WAR EAGLE MOTORSPORTS
FORMULA SAE TEAM
Race Report
Formula SAE, 11-14 May 2016, Brooklyn, Michigan

Auburn's Formula SAE team built another powerful, lightweight racecar for the 2016 FSAE Michigan Competition at Michigan International Speedway. This year we added a full aerodynamic package (front and rear wing sets), though these wound up just short of ready-to-play in the big league. Sans wings, we finished 2nd in the Acceleration event (tying our best-ever place in a Michigan event), and were positioned well going into the Endurance race (which settles the overall competition). But the luck of racing threw a hail storm at the (previously dry) track just before we went out, threw another during our run, left us slipping and sliding, and then dried off for cars running later. We wound up in 15th place overall (out of 120), missing the top ten by only 19 points.

FSAE Background

Almost every major North American engineering college fields a Formula SAE team for competition in either Michigan or Nebraska, or in the related Formula Hybrid competition in New Hampshire. Official overseas competitions are held in Australia, Austria, Brazil, England, Germany, Italy, Japan, and Spain, with unaffiliated competitions in several other countries. Approximately 500 teams worldwide compete in Formula SAE, making it the largest motorsports manufacturers series in the world. The Michigan Competition at Michigan International Speedway (MIS) in Brooklyn (an hour west of Detroit) has by far the longest history and the caché of the "World Series of Intercollegiate Engineering". FSAE-MI is the premier event in engineering student design competition. Michigan entries are limited to 120, and these usually sell out within 10 minutes (geographic server path being a serious limiter). The 2016 Michigan Competition included entries from 35 U.S. States (top participating states were: Michigan – 11 cars; Florida – 8 cars; and New York and Pennsylvania – each 6 cars), as well as 33½ cars from 10 other countries/territories: Austria (2); Brazil (1); Canada (19); Germany (2½); Italy (1); Mexico (1); Singapore (1); South Korea (1); Puerto Rico (2); and Venezuela (3). [The ½ car represents cooperation between Oregon State University and the Duale Hochschule Baden-Württemberg - Ravensburg (DHBW-R - Germany) in a single entry].

Each college starts every year from a blank sheet of paper to design and build a single-seat, open-wheel autocross car, the lightest ones getting to below 400 pounds curb weight. The teams are subject only to a 610 cc engine displacement limit, a 20 mm diameter intake restriction, wing span and placement limits, and absolute adherence to the letter and spirit of a thick set of safety rules. The goal of the Competition is to design and build a prototype for the weekend autocross enthusiast. The teams must demonstrate their prototype cost and manufacturability and sell their design to an investment audience, as well as proving their machine's abilities on the racetrack. Designs are judged by a who's who of race engineering professionals, with strong support from top engineers in the racing and automotive manufacturing industries. Although FSAE cars do bear a certain resemblance (due to requirements for: open-wheel architecture; at least

four wheels; minimum wheelbase; minimum wheel size; working suspension), design judges and qualified automotive engineers never fail to express surprise at the design diversity from team to team and from year to year. Apparently, the perfect design in this ultra-competitive discipline has yet to be identified. Or perhaps it's that each design is only an expression of each team's goals and philosophy, and success can come in many different forms. The resulting cars are amazing – Auburn's best accelerating car (this is an FSAE combustion class record) can do 0 to 60 mph in 2.7 s.

FSAE competitions are 3½ day affairs, beginning with an opening half day for the hyper-exacting Technical Inspection. Cars not passing Tech that day may try again, throughout the Competition, but suffer from getting further and further behind on the rest of the schedule. The next day presents additional inspection issues: checking tilt (no leaks at 45°, no rollover at 60°); noise (110 dB(C) max); and brakes (four wheel lockup from speed). Also on this day are the static events that make up 32.5% of the points: Design (explanation of the technology and design process to a judging panel); Presentation (selling the merits of the design as a product to an investment panel); and Cost (proving the reported manufacturing cost estimate). The second full day sees the cars running in: Acceleration (time to 75 m); Skid Pad (time on a 50 ft. diameter circle); and Autocross (what the cars are made for – usually a 1 km course) – another 27.5% of the points. The final day is reserved for Endurance - 22 km of lapping on a course similar to the Autocross course, with one stop for a driver change. Endurance includes a measurement of Fuel Efficiency (a function of the product of average lap time and total fuel consumed), and Endurance time plus Efficiency comprise the last 40% of the points (30% for Endurance, 10% for Fuel Efficiency). Only about one third of the entries are typically able to complete the Endurance Race, and thus get any Endurance/Efficiency points at all.

Although stirring race results are the immediate goal of any FSAE team, the real product is the teamers themselves. They learn the hard project engineering lessons of teamwork, metric-based overall design, devil-in-the-details machinery design, project planning and scheduling, financial control, supplier interface, communication (written and oral), and how to enhance each ability to make the whole greater than the sum of its parts. Most importantly they learn (and prove that they have) that special moxie that it takes to get a real running product out the door on time, under budget, and up to a demanding – and rigorously measured - performance specification. They learn that a prototype design is just that – a prototype. It isn't ready to race until they learn a whole lot more about how to get the most from what they have just built.

FSAE has been running since 1981. Auburn has competed since 1996, placing 2nd in 2013 in Nebraska, 3rd in 2004 in Michigan, 3rd in 2007 in California, 4th in 2003 in Australia, 5th in 2003 in Michigan, 6th in 2006 in California, 7th in 2014 in Michigan, and 8th in 2009 in California. Team members tend to be mechanical engineers, though a spectrum of other engineering and non-engineering disciplines are also represented (given current team interests, there is a push for more aerospace engineers, computer scientists, electrical engineers, industrial engineers, and managers in marketing,

management, and accounting). Team alumni are widely sought after, with professional racing and the automotive manufacturing industry working hard to retain first dibs.

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FSAE Michigan 2016

Universität Stuttgart (Germany) walked away with the 2016 win, ahead of both Graz (Austria) schools – Technische Universität Graz and Fahhochschule Graz. Global Formula Racing (GFR - Oregon State and DHBW-R) was fourth, followed by Michigan State University to round out the top five. The top ten included Wisconsin, Missouri Science and Technology, Michigan - Dearborn, Florida, and Fachhochschule Hamburg. Just out of the top ten were Pittsburgh, National University of Singapore, Carleton (Canada), Cincinnati, and Auburn. Stuttgart ran lots of power (Yamaha R6), not much weight (10 in. wheels), and a finely-fitted aero package. Both Graz cars followed similar philosophies. It seems that the preferred concept is becoming 'doing everything right', instead of one magic system or component choice. GFR ran its usual big aerodynamics package with a 450 single and 10 in. wheels. Michigan State followed the game plan of the top three.

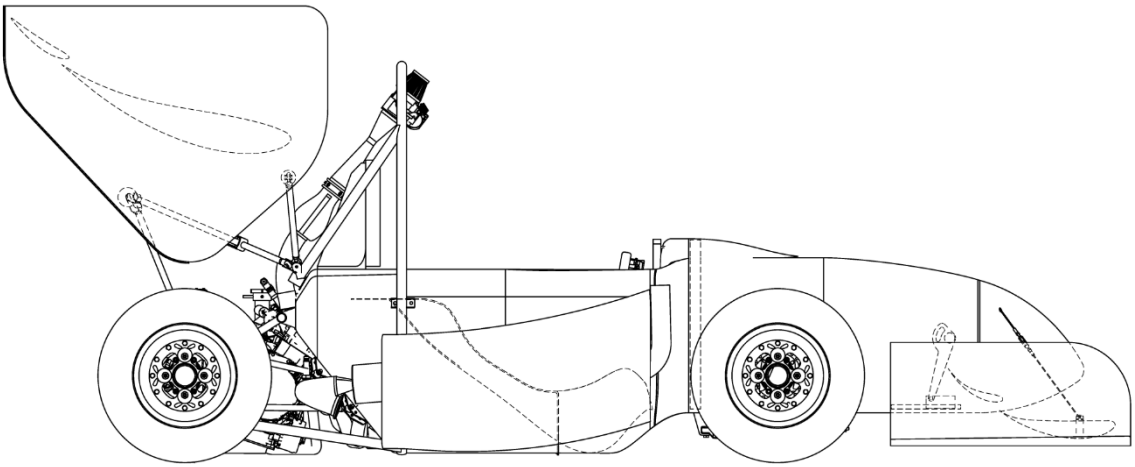
Auburn FSAE 2016

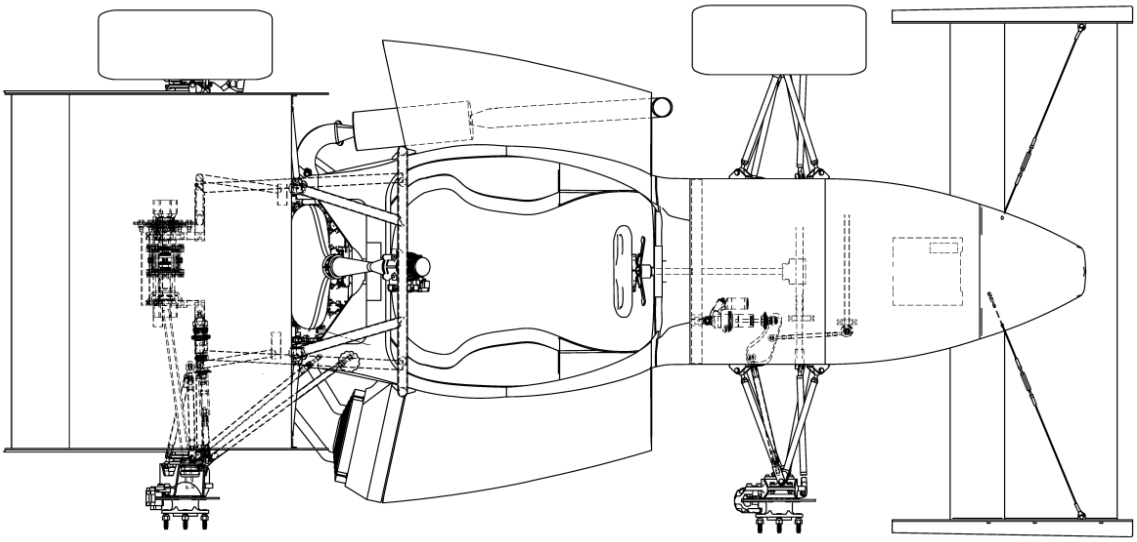
AU/FSAE 2016 was led by Captain Jonathan Ashworth and Division Heads Andrew Cookston (Electrics), Kyle Kubik (Chassis), Joe Stitt (Powertrain) and Payson Williams (Marketing). Other designers included: Drew Campbell (composites); Davis Edwards (brakes); Daniel Hardin (acoustics); Steven Hough (fluids); Alex Locker (cooling); Michael Moritz (aerodynamics); Lee Neidert (drivetrain); and Mark Stepnowski (cost, wheelsets). Vital jacks-of-all-trades included: Nathan Baker; Nick Boehm; Stuart Coats; Alex Conrado; Trey Danks; Trevor Dimock; Rickey Gable; Bryan Golden; Mike Holland; Daniel Maddux; Andrew McCooey; Harrison McCrorie; Preston McGurn; Isabel Perry; Ryan Reeves; Taylor Sanford; Evan Stegner; Garrett Vickery; Hunter Wilkinson; and Matt Zeng. Also joining us was Jeffrey Dejax, our exchange student from École d'Ingénieurs Sigma Clermont. Simon Descarpentries, Jeffrey's predecessor and now an engineer at Renault-Lille, flew from France to join us at competition. So if you're adding it up, you're right – at 35 souls on the ground, a new AUFSAE competition record.

The emphasis for 2016 was solidifying our many gains from previous years, trying to nail down electronic throttle control, engine cooling (though we did not solve our nagging behind-the-seat thermal management problem), acoustics, continued composite structure miracles, our usual erudite suspension design/performance, and more and more electronics. Wet sump lubrication (under weight/height reduction and huge lateral acceleration) was finally solved by good design and brute force analysis. All this was made much more difficult as a large fraction of the team's more effective members were dedicated to the aerodynamics effort. We like our light-and-powerful concept, but we know that to stay with the FSAE curve, we need to do aero and do it well.

The scramble had a predictable effect on project management, and we finished design late and the car ran late (though note that we have tightened up our definition of

'really finished' – this had an effect on the achieved completion date). But the team was experienced enough to make up ground quickly, and we were prepared going into Michigan (just).





One final adjustment, just days before departure, was the deletion of the aerodynamics package (the 'wings'). The car was sorting well with this new (for us) concept, and the drivers were getting used to it. But hitting a cone at speed in the last days of practice brought up both the urgent need for heavy front wing repair, and the nagging thought of what might happen to our (now apparently fragile) wings at race, where that kind of damage would lead to a DQ. We decided that the better side of valor was to leave them for the Michigan race.

Day One.5 – Static Events

SAE tried a few things this year. Fully pre-registered teams were able to park their trailers Tuesday night, saving the infinite lineup Wednesday morning. Also, we

participated in the beta test of a new Cost Report system. This was a little more work, but gained us a complimentary early Tech Inspection number. With the exception of a template clearance issue, which called for review all the way up to Top Tech and a lot of talk and faces, we were eventually passed on that, and on everything else, thus passing Tech Wednesday night on the first time through – a rare event.

On Thursday, we failed Tilt Test. Really. (The former FSAE Program Manager once asked "has anyone ever actually failed Tilt Test?" in consideration of doing away with it). Our center of gravity is so low, on our usual track width, that it is hard to get the fuel tank vent high enough, and shielded from the cockpit, to not leak at a 45° roll. A quick fix with some tubing and guard plate, and that embarrassment was behind us.

We passed noise on our first try. One can be assured that this sentence brings tears to the eyes of many of our alumni.

Brakes too (though this is a test we have historically had less difficulty with). And so we were good to race.

The Cost Event (on Thursday) includes 40 points for the actual prototype cost, 20 points for the Cost Report (turned in a month earlier), 20 for evaluation and inspection at the event, as well as feasibility for volume production, and 20 for the team's on-the-spot solution to cost reduction in a system of the judges' choosing. We had a very good Report (18.76) and on-event evaluation (19), and made the full 20 on our cost-reduction solution. But we do have a well-turned out car, and our prototype cost of $18,233 (more onboard electronics this year) gave us only 7.26 points out of 40, for a total Cost score of 65.02 out of 100, good for 45th place. Tennessee Tech won Cost with a score of 96.44 ($5,507 on reported prototype cost and good other scores). The lowest prototype cost was Tennessee Tech and the highest was Worcester Polytechnic Institute with $37,406. Mean cost was $14,695, with a standard deviation of $4,443.

In the Presentation Event we scored 56.5 points out of 75 to place 27th. The National University of Singapore won the event with the full 75. We rolled out a new style of business proposal, looking beyond the car design to the business setting in which it would be used. Our judges felt that we needed a bit more of the old school technical presentation.

Our Design Event put us in a 26-way tie for 12th place with 100 points. Apparently something is distracting the Design Event. Stuttgart won Design with the full 150 points, followed by Fahhochschule Graz, Wisconsin, École de Technologie Supérieure, and Fachhochschule Hamburg.

Overall static events put us in 22nd place with 221.5 points (out of a possible 325). The top five at that point were Stuttgart (291.6), Wisconsin (256.8), Singapore (248.9), FH Graz (246.6), and Tennessee Tech (242.8).

Day Two – Short Dynamic Events

Davis Edwards and Nick Boehm drove Friday morning in Skidpad and Acceleration – two runs each in each event. In Acceleration, the car stood up and did what it was designed to do, pulling off a 4.103 s time for 75 m. That was good for 2nd place and 73.01 points out of 75, and tying our best event finishing place in Michigan. Michigan State won the event in 4.065 s for the full 75 points.

Our best Skidpad time of 5.015 s (best average of left turning circle and right turning circle) is a school record and was the fastest time in the field for a non-wing car. When tabulated against our winged friends though, the time yielded 10th place and 34.64 points out of 50. Stuttgart won Skidpad in 4.714 s.

Drew Campbell and Daniel Maddux took over driving for the Autocross event. Our standard strategy is for the first driver to make a solid run, staying on the course and not breaking the car – getting a decent score on the boards. Then the second driver cuts loose, pushing the car to its potential, but taking a few risks in the process. The first part of this went fine, yielding a run of 53.611 s. The drivers huddled, watching the GoPro files and discussing tactics. Then the second driver launched, hit the course hard, and ran out of gas. We had gotten a little greedy when fueling up for the day, hoping to get away with carrying less fuel weight. In perfect hindsight, that might not have been the best way to play the game. But as it was, there was no time to get to fuel and get back through the deepening line pushing into the end of the day. So our best was the 53.611, good for 28th place and 80.35 points out of 150. TU Graz won Autocross in 45.479 s.

Our short dynamic event total was 188.0 points (out of a possible 275), 13th best in the field. Stuttgart had the best day with 254.8. Heading into Endurance, we were in 13th place overall with 409.5 points. Stuttgart led with 546.4.

Day Three – Endurance and Fuel Efficiency

Endurance is run in reverse order of Autocross finish. So the slower autocross cars ran in the cold-but-dry Michigan spring morning weather. We ran shortly after lunch with the faster-but-not-really-fast group, a consequence of the fueling decision of the day before. A few cars before we were released onto the track, hail started to fall. At first just enough to make us nervous, but soon we had to admit that the track was seriously wet. Standing puddles over much of the course. Drew and Daniel did their best. Our testing data showed that even in the wet, our racing slick tires performed better than our mandated rain tires. And so when the track was declared damp, allowing cars to change to rains if desired, we stayed on our slicks. Drew had a very tough time staying on the course, collecting cone and off-course penalties, but completing his stint. Shortly after the driver change, with Daniel now sliding the car around, the hail came back hard and the race was suspended. The track was declared wet, requiring rains. Daniel came back out on the grooved tires, actually performing a little better (it seems that the concrete tarmac that we practice on has rather different wet performance characteristics than the smoothed asphalt of MIS). Rough as it was, we did finish the race. And then the weather got nice again. The sun dried out the track in time for the cars who had beaten us in Autocross to get good runs and get further ahead.

Our raw time was 1625.726 s for 22 km. But this was adjusted by 4 cone and 3 off-course penalties to 1693.726 s, good for 30th place and 168.0 points. TU Graz won Endurance in an adjusted 1416.256 s for the full 300. Finishing percentage was unusually high – 65 finishers out of 100 starters (out of 120 entries). The usual percentage is closer to 35%. But overheating is often the failure cause, and the cold weather made this less likely.

Our Fuel Efficiency suffered as well, with a lot of fuel expended to spin the tires. We burned 4.539 l to place 43rd with 56.4 points. California Polytechnic State University – San Luis Obispo won Efficiency with 2.606 l of fuel burned to gather 100 points.

Conclusions

Adding it all up, our point total (633.9) landed us in 15th place. This is frustrating, because we had the car and people for a top ten, but didn't manage our luck well enough to pull it in. Nevertheless, our cars are better (even as the field improves), and we have trained some illustrious alumni.

It's always hard to say goodbye to the good teammates, even though we know that they are ending merely the active stage of their membership in War Eagle Motorsports, and are entering that honorable institution, the War Eagle Motorsports Alumni Association. I.e. we know where to find them. Our best wishes for fair winds and following seas go to: Jonathan Ashworth, who will return to Auburn to finish the Electrical part of a dual major in Electrical and Mechanical Engineering; Kyle Kubik and Alex Locker who will begin graduate study in Mechanical Engineering at Auburn; Lee Neidert, who will join Alternate Energy Solutions/Ga in Peachtree City; Mark Stepnowski who is leaning toward General Electric; and Joe Stitt who was snapped up by Honda Racing Development. Daniel Hardin is just finishing up his Master's thesis in Mechanical Engineering, and considering his options.

For 2017, we have a new team organization. Payson Williams will be Team Principal. Drew Campbell is Technical Lead, while Nick Boehm is Business Lead. Key technical group leaders are: Davis Edwards (structures); Steven Hough (powertrain); Tori Moffa (driverless); Michael Moritz (aerodynamics); and Hunter Wilkinson (electrics). Key business group leaders are: Sarah Ennis (sponsorships); Harrison McCrorie (media); and Bradford Smith (outreach). Formula SAE Electric continues, with a goal of putting a working powertrain on a dynamometer (then we'll wrap a chassis around it). And yes, there is a new project for a driverless Formula car.

2017 technical plans include: an engine switch (new FSAE rules allow a larger displacement with the same intake restriction, opening up some interesting choices for building the powertrain group); stronger, lighter, higher downforce wings; a tub that is designed-for-manufacture; and continued improvement of electronic control.

But the 2016 season goes on. As is becoming our tradition, this is led by the incoming team management – as the graduating seniors retire after Michigan. We are looking forward to strengthening the aerodynamics package and running a very different kind of Formula car at Formula SAE Lincoln (Nebraska) in June. And at the end of the summer, back to Formula Student Germany in Hockenheim.