

WAR EAGLE MOTORSPORTS
FORMULA STUDENT COMBUSTION

Race Report

Formula SAE Lincoln, 15-18 June 2016, Lincoln, Nebraska

Auburn. Formula! Victory!! War Eagle!!! The planets aligned for Auburn Formula SAE. We made our own luck, reached out and pulled it in, and came through for the win. We showed up with a well-sorted car and a team that knew what it was doing. We won the Endurance Race and the Acceleration Event – the 2nd and 3rd times we have ever won an FSAE event. We ran with a full aerodynamics package for the first time. The Endurance drivers (the winning Endurance drivers, that is) liked it.

Formula SAE Lincoln started in 2012 as an easier-to-organize, easier-to-get-to alternative to the old Formula SAE West Competition at the Auto Club Speedway in Fontana, California. The new site is the Lincoln Airpark – an under-utilized vastness of flat concrete. Perfect for autocross, which is what FSAE cars are built for. The purpose of a second North American competition is to provide more FSAE entry slots, since FSAE Michigan sells out in as little as 10 minutes. But after the overflow teams are satisfied, and once the waiting list has filled in for withdrawn teams, there is usually room for about 20 double entries from FSAE Michigan teams that feel like they just have to climb the mountain one more time. FSAE Lincoln 2016's 80 team sold-out limit came from 26 US states (15 cars from California alone) and six other countries: Brazil (1); Canada (8); India (1); Japan (1); Mexico (3); and South Korea (1).

Co-located with FSAE-LN is FSAE Electric, sold out at 30 teams from 13 US states and four other countries: Brazil (1); Canada (4); the Czech Republic (1); and Pakistan (1). FSAE-E runs the same events on the same courses as FSAE-Combustion – though of course Technical Inspection and Design are very different.

As a newer competition, FSAE-LN doesn't have the stable cadre of judging and event staff that FSAE-MI has, but the reverse of that medal shows an opportunity to bring a fresh approach. At least two of our alumni hold responsible positions in event administration. We hope that there will be more!

The competition opened for us in Nebraska with Tech Inspection, which went smoothly. We had earlier passed Tech in Michigan. While this is no guarantee that a fresh set of inspector's eyes won't find anything else, in this case we slid through. No issues on Tilt Test. Noise Check and Brake Check went just fine as well. We had a full tech sticker and were ready to race.

The car, with wings, weighed in at an estimable 469 lb. A bit heavy. But measures had been taken to improve robustness (the cause of much grief the previous year), and in its first iteration, the aerodynamics package had not yet considered structural optimization.

In static events, Cost went well, just as it did in Michigan: 18.76 out of 20 for the report; 20 out of 20 for on-site evaluation; and 20 out of 20 for the cost reduction case; but only 9.48 out of 40 for the prototype cost. Our cost was \$19,553 (the nice electronics do add up). Low was \$7,611 (University of Texas at San Antonio), mean was \$14,511, standard deviation was \$4,824, and high was \$38,120 (Southern Methodist University). Our total of 68.24 points (out of 100) placed us 29th. Wayne State won Cost with 89.36 points (30.35 on cost, 59 on the other elements).

Presentation was a character-builder. We have a new business plan for incorporating our racecar design into a profitable enterprise, and the delivery and content of our investment pitch is starting to look pretty good. But we ran into a presenter's nightmare – just as the lead presentation judge said “go”, the projector packed up. It's a slippery slope – the desire to try one more little thing to fix it – and in the heat of battle it is difficult to say when to bail and go with the laptop. We worked at it a little too long, and did eventually find the bent video cable pin, but by then the confidence of judges and presenters had been shaken, and the presentation had been disrupted and shortened. We salvaged 40 points out of 75 for 56th place. Illinois won Presentation with the full 75.

In Design, we were slightly handicapped, with some of our seniors leaving the team after Michigan. This is a great way for the incoming leadership to come up to speed quickly, but it does put them in the position of explaining design work they hadn't done, or at least lead. But we were still deep enough to put on a great show, landing in Design Finals along with California Polytechnic at Pomona, California State University at San Jose, École de Technologie Supérieure (ETS), University of Akron, University of Washington, and University of Wisconsin (only half of these, not including us, were listed on the Competition website the night after preliminary Design judging – so we spent a night and a morning in a blue funk until the posting was corrected the next day). At Finals, the judges were sharp, and we got credit for our accomplishments, but the areas where improvement is needed were exposed. We wound up in 5th place behind ETS, Wisconsin, Washington, and Akron, gaining 125 points out of 150 (ETS got the full 150).

After static events, we had 233.2 points out of 325, sitting in 14th place. Wisconsin led with 291.0, followed by Washington (274.4), ETS (269.8), Akron (260.0), and Missouri University of Science and Technology (255.2).

We started our second day with Skid Pad, Nick Boehm and Davis Edwards sharing the driving slots. We've been working up to the mass properties, suspension design, and powertrain drivability parts of Skid Pad for several years. This year we added the aerodynamic downforce part, and the combination of these kicked us into a podium finish. Our best time out of four attempts (two for each driver) was 4.912 s, a school record. With that we placed 3rd and pulled 44.02 points out of 50. Missouri S&T won in 4.813 s, followed by Washington in 4.870 s.

Moving over to Acceleration, we had concerns. We are an Acceleration car, but all that nice downforce from the wings in Skid Pad can mean lots of aerodynamic drag on

Acceleration. Seems we didn't need to worry. Nick and Davis made a best time of 4.025 s. Not a school record – our 3.855 s run at Lincoln in 2014 is the class record for all Formula SAE Combustion cars – but easily enough to win the event and take the full 75 points. University of Pittsburgh was 2nd, way back in 4.152 s. This became only the 2nd time we have won a Formula SAE event (for the 1st time, see 2014 above).



That afternoon Drew Campbell and Daniel Maddux lined up as our two drivers in the Autocross event. Having a reliable car that stayed available throughout the development process meant the effort to develop the car and drivers was successful, and we achieved the approbation of “well-sorted”. The downforce helped a lot to stabilize the car, and let the drivers dial up the daring. In Autocross, that meant a single best lap time of 58.339 s. Not the best – Missouri S&T ran a 57.089 to win – but close enough that we got a good 140.16 points in 6th place, not far behind S&T’s 150 to win.

Our short dynamic total was 259.9 out of 275, 2nd best in the field (S&T had the best second day with 267.8). Overall, going into the Endurance Race on the third day, we were sitting in 7th with 493.1 points out of 600. Wisconsin lead at that point with 527.1, followed by S&T (523.0), ETS (515.2), Washington (512.1), San Jose (499.7), Akron (498.7), and Auburn.

It is worth noting that the team didn't really know any of this point-and-place precision - final Design points had not yet been posted. We knew that we had done well in Design, but that we had not made the top three teams which are announced in a Design Review just before final awards. And we did not know which teams had made the top three. So we knew we were doing well, and had a good chance to place well overall, but didn't know how far back we were, or how many points had to be made up. Not that it mattered – we were already doing everything that we could.

One of the wild cards in the calculus of Formula is that to place well overall, a car must finish the Endurance Race (almost no points if the car does not finish, and the event is worth 300 points). Historical completion rate is only about 35% for these hand-built, weight-shaved prototypes running at full g's in every coordinate for 22 km. What often kills them is engine cooling, either directly, or as a factor in some other failure. And heat

at Lincoln is brutal, out in the Nebraska summer, on an infinite concrete frying pan. Fortunately, after Michigan, we took a very hard look at cooling system redesign to try to beat those daunting odds. The heat exchanger that resulted had about double the heat transfer surface area of the HX that AU2016 was originally built with.

And those were our secrets – reliable, consistent, and fast. Drew was the lead driver, finishing his turn of 7 laps with only one heart-stopping shifting mechanism bobble, and really waking up the announcer. Daniel drove cleanup for 8 more laps, putting the car where he wanted it, and getting the crowd behind him. Our fastest lap was 89.358. Average was 91.658, and all of our laps, including slow-downs waiting to pass, yellow flags, shift hiccups, and all were between 89 and 94.083. S&T ran the fastest lap of the day in 85.777, but their consistency was much worse. Washington ran well with a 88.418 best lap, but had consistency and mechanical issues. Akron broke its wing, and had to retire. San Jose leaked oil. ETS and Wisconsin broke. Illinois was DQ'd for an oversized wing. Our total raw time of 1374.879 s was adjusted by three cone strikes to 1380.879, which was still faster than any other team's raw time (S&T had 1386.898 s). And so we won a Formula SAE Endurance Race, taking all 300 points. Our first ever Endurance win, and only our third ever FSAE event win. BTW – only 21 out of the 80 entrants completed the Endurance Race.



Following Endurance, our fuel consumption was measured (and re-measured, in an infinite process of impounding for the top Endurance finishers) and our efficiency was calculated. For this 100 point event, we scored 60.4 points for our 4.764 liters of fuel usage combined with our average lap time, placing 16th. University of California at Berkeley won Fuel Efficiency with 1.948 liters and the full 100 points. We usually make about 80 points in this event. Possibly a wing effect (dragging those drag surfaces), or possibly we're still optimizing the powerplant.

Adding it all up, we made another school record for total points – 853.6. This was just enough to squeak out the win over 2nd place Washington (853.1), 3rd Pomona (834.6), 4th S&T (825.1), and 5th Iowa State (785.5). Also a school record in overall place – our first win. One could say that we got lucky, just edging Washington. It would be more accurate to say that a championship performance in the Endurance Race, and great dynamic performance overall, were enough to pull us out of the hole left by Presentation and Fuel Efficiency, and take us to the top. Just.



Thanks again to all of our sponsors, this year and over the years, who have stuck with us, supported us, fed us, and helped us take our position as a top team. We have one more race this year – Formula Student Germany – and then we'll hit the drawing boards (well, CAD/CAE terminals) to create that fantastic AU2017 car.