SAE AERO COMPETITION: HIGH STRENGTH-TO-WEIGHT RC AIRCRAFT

Team 9: Alex Berger, David Dahl, Jamie Greenberg, Zach Zwicker

Advisors: Bruce Kothmann, Robert Jeffcoat

B

Parameter		Stability Requirement	Calculated Value	Stable
Static Margin	$SM = h_h - h$	S.M. > 0	0.11	Yes
Horizontal Tail Coefficient	$V_h = \frac{S_h l_h}{Sc}$	$0.3 < V_h < 0.6$	0.518	Yes
Vertical Tail Coefficient	$V_v = \frac{S_v l_v}{Sb}$	$0.02 < V_v < 0.05$	0.0248	Yes

STABILITY ANALYSIS

By calculating basic stability derivatives, it was possible to determine whether or not the aircraft would be dynamically stable in flight. A dynamically stable aircraft will return to level flight after a momentary disturbance.

B4

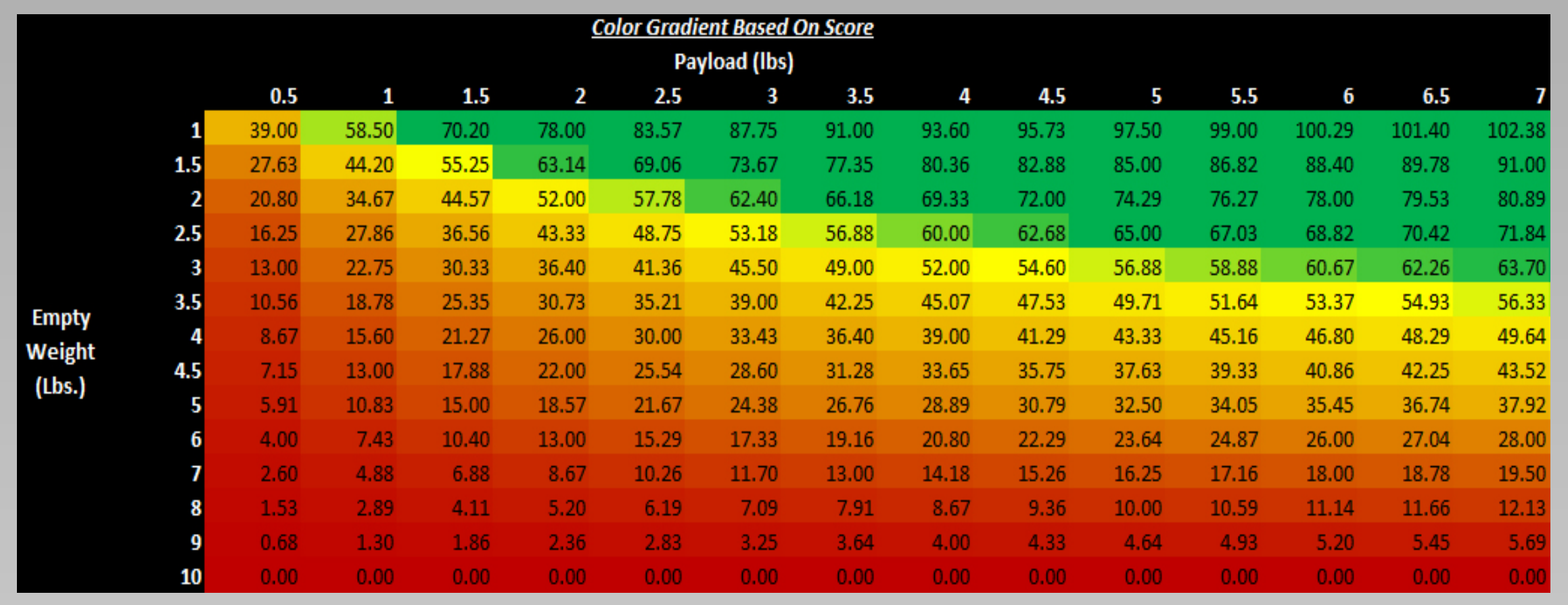
SAE AERO DESIGN CONTEST

The SAE Aero Design Competition (Micro Class) challenges teams to design a remote-controlled aircraft that maximizes its payload fraction (PF). The PF is defined as: $PF = \frac{Payload}{GrossWeight}$. Furthermore, the SAE scoring formula takes into account the payload fraction as well as the empty weight of the aircraft. The scoring formula is determined by: $Score = 13 \times (10 - EmptyWeight) \times PF$.

Due to this, there is an incentive to minimize the aircraft's empty weight. The first step towards interpreting this data was to determine how the aircraft's empty weight affected the score. In other words, was it more advantageous to increase the payload capacity or to decrease the aircraft's empty weight? A scoring chart was produced to interpret the relationships between these two parameters (scores indicated by shades of green have proven to be successful in past SAE Competitions). This analysis shows that the score will improve more by removing ½ lb of empty weight versus increasing the payload by ½ lb.

The micro class airplane, and all contents needed to fly (including transmitter, batteries, etc.) must fit within a specified carrying case measuring 18" x 13" x 5.63" on the inside. A further requirement mandates that the entire model is assembled within 3-minutes by 2-people. These requirements were met by implementing simple modular elements that were able to deconstruct to fit within the case.

Further competition requirements include a 100-ft takeoff distance and a 200-ft touchdown zone. In addition to the flight scoring, the competition including an oral presentation and a technical design report. Although the flight component was unsuccessful, above-average scoring for the presentation and technical design report allowed the team to finish 4th out of 8 entrants in the Micro Class.

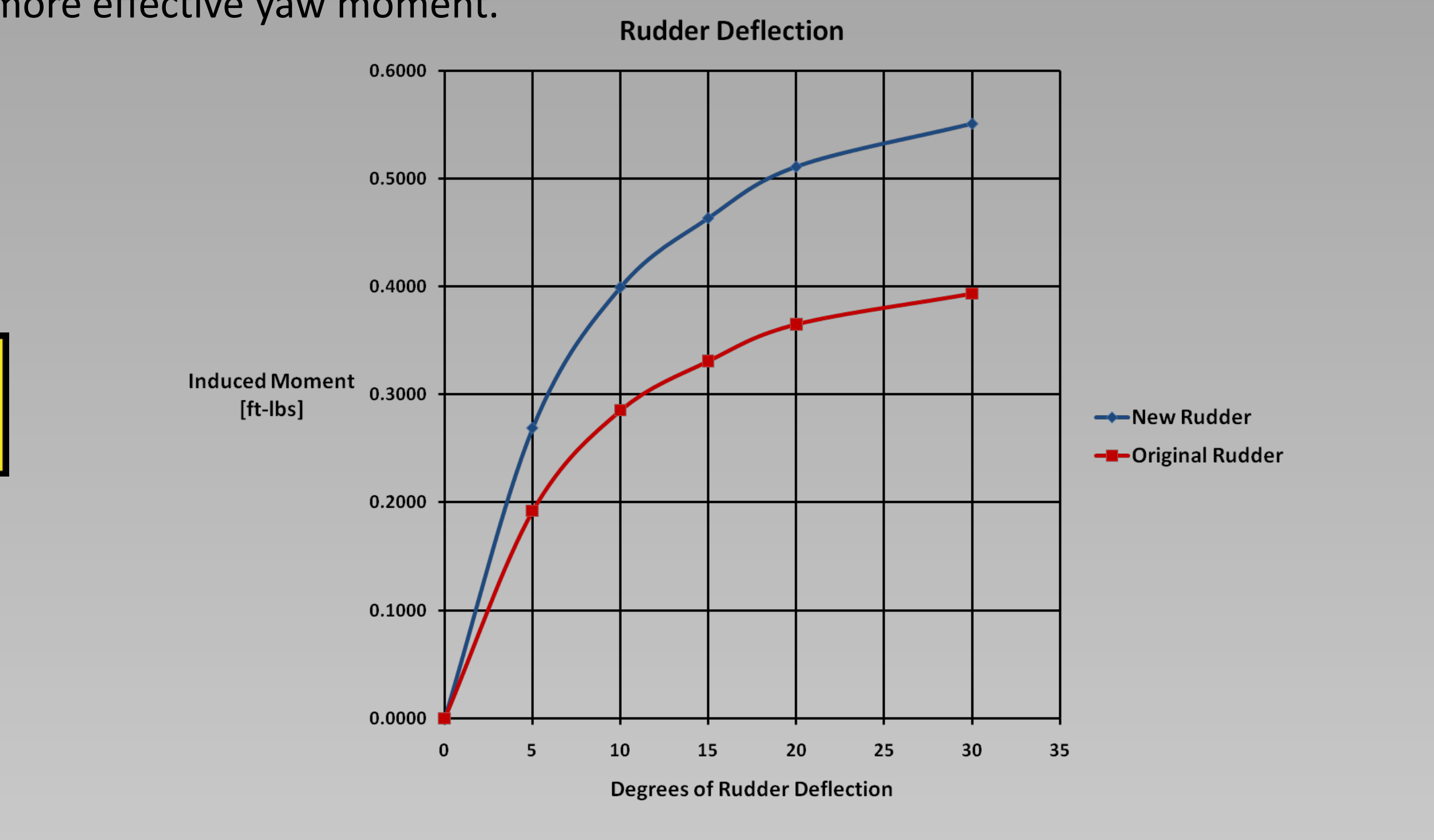

Color Gradient Based On Score

Empty Weight (Lbs.)	Payload (lbs) 0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
1	39.00	58.50	70.20	78.00	83.57	87.75	91.00	93.60	95.73	97.50	99.00	100.29	101.40	102.38
1.5	27.63	44.20	55.25	63.14	69.06	73.67	77.35	80.36	82.88	85.00	86.82	88.40	89.78	91.00
2	20.80	34.67	44.57	52.00	57.78	62.40	66.18	69.33	72.00	74.29	76.27	78.00	79.53	80.89
2.5	16.25	27.86	36.56	43.33	48.75	53.18	56.88	60.00	62.68	65.00	67.03	68.82	70.42	71.84
3	13.00	22.75	30.33	36.40	41.36	45.50	49.00	52.00	54.60	56.88	58.88	60.67	62.26	63.70
3.5	10.56	18.78	25.35	30.73	35.21	39.00	42.25	45.07	47.53	49.71	51.64	53.37	54.93	56.33
4	8.67	15.60	21.27	26.00	30.00	33.43	36.40	39.00	41.29	43.33	45.16	46.80	48.29	49.64
4.5	7.15	13.00	17.88	22.00	25.54	28.60	31.28	33.65	35.75	37.63	39.33	40.86	42.25	43.52
5	5.91	10.83	15.00	18.57	21.67	24.38	26.76	28.89	30.79	32.50	34.05	35.45	36.74	37.92
6	4.00	7.43	10.40	13.00	15.29	17.33	19.16	20.80	22.29	23.64	24.87	26.00	27.04	28.00
7	2.60	4.88	6.88	8.67	10.26	11.70	13.00	14.18	15.26	16.25	17.16	18.00	18.78	19.50
8	1.53	2.89	4.11	5.20	6.19	7.09	7.91	8.67	9.36	10.00	10.59	11.14	11.66	12.13
9	0.68	1.30	1.86	2.36	2.83	3.25	3.64	4.00	4.33	4.64	4.93	5.20	5.45	5.69
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

G

Torque Roll: Redesigning the Tail

During early flights, it was discovered that the aircraft had a tendency to roll sharply to the left just after takeoff. This was likely a result of the torque created by the motor. To fix this problem, the tail was redesigned to be larger and have a more effective yaw moment.



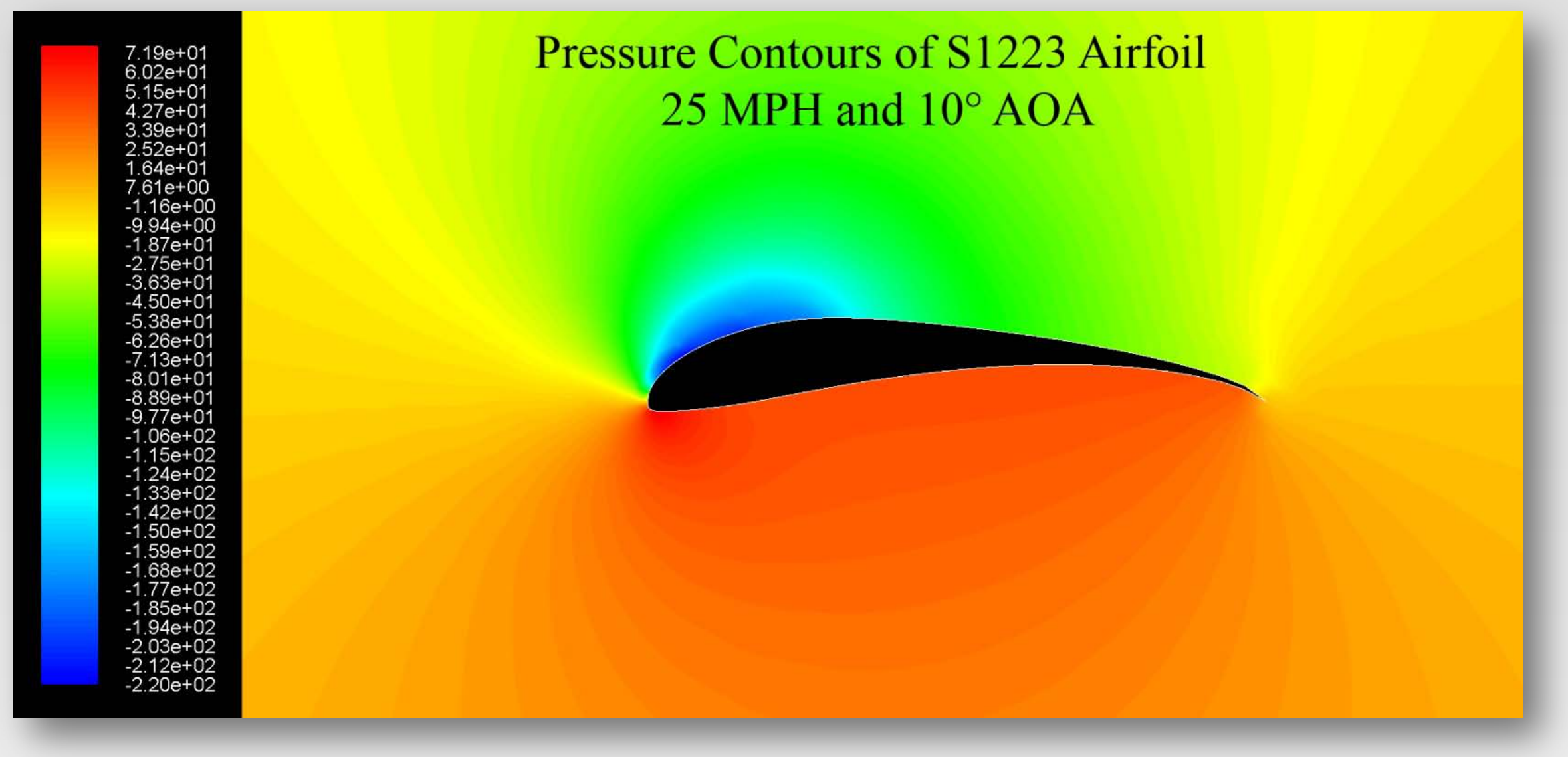
C1

C

Aircraft Properties	
Physical Dimensions	
Wingspan	43.7 in.
Length	24.3 in.
Height	13.6 in.
Empty Weight	2.25 lbs.
Aircraft Systems	
Motor	RimFire .32 42-50-800
Propeller Diameter	11 in.
Batteries	4S LiPo, 2S LiPo
Servos	4 Futaba Microservos
Radio Transmitter	2.4 GHz

S1223 Airfoil

The airfoil shape used on this aircraft was the Selig S1223. The S1223 was chosen due to its superb ability to generate lift at low Reynolds numbers. (The Reynolds number relates the inertial forces to the viscous forces of a fluid in motion.) Because the wings have a short chord and the aircraft is flying very slow, in-flight Reynolds numbers are expected to be between 75,000 and 150,000 This is considered extremely low for aircraft, and special low-speed airfoils must be used to ensure the most efficient production of lift. With a typical, cambered NACA airfoil, the boundary layer can separate very easily, destroying most of the lift. Because the S1223's upper and lower surface come together gradually at the trailing edge, the boundary layer remains attached throughout the chord.



Fluent Analysis

The S1223 was tested in Fluent to examine the airflow patterns over the airfoil. The absence of any shockwaves or boundary layer separation over the surface makes the S1223 extremely effective at low Reynolds numbers.