PYROTECHNIC SHOCK SIMULATION

Project Plan and Product Specifications

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1 Problem Statement

Harris Corp. has expressed a need for an apparatus enabling an accurate simulation of pyrotechnic shock via a hammer mechanism. The first prototype constructed the previous year – while fulfilling its purpose of gathering information on high load, high frequency shock – yielded noisy data as a result of too many parameters and high tolerances within the structure of the mechanism [1]. A prototype that is more stable and that would yield more repeatable results is desirable.

The current methods for shock testing lack accurate and precise results, as well as repeatability and efficiency.

2 Project Scope

The objective of our team is to improve the existing hammer blow impact test device. The previous team encountered problems with repeatability of the test. Currently, too many variables exist in the device. Unnecessary variables need to be eliminated in order to create an accurate and repeatable test. It needs to be determined whether it is more efficient and beneficial to improve upon the existing design or create a new design. The primary idea for a new design would be a pneumatic hammer device rather than a swinging hammer. Ideas for improvement of the existing device include stiffening the frame and mounts, removing the strike plate from the design, and improve hammer stiffness and release.

3 Project Objectives

Design a testing apparatus and modeling system for Harris Corporation that would accurately and efficiently simulate shock responses.

Objectives [1]:

- Research existing methods for simulating and testing shock responses
- Improve repeatability of last year’s test device
- Improve hammer mechanism stiffness and release from last year’s device
- Evaluate designs to improve attachment of plate to frame
- Optimize processing for modeling SRS curves

- Improve FEM analysis process using results from improved test device
- Reduce set of parameters used for tests from last year
- Perform impact tests with improved device and improved modeling

An additional goal, if time permits, is to work on adding damping effects, more mass, and stiffeners to the fixture plate and analyze these results against the previous ones [1]. Table 1 displays what was specifically provided by Harris.

Table 1- Requirements Provided by Harris for Second Year Project

Requ. #	Category	Description
1	Mechanical	Refine impact test device and fixture plate developed on year 1 project to improve repeatability.
2	Mechanical	Evaluate SRS generation from year 1 project and develop improvements to speed up processing
3	Mechanical	Fabricate design improvements and validate repeatability. Use results to improve FEM analysis process.
4	Mechanical	Perform impact test on fixture under a reduced set of test parameters. Test parameters to be identified by Harris by SDR.
5	Cost	Bill of Materials shall be generated early enough to budget costs for test fixture improvements and any needed instrumentation purchases
6	Mech (stretch goal)	Evaluate ability to tune fixture plate by adding damping, mass, stiffeners. Correlate results to FEM analysis

4 PLAN/METHODOLOGY

Figures 1-3 display the first iteration of the Gantt Chart created to plan the work for this fall semester. The deliverables with a designated due date are marked with a green arrow at the end of their respective timeline bar. Other tasks may change as new developments arise and further progress is made. The chart is organized in a chronological manner, such that most of the tasks need the previous tasks to at least be started beforehand. This was done to simplify the timeline, so multiple arrows stemming from each task would not create a map of arrows.

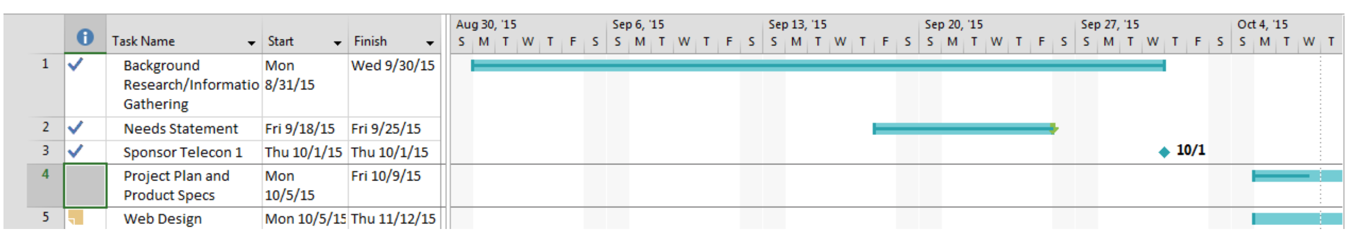


Fig. 1- First part of Gantt Chart for Fall Semester 2015

Fig. 2 - Second Part of Gantt Chart for Fall Semester 2015

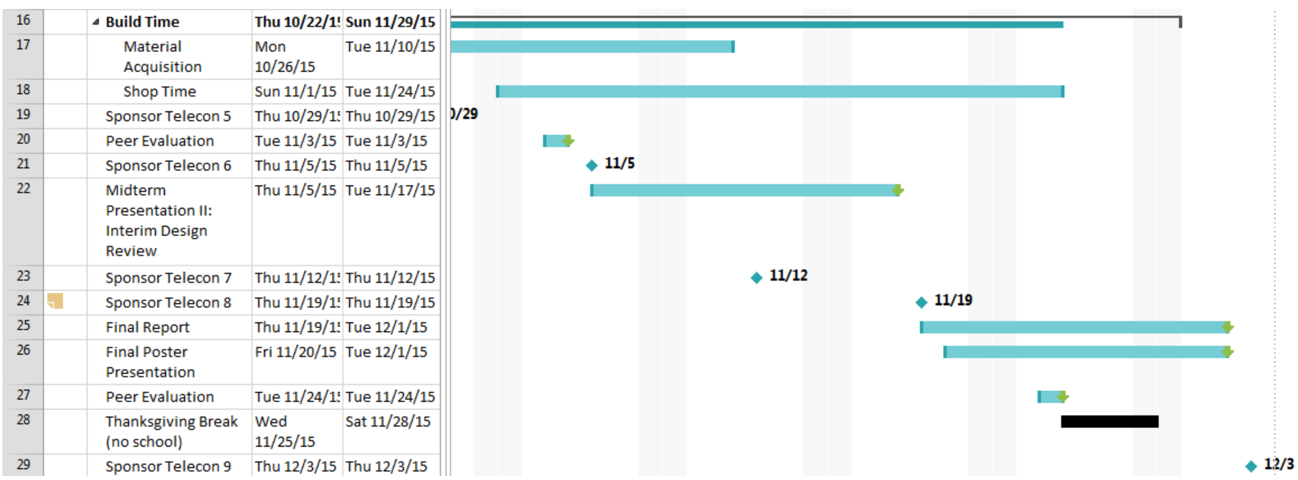
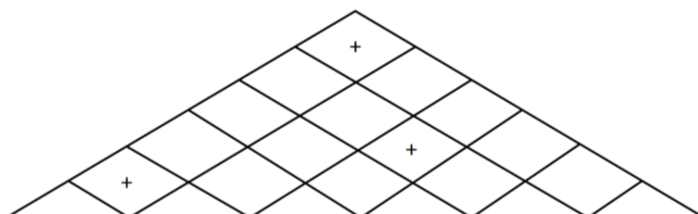


Fig. 3- Third Part of Gantt Chart for Fall Semester 2015

It is also important to see that a couple tasks have notes. For the Web Design task, the time timeline designated for its completion is October 5 to November 12, but there is an initial draft design due October 15 and it is not due until November 24. The note for Sponsor Telecon 8 reminds the team that a pdr for Harris is desired by then, based on Midterm Presentation II and the work leading up to that.

The main task of Initial Designing/Brainstorming includes the subtask of learning more about last year's software and how they generated the SRS curves. Obviously, there is also the need to actually brainstorm solutions for improving the design of the test device to meet the requirements during this task as well. The Final Design Selection task has subtasks that specify material selection and CAD drawings/refinement. After deciding on a final design, it is necessary to know what materials would be best suited for each component and drawings will need to be made, not only for building purposes, but for the shop if machining of anything needs to be done. For Build Time, time designated for material acquisition and shop time are seen. Time for purchasing and ordering parts needs to be accounted for as well as time needed to machine the parts, depending on what the final design requires.

Figure 4 displays a House of Quality (HOQ) made using the customer's requirements and engineering characteristics from Harris. It can be seen that the strike plate connection and the adjustment of the hammer ranked the highest. This figure will play an important role in designing stages.



		Engineering Characteristics						**Comparison**	
Customer's Requirements	**Customer's Importance**	Frame Stiffness	Strike Plate Connection	Hammer Adjustment	SRS Modeling Processes	Swing-arm Connection	Frame Mount	Prototype	Our Goal
Accuracy	4	4	5	4	5	3	2	3	4
Repeatability	5	5	5	5	4	3	3	2	5
Simplicity	4	2	3	3	3	3	2	3	4
Cost	3	2	2	2	1	1	2	4	4
Reliability	2	3	2	3	1	3	3	3	4
∑(CI x EC)		61	67	65	57	48	43		
Relative Weight		17.9%	19.6%	19.1%	16.7%	14.1%	12.6%		
Rank		3	1	2	4	5	6		

Fig. 4- House of Quality

5 CONSTRAINTS

The constraints provided by the sponsor last year continue to affect this year's work. The list of constraints can be seen in Figure 5 [2]. Additionally, there is a monetary constraint of $5000 for the team to use.

Table 1: Requirements and constraints provided by Harris.

Requ. #	Category	Description
1	Mechanical	Test device capable of testing unit up to 50 lbs and 16" L x 16" W x 12" H
2	Mechanical	Generate SRS pyrotechnic shocks of up to 5000 g peak and 10 kHz
3	Mechanical	Develop method to model test system to guide adjustment of test parameters (hammer drop height, air hammer pressure, hammer head shape / material, etc) and sizing / tuning of resonant fixture.
4	Mechanical	Create software tool allowing input of various test and fixture parameters to estimate an SRS response
5	Mechanical	Software tool can be based on analytical methods, experimental methods or a combination of both
6	Mechanical	Build prototype test device and correlate software tool to generate a specific SRS with shock test results
7	Cost	Bill of Materials shall be generated early enough to determine level of detail to be built given the limited budget

Fig. 5 - Table of Constraints Provided by Harris for Senior Design Team 15.

6 Resource Assignment

All deliverables and reports will be worked on as a team. Sarah and Luis will be heading the design improvements. As financial advisor, Justin will deal with most tasks handling buying and ordering of materials. Max will be the main communication head with the sponsor and keeper of the website. Tiffany will keep track of scheduling and updating tasks as they arise.

7 Product Specifications

7.1 Performance Specifications

The performance specifications are a much more clear set of objectives. Regardless of what the final design of the apparatus is used, many things must be accomplished by the test. It must be able to create and then model in software a maximum level, matching SRS curves on a consistent basis. In addition, it must be able to do so for different masses without losing accuracy or precision. It must save the time previously spent in trial and error by providing modeling software that controls the test parameters. The frequency range must stay in the resolution set by company standards, and by extension, NASA and military standards. The information must displayed in a software that can be accessed by the company to perform analysis reliably. The apparatus will be improved in stages in order to obtain more consistent data. As of now, the design yields inconsistent and sometimes inaccurate data, and this will be fixed with various design changes to the testing apparatus. In order to provide a viable solution for Harris Corp., these conditions will at the very least have to be maintained to preserve the integrity of the testing and subsequent data analysis.

7.2 DESIGN SPECIFICATIONS

In order for this hammer blow test to be of use to Harris Corp., it must allow for repeatable events. This means that when the test object is subject to the simulated pyrotechnic shock or hammer blow and the subsequent SRS is generated, when the same conditions are met and the test is repeated, a similar SRS should be created. The purpose of the hammer blow test is to predict the behavior of particular shocks and their consequences on specific hardware, however if the test cannot generate the same results under the same conditions then the test is not valuable. This is why our design will focus on anchoring the mechanism to ground and preventing unwanted variables from affecting the test rig. By cultivating the model's sturdiness, we hope to consequently improve the repeatability of the test. After this customer requirement is met then we will continue to refine the prototype by including mechanisms that would widen the range of experiments that could be carried out. For this reason many of the design specifications that may account for welcomed experimental variability and freedom are hard to define at the moment.

After reviewing with our mentor about the specific needs of the hammer blow test, we have agreed upon some quantitative conditions. The test rig must be able to test a plate of 16''L x 16'' W with weight of 5-50lbs. In regards to improving the previous design, the massive amount of friction as it pertains to the pendulum hammer will be minimized as well as the friction and vibrations that resonate throughout the frame. The quick release mechanism which was previously a pin and socket will be replaced possible with a magnetic design. Also the methods of damping the strike plate will be further explored and optimized to create isolated shocks. There is no specified size for the overall machine so we will continue valuing the sturdiness of the design over optimization for compactness. The design must also include accessible ports for the data acquisition sensors. Furthermore we will be utilizing the software designed by the previous Harris design team which generates SRS curves however there will be time spent refining this software with the aim of making the analysis process more efficient and precise. Lastly, to insure the simulated shocks are as close to real pyrotechnic impacts, at least half of the SRS magnitudes maximum must be greater than the nominal test specification.

8 REFERENCES

1. Wells, Robert. “University Capstone: Development of Hammer Blow Test Device to Simulate Pyrotechnic Shock (Second Year Project).” 14 Aug. 2015.

2. DeMartino, Charles, Chad Harrell, Chase Mitchell, and Nathan Crisler. *Development of Hammer Blow Test Device to Simulate Pyrotechnic Shock.* Senior Design Team 15. 10 Apr. 2015. Web. 21 Sept. 2015. <http://eng.fsu.edu/me/senior_design/2015/team15/NeedsAssessment.pdf>.