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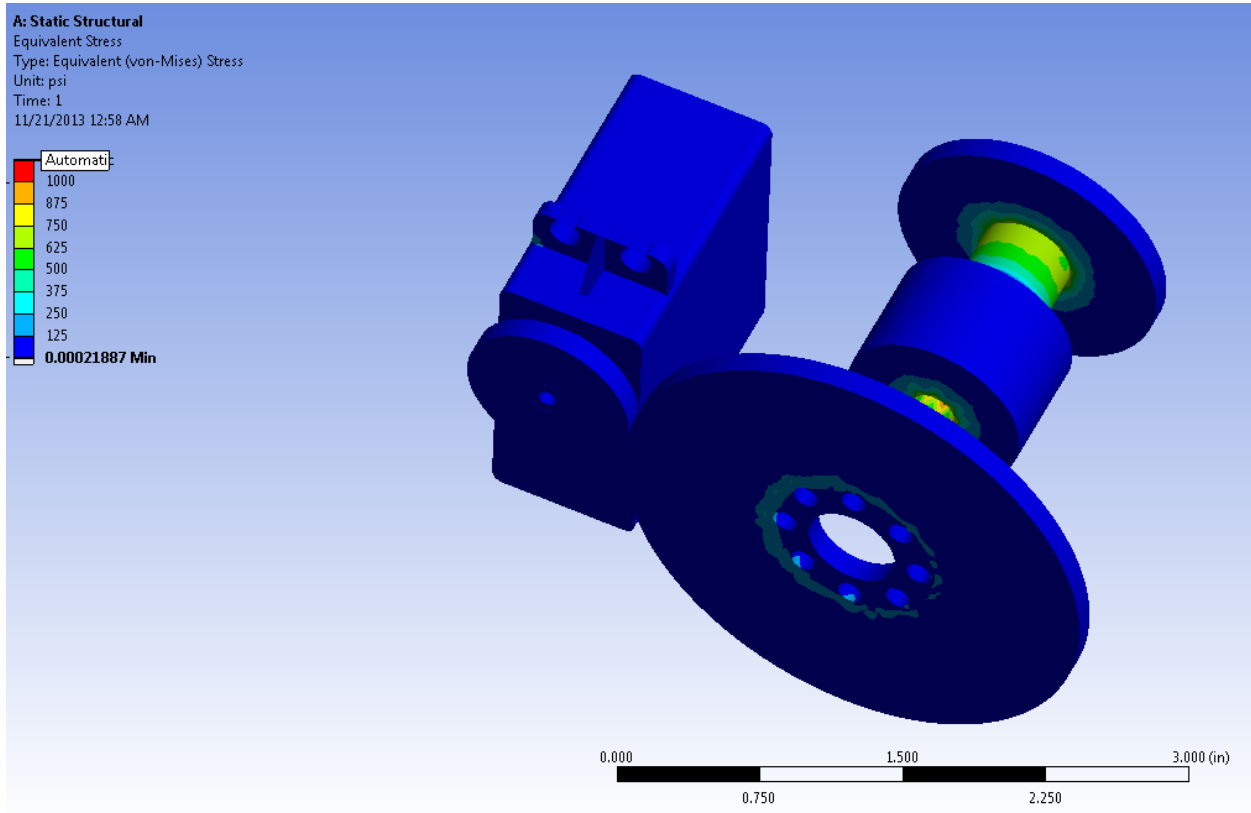
Figure 1: Stress on Plastic Parts Designed for Max 1ksi (yield strength)
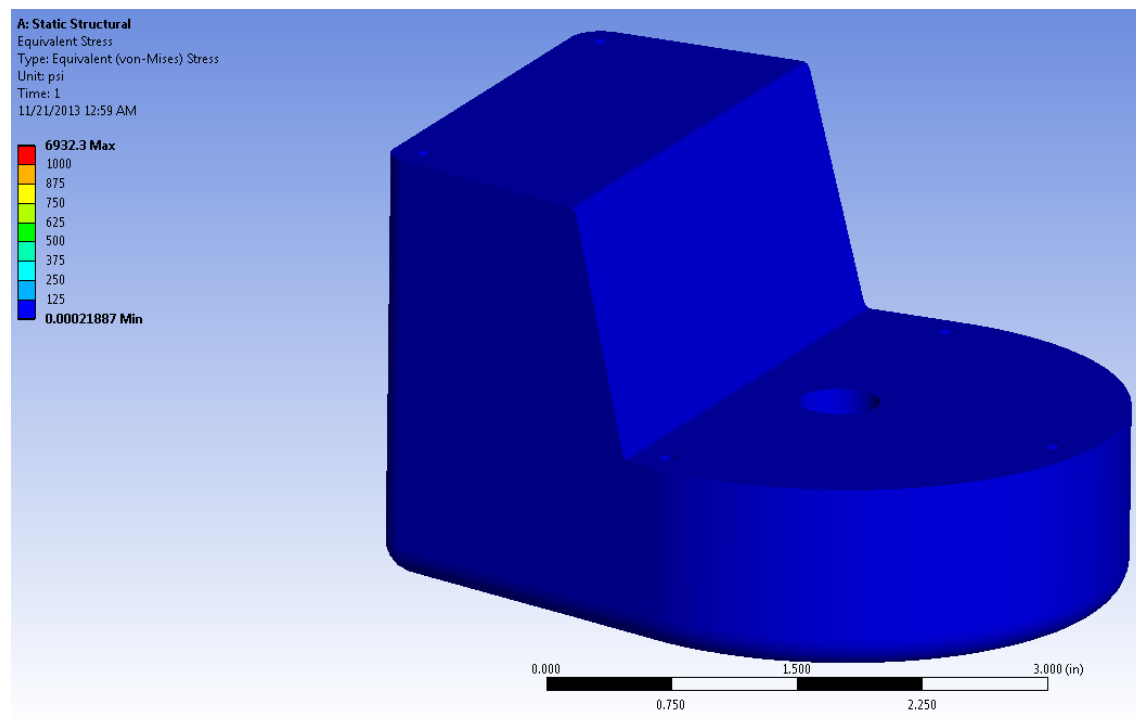
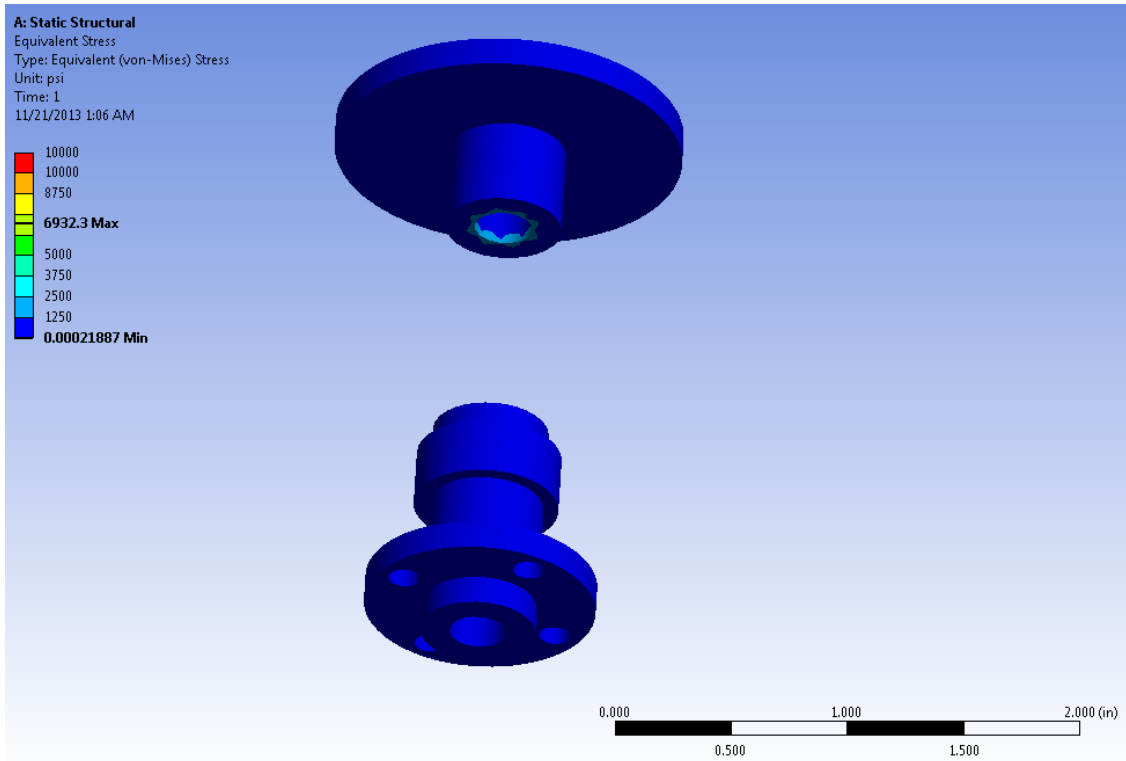**Figure 2: Stress on Plastic Parts Designed for Max 1ksi (yield strength)**

Figure 3:

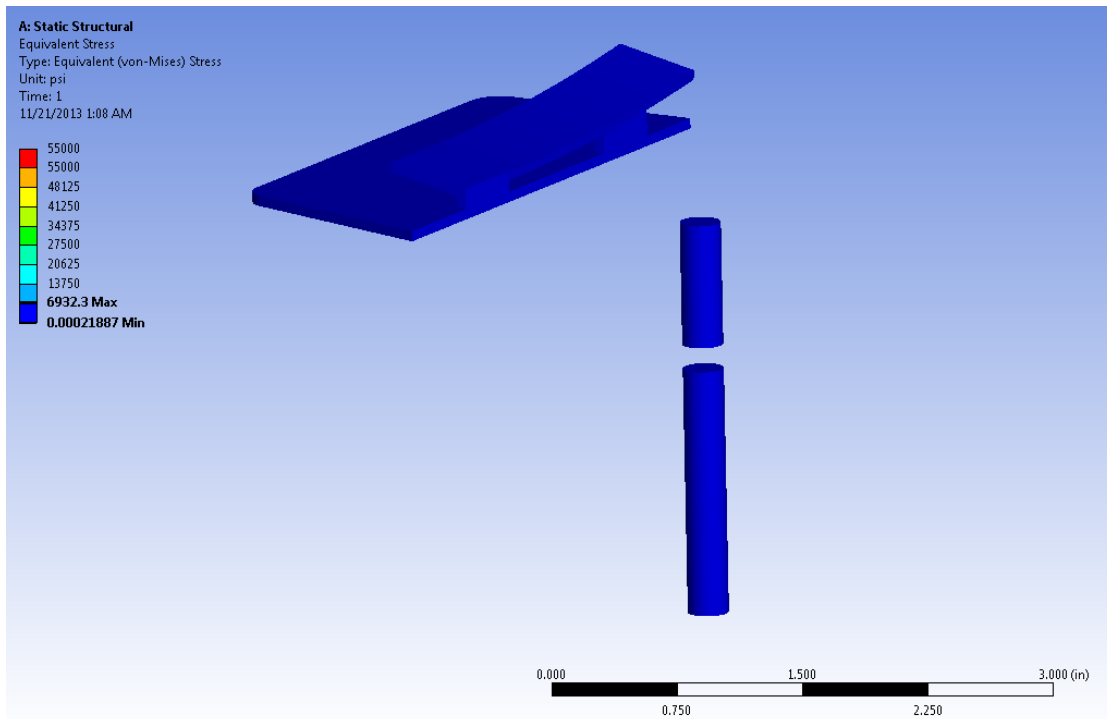**Stress on Aluminum Parts Designed for Max 10ksi (acceptable endurance limit)**

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.
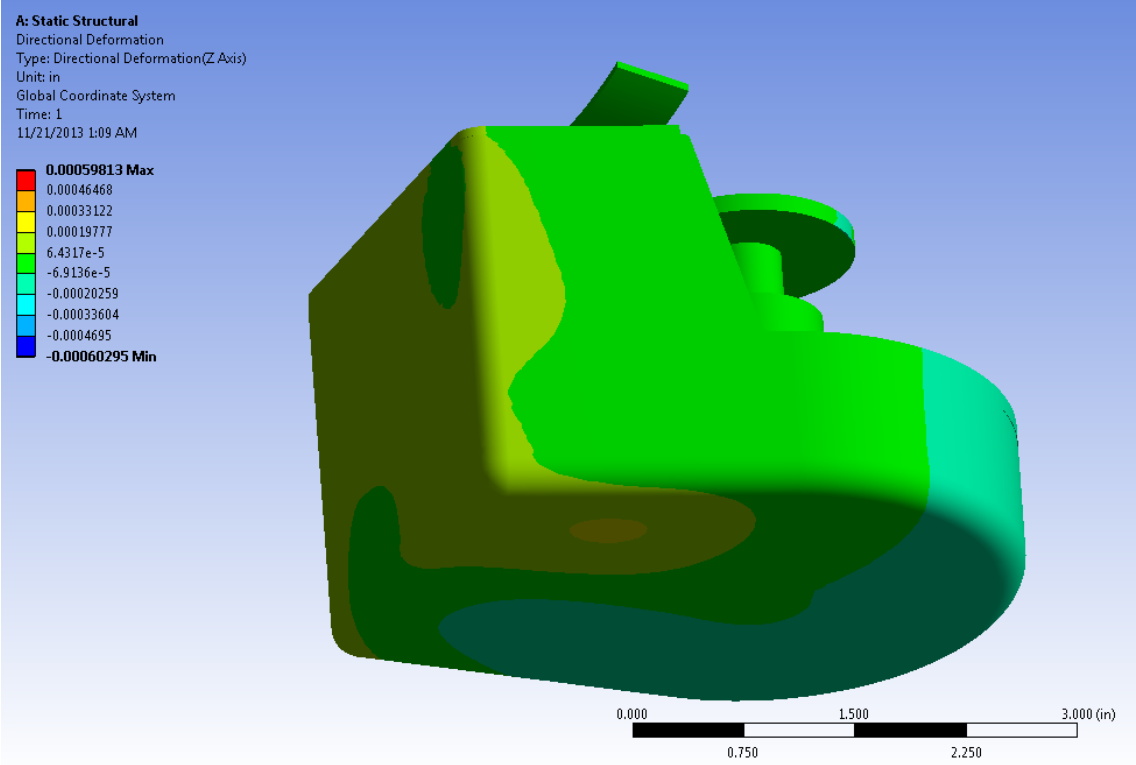

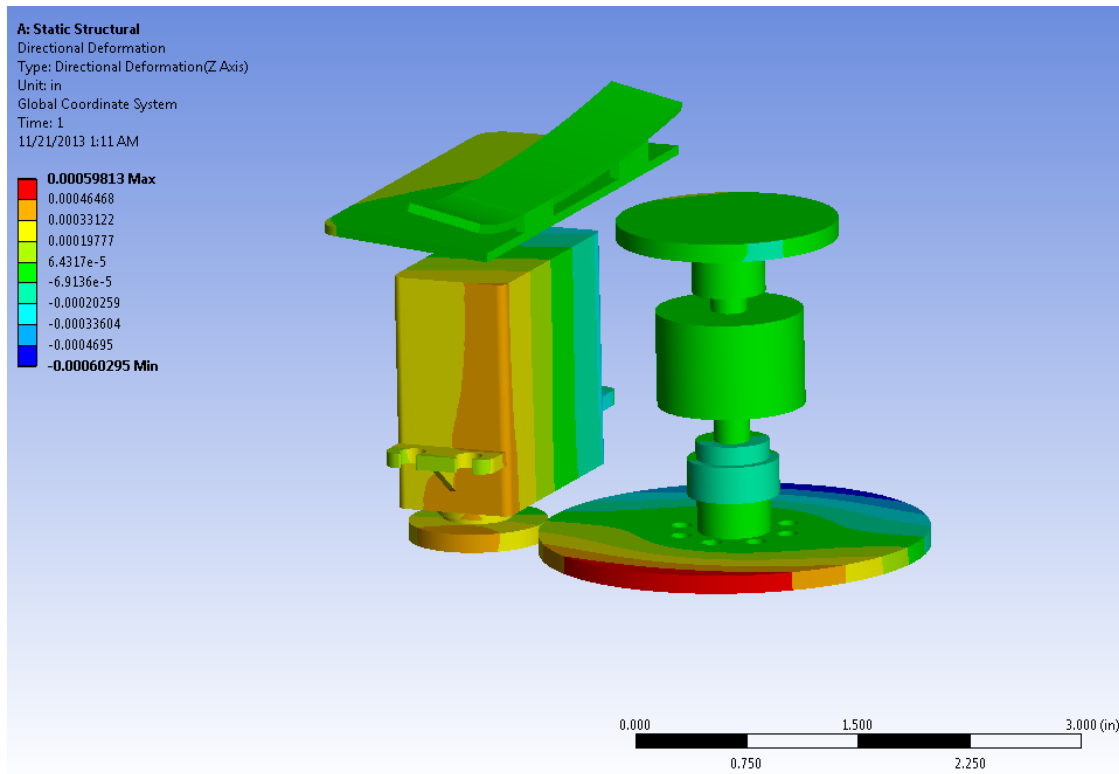**Figure 4: Deformation of the Outer Case**

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

Iteration	Flexible Coupling			Solid Coupling		
	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.