System Analysis 1 Progress Report

Submitted to:

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This experiment demonstrated different configurations (either puller or tractor style and pusher style) for different designs of propellers for the AEV. Propellers are the current plan for the AEV project, meaning this data can be used to determine the best combination of settings and placement of propellors to maximize efficiency. This is important to the design of the AEV because the purpose of the AEV is to maximize energy efficiency.

By examining the data from the different data tables, the reader can identify that for each propeller, the values for when the propeller was in the puller configuration and when the propeller was in the pusher configuration are different. The difference between the puller and pusher configurations is the way the propellers are spinning. When the propellers are spinning counterclockwise relative to the outside observer looking at the vehicle, the AEV is being pushed, and when the propellers are spinning clockwise relative to the outside observer looking at the vehicle, it is being pulled. Obtaining both the pusher and puller data is important because the AEV must travel in both directions, meaning that the AEV must be both pushed and pulled during its travel, therefore a propeller that is efficient in both pulling and pushing the AEV should be used.

The data retrieved from the experiment shows useful information about what settings should be used in the code and the placement of the propellers. In figure 1, the EF-3 bladed type in the puller configuration has more thrust per percent power than all other types of configurations. The EF-3 bladed propeller in the pusher configuration has the second best thrust per percent power. This makes the EF-3 bladed propeller a sought-after propeller in the AEV design. In figure 2 the propulsion efficiency is related to the advance ratio. The higher values on the graph are better because they are more efficient. The EF-3 bladed propeller has the highest efficiency in the pusher and puller configurations around the 0.35 to 0.45 advance ratio range. This advance ratio range corresponds to a value of 30-40% for the motor speeds. These values are only slightly higher than the motor power values already being used currently. Using the EF-3 bladed propeller in this range of power will be the most effective to reducing power consumption.

To obtain the maximum efficiency of the AEV, it should be powered between 30-40% of its maximum capability. The AEV should be powered between 30% and 40% because that is where the propeller has its best propulsion efficiency.

Ben Bazan completed Table 7, what motor speed the AEV should run at to get maximum efficiency and the difference between the puller and pusher configurations. Nick Stassen completed Table 8, how this experiment can aid in the strategy and design of the AEV, and justifying the choice of propellor for the AEV based off the experiment. Matthew Geiger completed all tables and figures.

Appendix

Table 1: Wind Tunnel Testing Data – pusher EP 3030

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	160		0
0.39	164	3413	20
0.48	167	4191	25
0.58	170	4970	30
0.68	174	5677	35
0.77	178	6307	40
0.84	181.5	7111	45
0.95	186	7724	50
1.03	188	8383	55
1.09	189	9600	60

Table 2: Wind Tunnel Testing Data -- puller EP 3030

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	160		0
0.38	164.2	2335	20
0.48	167	2934	25
0.59	171.7	3652	30
0.7	177	4311	35
0.82	182	4970	40
0.92	187	5688	45
1.23	196	7399	50
1.13	195	8411	55
1.23	197	9100	60

Table 3: Wind Tunnel Testing Data -- pusher EP 3020

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	172.3		0

0.28	173	3113	15
0.37	174.5	4071	20
0.46	177.5	4970	25
0.55	182	5928	30
0.64	185	6826	35
0.73	188	7724	40
0.8	191	8562	45
0.87	193	9341	50
0.93	194	10119	55
0.99	197	10838	60

Table 4: Wind Tunnel Testing Data -- puller EP 3020

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	161		0
0.28	162	2095	15
0.38	163.4	2754	20
0.48	166.3	3592	25
0.59	171	4491	30
0.7	175	5389	35
0.82	181	6227	40
0.92	185	7005	45
1.23	194.5	7844	50
1.13	194.9	8622	55
1.23	196	9700	60

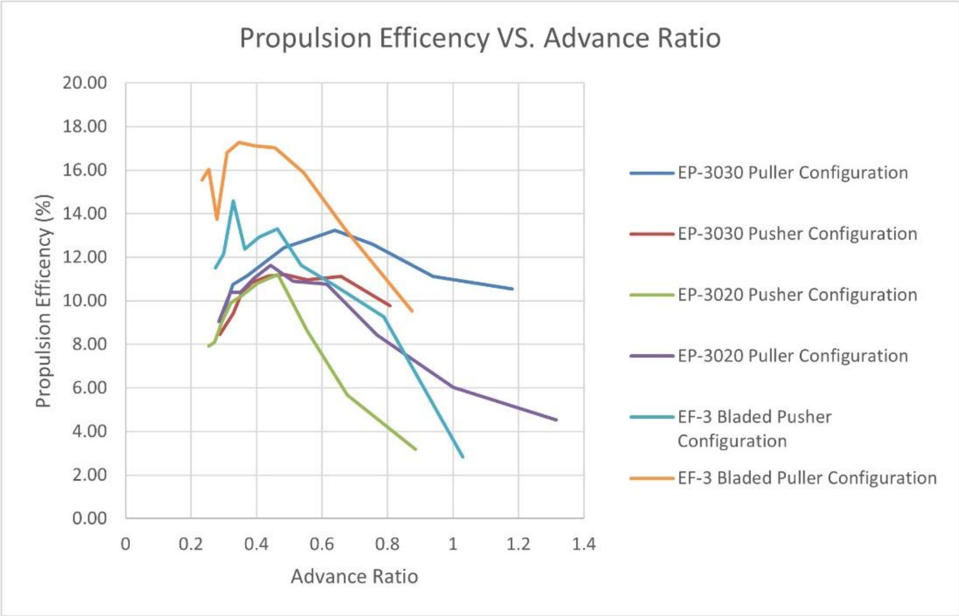
Table 5: Wind Tunnel Testing Data – pusher EF-3 bladed

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	160.4		0
0.27	161	2295	15

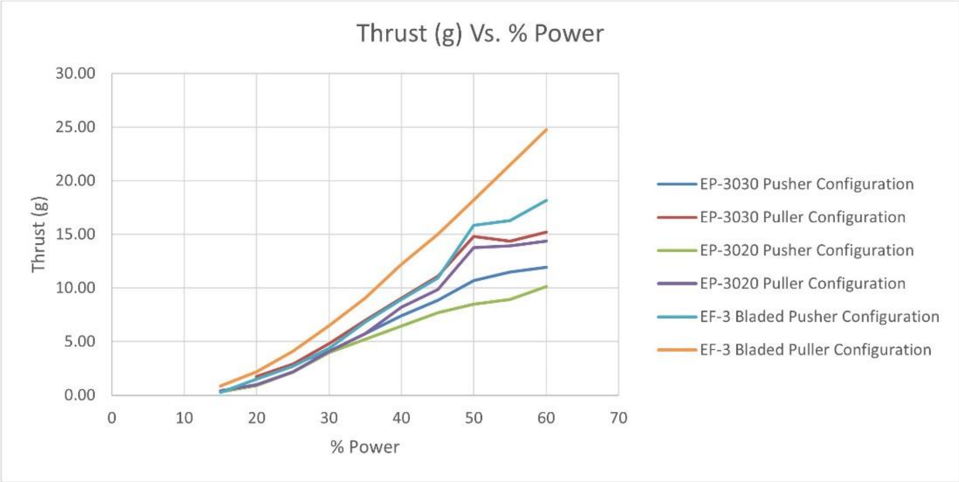
0.37	164	2996	20
0.47	167	3696	25
0.58	171	4397	30
0.68	177	5098	35
0.8	182.1	5797	40
0.91	187	6498	45
1.01	199	7198	50
1.13	200	7899	55
1.22	204.6	8599	60

Table 6: Wind Tunnel Testing Data -- puller

Current	Thrust Scale Reading	RPM	Arduino Power Setting
amps	*grams*	*RPM*	*%*
0	166.9		0
0.28	169	2700	15
0.38	172.2	3524	20
0.48	176.9	4348	25
0.59	182.7	5172	30
0.7	188.9	5996	35
0.82	196.6	6820	40
0.92	203.4	7644	45
1.23	211.2	8468	50
1.13	219.2	9292	55
1.23	227.1	10117	60



(Figure 1) Propulsion Efficency Vs. Advance Ratio



(Figure 2) Thrust Vs. % Power

Table 7: Ben Bazan Individual EP-3030 at 20% Arduino power -- Puller

Thrust Calibration	RPM	Power Input	Power Output	Power Output	Propulsion Efficiency	Advance Ratio
grams	*RPM*	*Watts*	*Watts*	*Horsepower*	*%*	*--*
1.73	2335.00	0.56	0.06	0.00	10.54	1.18025932

Table 8: Nick Stassen Individual single point (35% Arduino power) calculation for EF-3 bladed rotor

Thrust Calibration	RPM	Power Input	Power output	Power output	Propulsion efficiency	Advance Ratio
grams	*RPM*	*Watts*	*Watts*	*HorsePower*	*%*	--
$Tc = 0.411 * (T - T0)$	(given)	P_{in} = V * I * %P	P_{out} = T_c * v	P_{out} (watts) / 746	P_{out} / P_{in} * 100%	v / (RPM/60)* D
9.042	5996	1.813	0.310	0.310/746	17.124	0.394

Table 8: Nick Stassen Individual

Matthew Geiger Individual

To calculate the thrust a measurement is first required with no power being applied in order to establish a base line. Once this is done a formula is required to convert the thrust scale reading to thrust calibrated. This equation is (0.411 *(thrust scale reading -calibration thrust reading)). To calculate power input the current that is measured by the Arduino is multiplied by the arduino percent power converted into decimal form and multiplied by the voltage from the battery this is given by the formula (Pin=V*I*% Power). To calculate power output the thrust calibrated is converted into newtons by dividing the grams by 1000 to convert into kilograms and then multiplying by 9.81 which is the acceleration due to gravity and then multiplying by wind tunnel are velocity, the formula is given by (Pout=Tc /1000 *9.81 *v). Now knowing power output and power input propulsion efficiency is calculated dividing power output by power input and multiplying by 100 to put it into percentage form, the formula is given by (Propulsion efficiency= Pout/Pin *100). The advance ratio is now calculated using the diameter of the propeller blade, the RPM of the propeller along with the speed of the wind tunnel given by the formula (Ar=v/((RPM/60)*D).

Using these formulas for the first data point on EP-3030 pusher configuration the following data is found

Current= 0.39

Thrust scale reading= 164

RPM=3413

Arduino % power setting= 20

Thrust calibrated (g)= 1.64

Power input=0.58 Watts

Power output= 0.06 Watts

Propulsion Efficiency=9.78 %

Advance Ratio= 0.80747