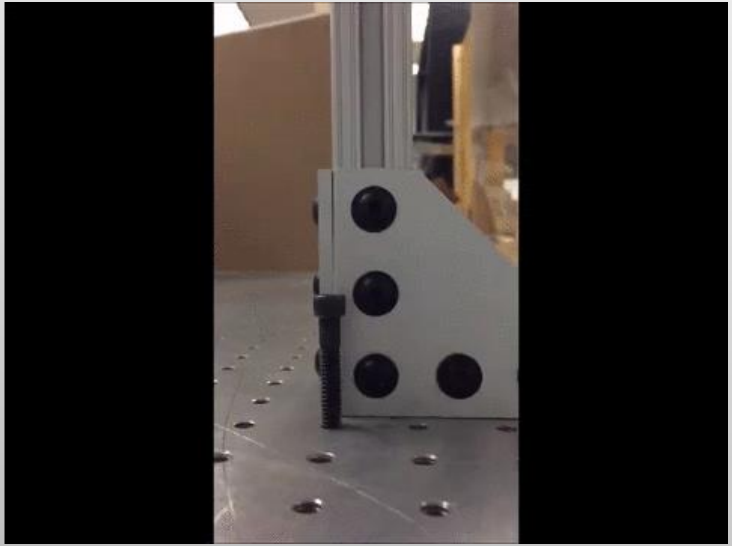


Figure 11: Un-anchored Test

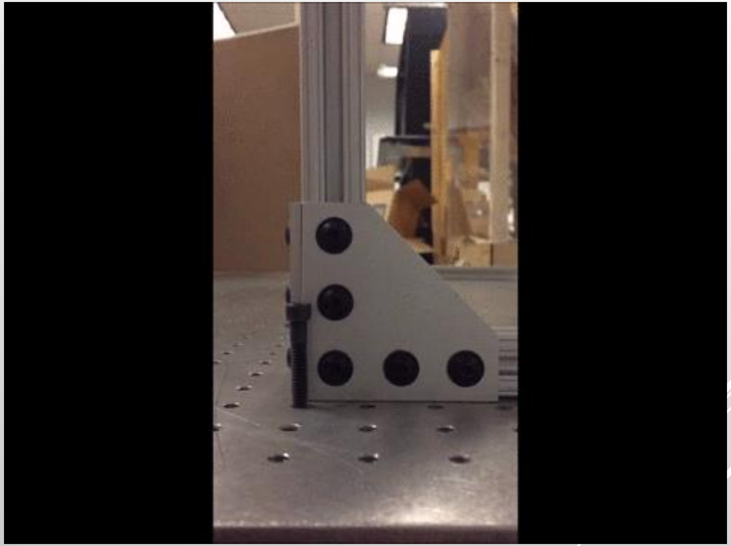


Figure 12: Anchored Test

PROGRESS - PIVOT

- 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

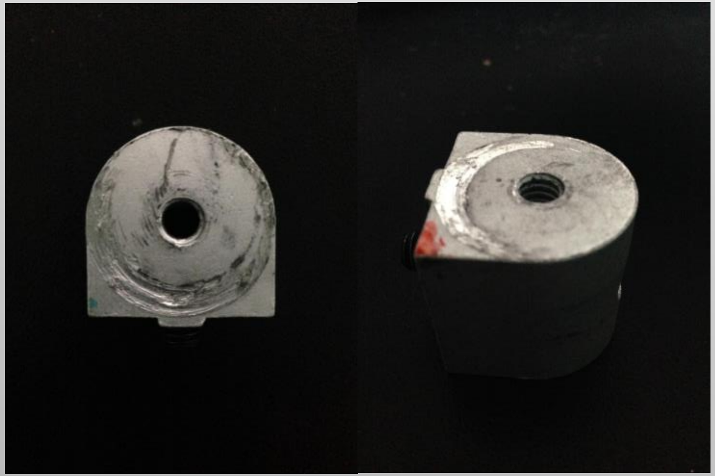


Figure 13: Wear Static Pivot

Figure 14: Dynamic Pivot

PROGRESS - DECOUPLING

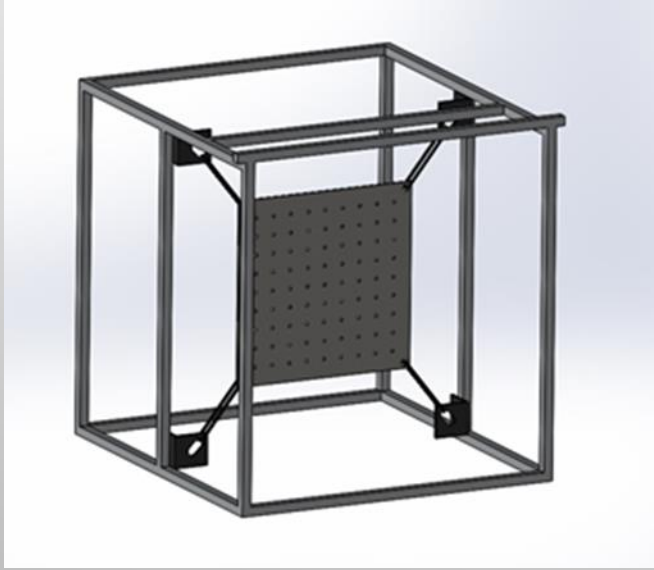


Figure 15: Tethered Suspension Design

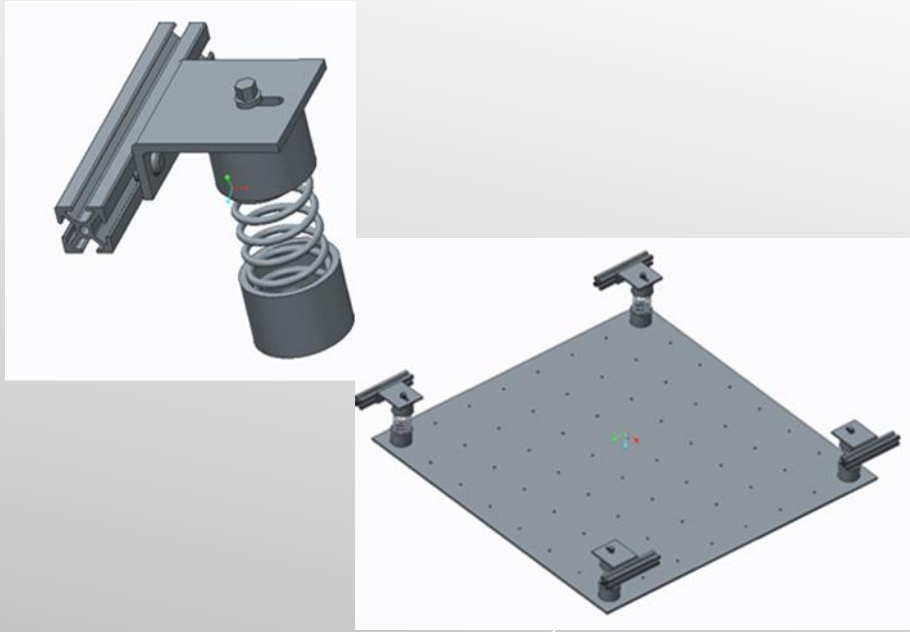


Figure 16: Spring Suspension Design

PROGRESS - DECOUPLING

- Tethered design preferred due to time efficiency low cost and reduced variables to consider.
- Tethered design will include plate with more holes
- Allows for more variability and smaller strike plate

IMMEDIATE PLANS FOR THE FUTURE

- Acquire DAQ card and computer tower
- Run tests with design modifications to test for repeatable results, possibly take initia look at changing variables and their effect on the SRS curve
- Design and order new test plate to be suspended in frame

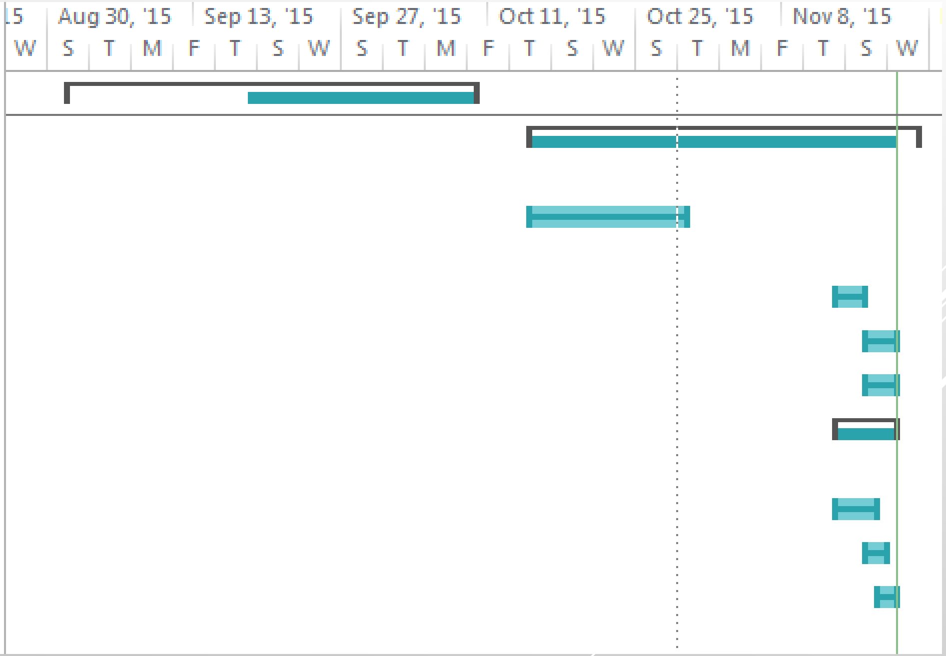
LONG TERM PLANS FOR THE FUTURE

- Continue decoupling plate from frame if unfinished
- Experiment with changing various parameters, collect shock response data, and generate new SRS curves
- Identify how to tune fixture to achieve desired SRS results; this requires an understanding of the relationship between various fixture parameters and the resulting changes in the SRS curves
- Abaqus modeling of stress locations

Figure 16: Current design variations including tuning belts, hammer heads and test plates

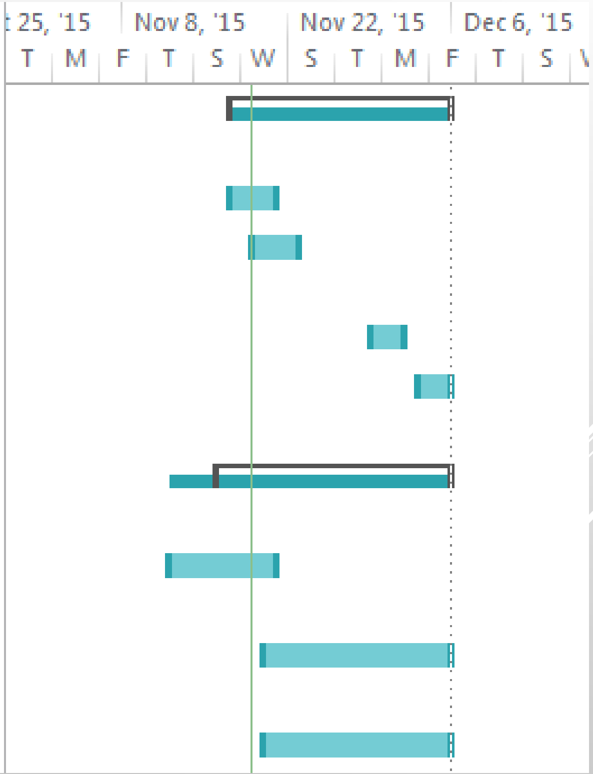
GANTT CHART

	Task Name	Duration	Start	Finish
✓	**Background Research**	**29 days**	**Tue 9/1/15**	**Fri 10/9/15**
✓	**Initial Changes**	**27 days**	**Thu 10/15/15**	**Fri 11/20/15**
✓	Brainstorming Improvements	11 days	Thu 10/15/15	Thu 10/29/15
✓	Baseline Testing	2 days	Fri 11/13/15	Sun 11/15/15
✓	Baseline Analysis	3 days	Mon 11/16/1	Wed 11/18/15
✓	Initial Calculations	3 days	Mon 11/16/1	Wed 11/18/15
✓	**Finalize Initial Changes**	**4 days**	**Fri 11/13/15**	**Wed 11/18/15**
✓	Order/Buy Parts	2 days	Fri 11/13/15	Mon 11/16/15
✓	Adjust Test Device	2 days	Mon 11/16/1	Tue 11/17/15
✓	Testing with Changes	2 days	Tue 11/17/15	Wed 11/18/15



GANTT CHART

Task Name	Duration	Start	Finish
Secondary Changes	**15 days**	**Tue 11/17/15**	**Sat 12/5/15**
Brainstorming/Rese	4 days	Tue 11/17/1	Fri 11/20/15
Bill of Materials/Ordering	3 days	Thu 11/19/15	Sun 11/22/15
Adjusting Device	3 days	Sun 11/29/1	Tue 12/1/15
Testing with Changes	3 days	Thu 12/3/15	Sat 12/5/15
Software and Modeling	**16 days**	**Mon 11/16/15**	**Sat 12/5/15**
Background Research/Understa	7 days	Thu 11/12/15	Fri 11/20/15
Baseline Model Generation	12 days	Fri 11/20/15	Sat 12/5/15
SRS Generation	12 days	Fri 11/20/15	Sat 12/5/15



CONCLUSION

- Pyrotechnic shock is the resulting violent vibrations from controlled explosions.
- When pyrotechnics are used it is important to be sure that the surrounding components, especially electrical, will not fail.
- To be sure of this we simulate the shock with large impact forces and record the accelerations
- They are then plotted against varying natural frequencies in what is called an SRS curve.
- We are charged with the task of testing the numerous variables that effect the SRS curves given a previously designed test rig.
- So far we have modified the design to create stability and eliminated other undesirable variables that are affecting the data.
- Our plans for the future are to create further enhanced repeatabiliy and accuracy and then to collect data which we will use to systemize and correlate variables to specific SRS curve outputs.

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.