Element I – Score 4
Auto Visor Project

This entry received a score of 4 independently from two expert raters based on the EDPPSR. The designers tested opening and closing time, two major design requirements ("the major area of concern regarding the functionality of our prototype was the meshing of the gears as well as the open and close time"). The data collection and tests are reasonable based on physical and mathematical modeling, although human factors (fogging, for example) were not explained. Force was modeled effectively. Although a few of the initial figures were not explained, most were connected to and elaborated upon in the text portion of the entry. Overall, the entry was well supported by visuals in the form of figures and data displays. The entry provides evidence of data collection and analysis, and includes statements about impacts.

Engineering Design Process Portfolio Scoring Rubric
Component and Element Titles

Component I: Presenting and Justifying a Problem and Solution Requirements
- Element A: Presentation and justification of the problem
- Element B. Documentation and analysis of prior solution attempts
- Element C. Presentation and justification of solution design requirements

Component II: Generating and Defending an Original Solution
- Element D: Design concept generation, analysis, and selection
- Element E: Application of STEM principles and practices
- Element F: Consideration of design viability

Component III: Constructing and Testing a Prototype
- Element G: Construction of a testable prototype
- Element H: Prototype testing and data collection plan
- **Element I: Testing, data collection and analysis**

Component IV: Evaluation, Reflection, and Recommendations
- Element J: Documentation of external evaluation
- *Element K: Reflection on the design project*
- Element L: Presentation of designer's recommendations

Component V: Documenting and Presenting the Project
- Element M: Presentation of the project portfolio
- Element N: Writing like an Engineer

Please Note: Elements M and N require no submission from the portfolio author(s) and are intended to be scored based on the portfolio work as a whole from what has been submitted from Elements A through L

Element I: Testing, data collection and analysis

5 Through the conduct of several tests for high priority requirements that are reasonable based on instructional contexts, or through physical or mathematical modeling, the student demonstrates considerable understanding of testing procedure, including the gathering and analysis of resultant data; the analysis of the effectiveness with which the design met stated goals includes a consistently detailed explanation [and summary] of the data from each portion of the testing procedure and from expert reviews, generously supported by pictures, graphs, charts and other visuals; the analysis includes an overall summary of the implications of all data for proceeding with the design and solving the problem.

4 Through the conduct of several tests for high priority requirements that are reasonable based on instructional contexts, or through physical or mathematical modeling, the student demonstrates ample understanding of testing procedure, including the gathering and analysis of resultant data; the analysis of the effectiveness with which the design met stated goals includes a generally detailed explanation [and summary] of the data from each portion of the testing procedure and from expert reviews, generally supported by pictures, graphs, charts and other visuals; the analysis includes an overall summary of the implications of most if not all of the data for proceeding with the design and solving the problem.

3 Through the conduct of a few tests for high priority requirements that are reasonable based on instructional contexts, or through physical or mathematical modeling, the student demonstrates adequate understanding of testing procedure, including the gathering and analysis of resultant data; the analysis of the effectiveness with which the design met stated goals includes a somewhat detailed explanation [and summary] of the data from each portion of the testing procedure and from expert reviews, at least somewhat supported by pictures, graphs, charts and other visuals; the analysis includes a summary of the implications of at least some of the data for proceeding with the design and solving the problem.

2 Through the conduct of one or two tests for high priority requirements that are reasonable based on instructional contexts, or through physical or mathematical modeling, the student demonstrates partial or overly general understanding of testing procedure, including the gathering and analysis of resultant data; the analysis of the effectiveness with which the design met stated goals includes a partial explanation [and summary] of the data (partially complete and/or partially correct), at least minimally supported by pictures, graphs, charts and other visuals; the analysis includes a partial and/or overly-general summary of the implications of at least some of the data for proceeding with the design and solving the problem.

1 Through the conduct of one or two tests for requirements (which may or may not be high priority) that are reasonable based on instructional contexts, or through physical or mathematical modeling, the student demonstrates minimal understanding of testing procedure, including the gathering and analysis of resultant data; the analysis of the effectiveness with which the design met stated goals includes an attempted explanation [and summary] of the data but may not be supported by any pictures, graphs, charts or other visuals; the analysis may be missing even a partial and/or overly-general summary of the implications of any of the data for proceeding with the design and solving the problem.

0 Any test(s) for requirement(s) or attempts at physical or mathematical modeling fail to demonstrate even minimal understanding of testing procedure, including the gathering and analysis of resultant data; OR there is no evidence of testing or physical or mathematical modeling to address any requirements.

Element I Reflective questions;
_ What did I/we learn from testing about how well this design met the stated design requirements?
_ Why should others believe my/our analysis of the data?

PROTOTYPE ANALYSIS

FORCE TRANSMISSION STUDY

One aspect of the MotoVisor prototype that was especially was the misalignment of the gears. As torque is applied by the motor, the gears, servo, and visor deflect. This creates a compliance issue. If the deflection is too great, the gears will become misaligned to the point where they start hopping teeth. So, a transmission housing was designed in order to reduce deflection. The shafts that the gears ride on are loaded in tree point bending in this configuration as opposed to being cantilevered.

In order to quantify deflection, a force transmission study was performed using ANSYS Static Structural FEA. The load case included a 30in-Lb load from the visor, corresponding to the maximum torque supplied by the servo and a fixture where the mounting bracket is attached to the helmet.

Although engineering judgment tells me that stress should not be an issue in this assembly, Von Mises stress was measured.

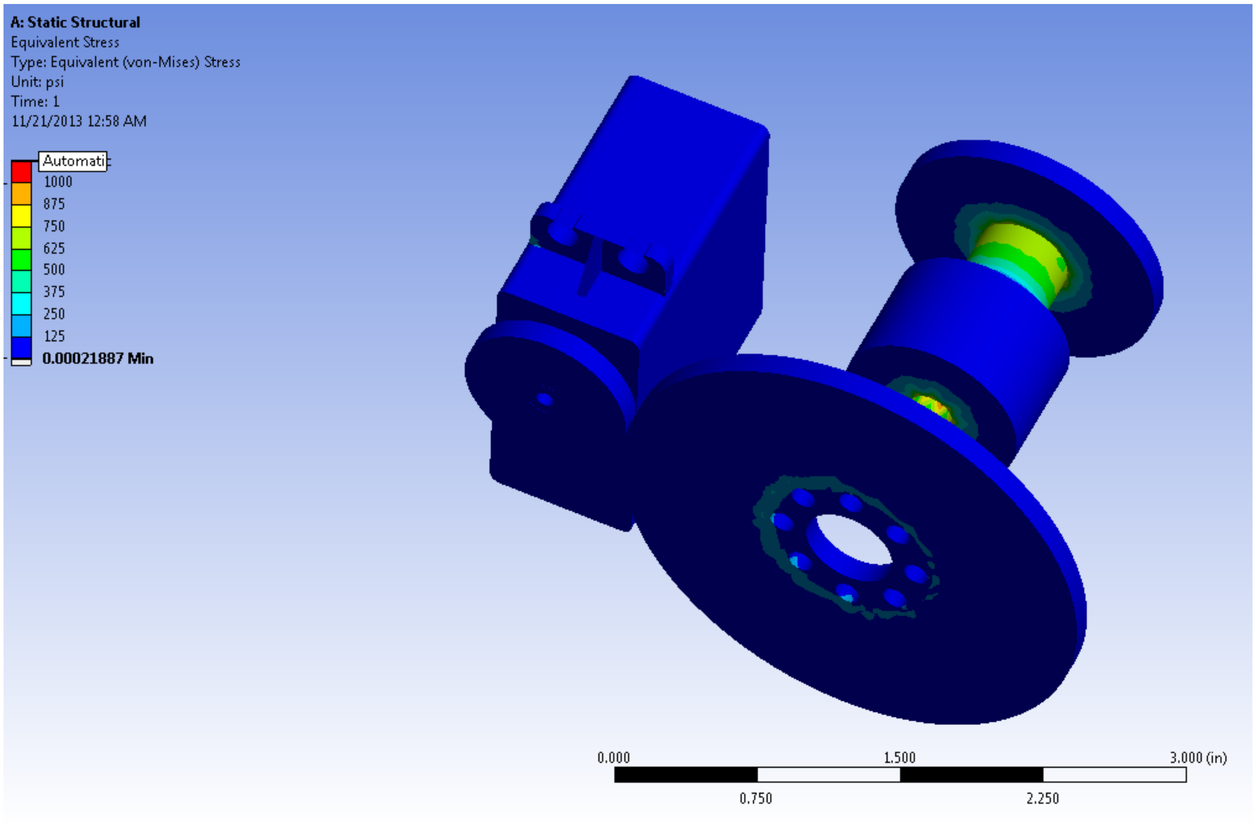


Figure 1: Stress on Plastic Parts Designed for Max 1ksi (yield strength)

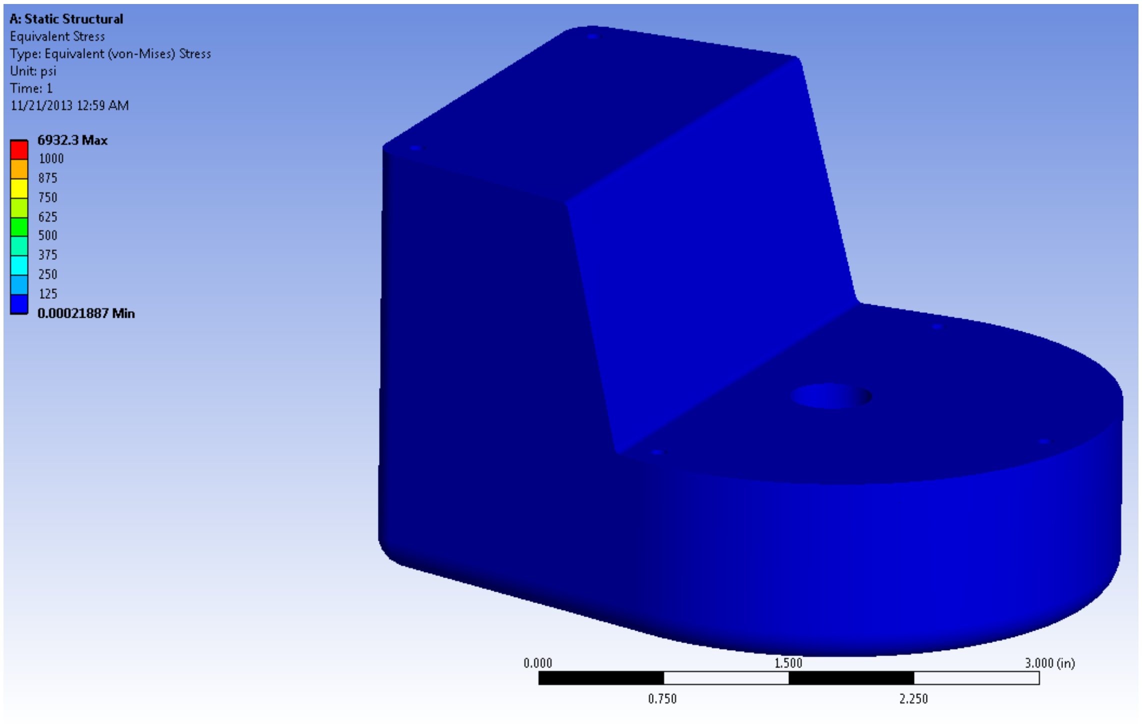
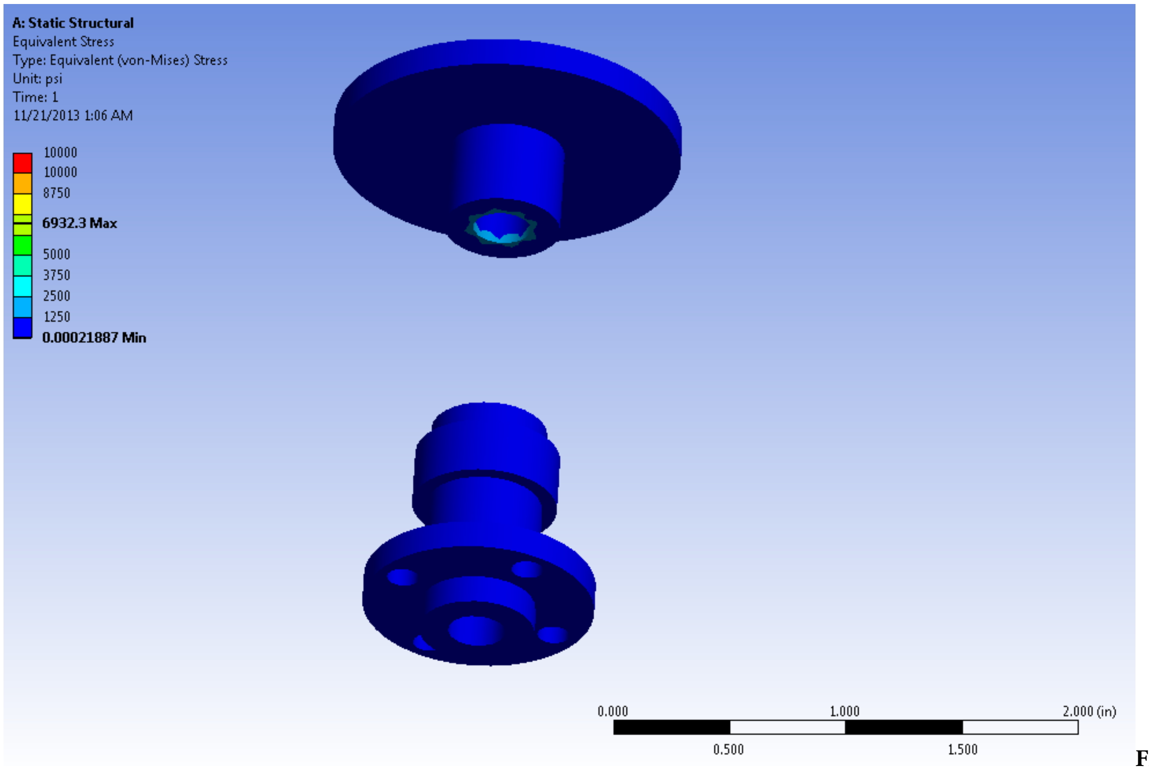
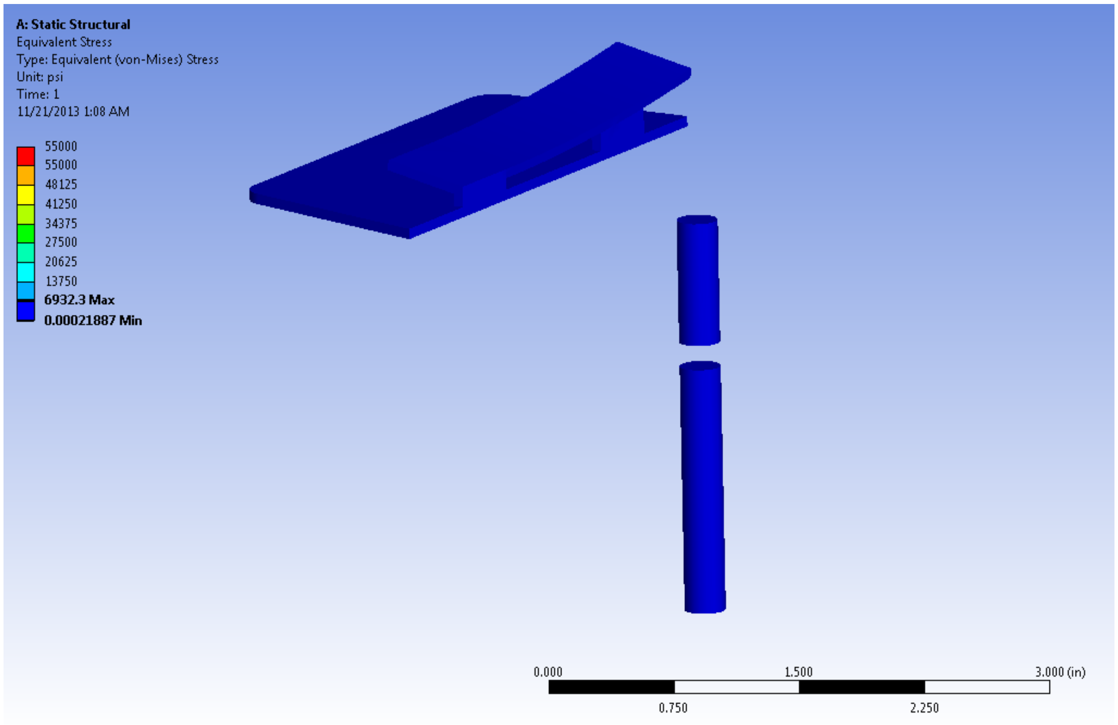


Figure 2: Stress on Plastic Parts Designed for Max 1ksi (yield strength)



A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: psi
Time: 1
11/21/2013 1:06 AM

Figure 3: Stress on Aluminum Parts Designed for Max 10ksi (acceptable endurance limit)



A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: psi
Time: 1
11/21/2013 1:08 AM

Figure 4: Stress on Steel Parts Designed for Max 55ksi (endurance limit)

The biggest concern is deflection. As little as .001" of deflection in the gears can cause teeth to hop.

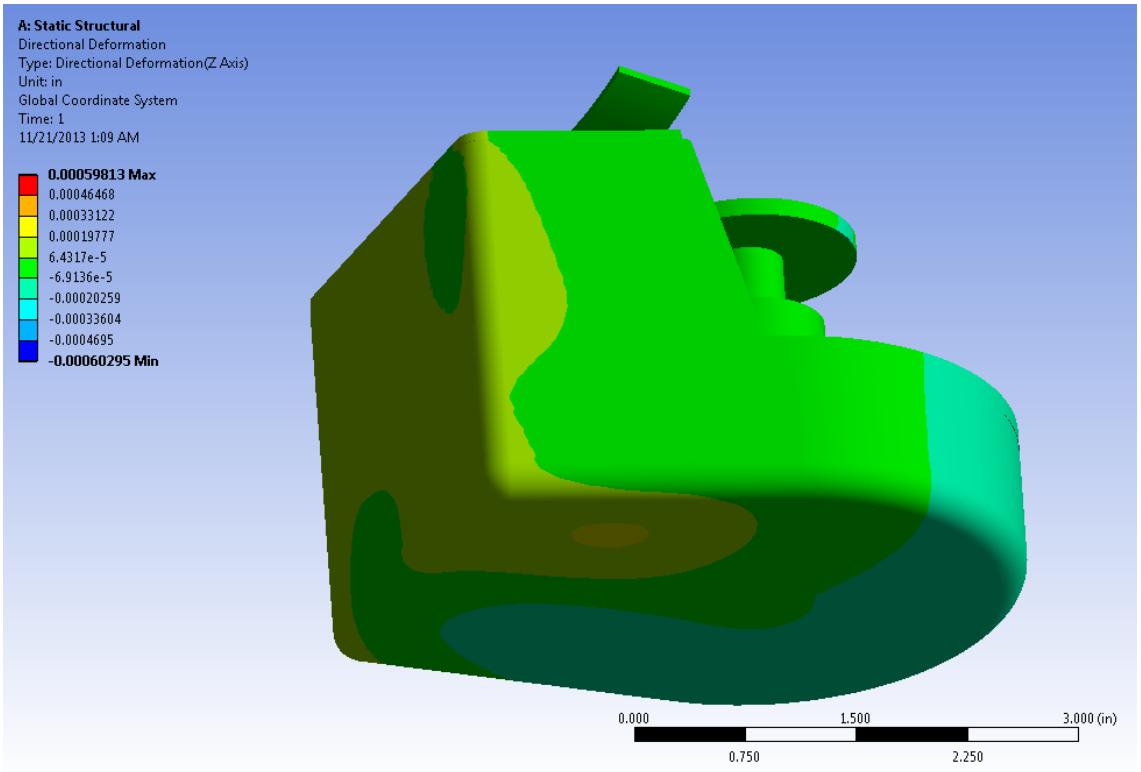


Figure 4: Deformation of the Outer Case

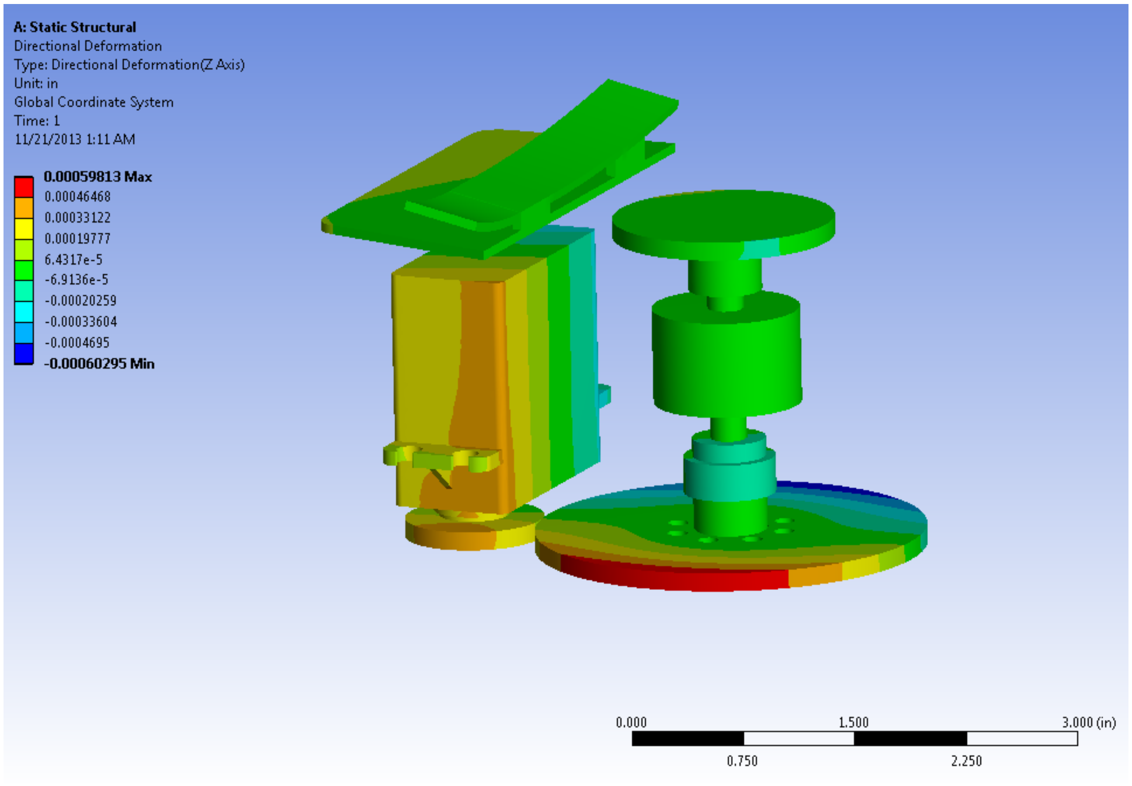


Figure 5: Axial Deformation of Transmission Components

The results of the FEA suggest that the axial deflection between the gears will be no more than .001" with a safety factor of 1.7.

PROTOTYPE TESTING RESULTS

The major area of concern regarding the functionality of our prototype was the meshing of the gears as well as the open and close time. We performed these tests in parallel on the final prototype to interpret its robustness and functionality. The complete assembly was tested as it would be used on the road. The sensor was placed in a team member's boot, and we stepped on and off of the sensor for 30 cycles of opening and closing. Testing was repeated with a flexible coupling and with a solid coupling. Time was taken with a stopwatch with an error tolerance of 0.01 seconds. The raw data is presented below in Table 1.

Table 1: Testing Results on Final Prototype

	Flexible Coupling			**Solid Coupling**		
Iteration	**Open Time (s)**	**Close Time (s)**	**Gear Skip?**	**Open Time (s)**	**Close Time (s)**	**Gear Skip?**
1	0.71	0.64	N	0.74	0.67	N
2	0.71	0.63	N	0.72	0.66	N
3	0.72	0.64	N	0.72	0.67	N
4	0.72	0.68	N	0.73	0.64	N
5	0.68	0.61	N	0.75	0.69	N
6	0.66	0.62	N	0.71	0.64	N
7	0.71	0.60	N	0.69	0.63	N
8	0.72	0.55	N	0.75	0.63	N
9	0.66	0.60	N	0.74	0.67	N
10	0.73	0.61	N	0.73	0.68	N
11	0.74	0.62	N	0.72	0.62	N
12	0.71	0.59	N	0.79	0.64	N
13	0.68	0.59	N	0.74	0.68	N
14	0.68	0.56	N	0.76	0.59	N
15	0.69	0.63	N	0.71	0.63	N
16	0.66	0.62	N	0.75	0.59	N
17	0.70	0.62	N	0.69	0.61	N
18	0.71	0.61	N	0.69	0.62	N
19	0.71	0.61	N	0.68	0.67	N
20	0.68	0.60	N	0.70	0.67	N
21	0.70	0.62	N	0.70	0.68	N
22	0.73	0.62	N	0.68	0.66	N
23	0.68	0.58	N	0.74	0.60	N
24	0.66	0.59	N	0.73	0.65	N
25	0.69	0.63	N	0.73	0.60	N
26	0.69	0.62	N	0.73	0.62	N
27	0.71	0.63	N	0.70	0.67	N
28	0.72	0.58	N	0.74	0.68	N
29	0.71	0.61	N	0.73	0.67	N
30	0.71	0.59	N	0.71	0.64	N
Average	*0.70*	*0.61*	-	*0.72*	*0.65*	-
Std. Dev	*0.02*	*0.03*	-	*0.03*	*0.03*	-

From this data, we see that the mean time to open with a flexible coupling is 0.70 seconds with a standard deviation of 0.02 seconds. Mean time to close is 0.61 seconds with a standard deviation of 0.03 seconds. With the solid coupling, hardly anything changed. The mean time to open was 0.72 seconds with a standard deviation of 0.03 seconds. Closing mean time was 0.65 seconds with a standard deviation of 0.03 seconds.

The time to open and close is almost identical, but slightly slower that with the flexible coupling. This may be attributed to added torque due to compliance in the assembly. In either case, the times are very consistent and preferable for the user; the visor does not open too slowly or too quickly so as to not be able to react in the case of accidentally triggering the opening of the visor. Additionally, there were zero incidents of skipping gear teeth. This is exactly what we had hoped for by creating the transmission case. A constant mesh is required for adequate operation and a long lifespan. We found through this testing that our prototype as it functions is a feasible concept for further development and subsequent production, without the need for more advanced constraints. As far as improvements go, it has been found that the flexible coupling is unnecessary. Future development can focus on mechanical design optimization of the drive shaft.