Auburn’s Formula SAE team placed 12th out of 120 teams from 10 countries and 36 U.S. states in the prestigious FSAE Michigan Competition at Michigan International Speedway (we were the 5th place U.S. finisher). It was almost even better than that – almost our best ever. We qualified for Design Finals for the first time in Michigan, and placed 3rd in the Presentation event. We placed 5th in the Autocross event, and were in 5th place overall going into the final day’s Endurance event. But for the fast cars at the end of the run order, an unfortunate track oiling incident, sandy cleanup, and enough delay for the rain to come in, gave the fastest Autocross cars some of the slowest Endurance times. The luck of racing is a fleeting thing. But the solid reality is that Auburn built its best FSAE car ever – a strong performer with a head-turning design; a product of mind and heart by a magnificent team.

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. Overseas competitions are held in Australia, Austria, Brazil, England, Germany, Italy, and Japan. Approximately 500 teams worldwide compete in Formula SAE, making it the largest motorsports series in the world. The Michigan Competition, now held 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 a day or two (the new record, set this year, is 10 minutes). The 2013 Michigan Competition included entries from 36 U.S. States, as well as 32½ cars from 9 other countries: Austria (1), Brazil (1), Canada (18), Estonia (1), Germany (3½), Mexico (1), Singapore (1), South Korea (3), 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, 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), 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 is that each design is only an expression of each team’s goals
and philosophy, and success can come in many different forms.

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 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 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 finishing time and fuel consumed), and finishing time plus
efficiency comprise the last 40% of the points (30% for speed, 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 3rd
in 2004 in Michigan, 3rd in 2007 in California, and 5th in 2003 in Michigan. Team
members tend to be mechanical engineers, though a spectrum of other engineering and
non-engineering disciplines are also represented. Team alumni are widely sought after,
with professional racing and the automotive manufacturing industry working hard to
retain first dibs.

FSAE is a real world experience, and is not possible without real world tools,
facilities, parts, and supplies. Access to these essentials would not be possible without
the generous support of our major sponsors. War Eagle Motorsports is enabled by:
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**FSAE Michigan 2013**

Germany’s Universität Stuttgart took home the win ahead of Tallinn University of Technology from Estonia. The top five filled out with Akron (USA), École de Technologie Supérieure (“ETS” – Canada), and Universite Laval (Canada). Completing the top ten were: Cornell (USA); Technische Universität Graz (Austria); Centro Universitario da FEI (Brazil); Michigan State (USA); and Florida (USA). Universidad Simon Bolivar (Venezuela) placed 11th ahead of Auburn. Stuttgart ran a full carbon monocoque with a 600 cc I-4 (Yamaha R6), minimal aerodynamics (groundplane), and 10 in. wheels. They weighed in at 408 lbs. There were a lot of big wings around the paddock, as teams seem to be deciding to either go way up on the aerodynamic package, or cut way down on it. The little 10 in. wheels are getting more popular. There is still a pretty even split between the I-4 sportbike engines that come up close to the 610 cc displacement limit and the light-but-finicky single cylinder 450’s. Although success is clearly a matter of outstanding concept embodiment, and not of concept choice per se, it
looks like the arch-typical FSAE racer is becoming a full carbon tub, 450 cc single, 10 in. wheel machine with huge aerodynamics and a weight reaching down towards 300 lbs.

**Auburn FSAE 2013**

AU/FSAE 2013 was led by Captain Roy Crump, Chassis Chief Engineer Austin Gurley, Powertrain Chief Engineer Zach Woollen, and Marketing Director Andrew Rains. Lead Designers included: Jimmy Gordon (drivetrain); Sherrod James (electronics); Brian Keyser (electronics and braking); Eric Lidvall (ergonomics); C.J. Milstead (weldments); Chris Moritz (chassis); Greg Olin (powertrain); Chandler Reynolds (IT); Henry Risberg (powertrain); Chip Stallings (chassis); Joe Stitt (powertrain); William Teague (chassis); and Kurt Wagner (composite structures). The vital jacks-of-all-trades were: Jonathan Ashworth; Jordan French; Kyle Kubick; Lee Neidert; and Mark Stepnowski. Bastien Oppenhauser joined us as an intern from the Institut Français de Mécanique Avancée (IFMA) in Clermont-Ferrand, France.

In 2012, AUFSAE decided to pursue a design development strategy, carefully improving the engineering design of a semi-stable concept, instead of working the kinks out of a brand new concept every year. Trouble was, 2011 wasn’t quite the concept we wanted to develop. 2011 was the most recent of a long line of AUFSAE chromoly space frames. With the racing world, the FSAE world, and the engineering design world using more lightweight composite structures, the 2012 team took a conceptual leap with a hybrid structure: a carbon composite tub enclosed the driver and formed the front of the car, while a chromoly spaceframe, efficiently accommodating the engine and rear suspension, was bolted to the back of the tub. This was the basic concept that the 2013 team settled on, to take further into engineering development.

AUFSAE 2013 developed a unique commercial approach to this concept. FSAE cars are intended to be commercial prototypes – sporting vehicles for the autocrossing public. In real life, they are defined by a Sports Car Club of America (SCCA) class, and privately owned ex-FSAE cars often take fastest-time honors when competing in SCCA Solo II events (beating cars that cost many times more). But FSAE cars are typically powered by motorcycle, ATV, or snowmobile engines, and these are not available as a steady supply stream to a potential FSAE car manufacturer (i.e., Yamaha might simply decline to supply us with 250 units per year for our projected production scheme). FSAE cars are powered by engines of convenience – rebuilt from salvage. So for its commercial approach, AUFSAE 2013 went realistic and chose a design concept that is engine neutral – the rear spaceframe can be adapted to fit an engine of the customer’s choice, or any engine of opportunity. Then the rear package bolts up easily to the common front tub. And so (investors, are you listening?), we have a fast car with a realistic business logic case – not just a manufacturing fantasy.

Of course, our prototype needs a specific engine, and we ran the Yamaha R6 for the third year – this time with a robust variable runner length system. Variable cam timing and generally good tuning and gas path design brought us to 80 hp at the axles – an AUFSAE record. The car is significantly lighter and lower than 2012. Cleaner and better packaged. Broader g-g plot. Lighter steering. More comfortable. Better thermal
management. What you would expect from a good team taking a good concept and working hard all year to make it better.

On the way to 2013, we rejected the FSAE current common wisdom of little wheels and big aero packages. We ran all the available 10 inch tires (rim diameter) on our simulations, and concluded that we have a wider performance envelop with the 13 inch wheels, even allowing a healthy weight savings by the smaller-wheeled cars. We rejected an aerodynamic package for the same reason, deriving that lower weight and drag and better lateral weight transfer from a softer suspension more than made up for the lateral resistance that an aero package’s downforce could gain for us.

All this design work was completed by the October 1st design freeze that experience has taught us to impose (in fact, we decomposed this to part design complete by September 1st, so that assembly design - and part redesign - would have a chance to meet the later deadline). We also met the next big goal of driving by the end of February (really it’s driving by E-Day, but E-Day came early this year, and so we missed it by a couple of days). Success in FSAE depends upon the team making two vital transitions every year – from design team to production team (i.e., freeze the design and get it into fabrication); and from production team to racing team (i.e., finish building it already, and start learning how to get the most performance out of it). Each of the three team types needs about the same amount of calendar time.

Our 2013 car weighed in at 442 lbs. (curb) – one of our lightest ever, and our lightest-ever I-4 car. The weight split is 48/52, very slightly rear-heavy (good for handling). Wheelbase is 65.5 in. on 50 in. and 48 in. front and rear tracks. Vertical center of gravity is 12 in off the deck. The Yamaha R6 engine, breathing through the FSAE 20 mm restrictor, tested 38 ft·lb at the wheels. We ran Hoosier bias-ply tires, and our electro-pneumatic, spark retard shift-without-lift system. Solid state relays with fault-detection capability enhanced electrical reliability.
Day One.5 – Static Events

In Michigan, the car just made it through Technical Inspection on Wednesday evening (a competitive advantage, not letting Tech spill into the full static events day on Thursday). Long lines and a poor position were a problem, but Tech’s addition of opening hours made up for that (FSAE event administration is tough, but usually more than fair). Thursday morning, we had no problems with Tilt (has anyone ever failed tilt?). Noise was a bit tense and took a few tries, but eventually we were judged to be just under the limit. Brake check (four-wheel lock-up) was no problem, and so we had a full Tech sticker to go racing with.

The Cost Event 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 did well on the Report (17.9) and on-event evaluation (18), and made the full 20 on our cost-reduction solution. But with a complete Report and a lot of nice things on the car, our prototype cost of $16,473 gave us only 12.6 points out of 40, for a total Cost score of 68.58, good for 46th place. Universidad Simon Bolivar won Cost with a score of 85.52. The lowest prototype cost was Universidad Autonoma Estado Mexico with $8,371. Mean cost was $14,363, with a standard deviation of $3,450. The highest prototype cost was RWTH Aachen Technical University with $29,172.

To jump right to the Presentation Event’s punch line, we placed 3rd. This ties the best we’ve ever done. And it surely takes nothing away from the heroic crew that put that 2006 3rd place show together in a hotel room the night before to say that this time we worked for it all year, planned for it, made it part of the design effort, and then went up to Michigan and delivered. Andrew Rains, Chandler Reynolds, and Jimmy Gordon did an excellent job of presenting a compelling business case (the video was awesome), raising themselves in the judges’ estimation with every spot-on response to a wide range of questions. In fact, after it was all over, the leader of our judging panel came over to see the car to make sure it was as good as we said it was. Skipping ahead, a new feature of FSAE is that the top three places in Presentation deliver their show again to the whole Competition field as a way of showing how it is to be done. It sure was fun seeing ours
again. 3rd place got us 67.2 points out of 75. Ecole de Technologie Superieure (ETS – a unit of the University of Quebec) won with the full 75.

We had a late slot for Design Judging – 4 pm (Design slots are no longer seeded by the judges’ relative impression of the non-scored Design Report, turned in a month earlier – this is a break from long-standing FSAE tradition). It did seem to go well. The judges’ questions were answered, they followed their system of progressively harder questions, and our guys stuck with them. There were a lot of smiles. Design judging goes from preliminary judging on Thursday (static day), to announcement of finalists Thursday night, to finals judging Friday night, to announcement of the winners at a design review before the awards ceremony Saturday night. So things got a little anxious back at the lakehouse Thursday night, waiting for the 9 pm online posting of the finalists. But sure enough, when the finalists were finally posted at 11:30, we had made it. Auburn’s first-ever Design Finals at FSAE-Michigan. You’ve got to hand it to the team – after the inevitable whooping and hollering, the team got right down to work to study and prepare for the main event the next night.

[Skipping ahead again, the finals were held on Friday night. The finalists were: Akron, Auburn, Technical Universität Graz, Laval, Michigan, Stuttgart, Tallinn, Global Formula Racing (Oregon State and DHBW-R), and Wisconsin. GFR wound up in first with 150 points. We tied for 7th with 105 points. We were the only car in finals without an aero package. Feedback from the judges was that we were still a little heavy for the rarefied air at the top of the field, and needed to make a much stronger case for not having a big aero package – i.e., lap sims.]

FSAE gathers a lot of industrial and technical interest, as a result of its outstanding ability to grow top-notch technical talent. Several companies add to their efforts to assist in the competition and publicize the opportunities that they offer by sponsoring special awards. Altair Engineering (makers of the HyperWorks software, among others) sponsors the William R. Adam Award for Development of New and Innovative Design Concepts. Well, we won it. Austin Gurley won it. Austin has been working on open-weave composite structures. These look like a latticed bread basket made of carbon fibers, but they have all of the torsional strength (and just as little buckling) as a tool steel half shaft, with almost none of the weight. We weren’t quite ready to use them as driveshafts (connection and balancing issues), but one made it onto the car as a headrest support structure, and the judges were entranced. The award was $1,000 for the team.

Overall static events put us in 7th place with 240.8 points (out of a possible 325). GFR led the field with 282.3.

Day Two – Short Dynamic Events

We started the morning with Skid Pad, with C.J. Milstead and Kurt Wagner doing the driving – two attempts each on a course that does one circle right to settle in and then one for time, then one circle left and one for time. Scoring time is the average of right and left. We ran 5.275 s for 31.96 points and 15th place – historically, our best time ever
on the MIS surface. But this year, it did seem that big wings were the answer, on this event, at this time, and in this place. ETS won Skid Pad in a remarkable 4.901 s for the full 50 points.

Acceleration is also run in the morning, with C.J. and Kurt still dividing the chores. We split between some runs using our launch control system, and some runs using our revolutionary (or at least, unusual), human-in-the-loop clutch slipping and throttle modulating system. The human response won out with a time of 4.307 for 20th place and 51.24 points out of 75. Cornell, with a well-developed turbo-charged R6 system (phenomenal awesome power), won Acceleration in a ripping 3.830 s.

Autocross is everything – the low-end torque so necessary to a good launch in the Acceleration event, the high-lateral-g steady turning of the Skid Pad event, plus an additional metric, the ability to snap-turn quickly into a corner. It’s the test of the overall racecar – what this product is designed to do. What we designed our racecar to do. And of course, driver skill matters a lot as well. Andrew Rains and Zach Woollen went out for the afternoon’s autocross, and came back with a magnificent 5th place in 49.794 s on a clean run (no cones or other penalties) for 132.14 points out of 150. GFR won the event with a time of 47.857 s.

Our short dynamic event total was 215.3 points (out of a possible 275), 6th best in the field. GFR had the best day with 248.5. Heading into Endurance, we were in 5th place overall with 456.1 points. GFR led with 530.8.

Day Three – Endurance and Fuel Efficiency

One could say that we felt good. Endurance is run in reverse order of Autocross. It was nice having a leisurely morning nutting and bolting the car, waiting for the start order to work up to us. It was nice rolling out to the track with the fast cars – the heavy hitters. Of course weather is always a problem in “spring” in Michigan, and we had been tracking the showers. But it looked like good luck – everything was dodging us except for that one little one out there, but it was far away. So the mood was anxious and excited, but mostly looking forward to our turn. Keep in mind that Endurance is never easy – the car might fail to restart at the driver change, or any element from a whole pantheon of badness might happen. But we had a fast, reliable car, and we felt it was going to be good.

The University of Michigan was 7th in Autocross, and so they started just a bit before us. They ran a dry-sump lubrication system. One of their oil hoses popped off, and laid a fine bead of oil down the center of the track. A slight stain, a half track-width away from any tires. But somehow it was decided to deploy the whole MIS oil spill response team. The track was closed. The trucks came out. 8 in. of Oil-Dry laid down by the front truck, and sort of swept up with a roller brush on the second truck. And then they went around again. The oil stain was still there, of course. And so was all that Oil-Dry, that just wasn’t going to get cleaned off much by those whirling brushes. By the time the track was reopened, that little shower had come in. And so the top six Autocross teams wound up racing the Endurance Race on wet sand.
Andrew and Zach were the Endurance drivers, and it was all they could do to stay on the course. No traction. No lateral grip. Just trying to finish to get some points. We wound up 17th in Endurance with 1565.934 s and, amazingly, no cones or other penalties. We got 196.0 points for that, out of 300. Not bad, globally speaking, but this year, we had hoped for so much more. Of the top six Autocross teams:

- GFR got DNS in Endurance (a battery issue possibly related to the delay);
- Missouri S&T failed restart at the driver change;
- Stuttgart finished 11th in Endurance with 1458.951 s (hats off to them – a minimally aero car, with not much more grip than we had);
- Kansas broke with 9 laps to go (electrical issues);
- Auburn as related above;
- ETS finished 8th in Endurance with 1443.444 s (perhaps the big wings help on sandy courses?).

Pretty poor showing by the top six.

The Fuel Economy Event has morphed into Fuel Efficiency. By a slightly complicated formula, this is a measure of average lap time multiplied by average fuel burned per lap (i.e., low value of the product is good). Running lots of throttle and taking lots of time cost us, and we used 3.994 liters of 93 octane to make an average lap time of 65.247 s. Our Efficiency score was 50.8 out of 100 for 18th place. Kettering won Fuel Efficiency, on a consumption of 2.334 liters of E85 and an average lap time of 68.248 s.

Conclusions

Adding it all up, we made 702.8 points out of 1000 to place 12th. We have a lot to be proud of (Presentation, Design Finals, Autocross – more importantly, reliability and consistency). We made a pretty strong splash (sayeth GFR – “Auburn is back”). And we have another race to go – the second annual FSAE-Nebraska in Lincoln, 19-22 June.

Every team has a what-if story to tell. These are usually a bit weak, first because, well, it didn’t happen. Second because every other team also has a what-if, and to really play this game, all the what-if’s should be combined, and that gets pretty subjective. But in this case, when it is bizarre circumstance rather than some failing by the team, it is hard not to think about it. Keeping our what-if as close to the ground as possible, let’s say Stuttgart won Endurance while GFR, Missouri S&T, and Kansas DNF’d (GFR will argue with this…). Just by Autocross finish, we would then be second in Endurance. So Stuttgart gets the 300 points, and we take 285 (that’s about 20 s back, as predicted by the Autocross result). That gives us 89 more points and a 6th place overall. But Akron’s, Tallinn’s, and Laval’s actual overall totals come from high points in the actual Endurance Race, when under our what-if they would all be down about 30 points, putting us in 3rd overall behind Stuttgart and ETS (who would also go up in Endurance points). We would also have been the top American finisher. But you can see how convoluted and speculative this gets. It is probably best not to go there.

An experienced team returns for 2013, to be led by Andrew Rains as Captain, Zach Woollen as Chief Engineer, Powertrain, and Kurt Wagner as Chief Engineer,
Chassis. We think we are starting to really hit on our concept of the best FSAE car. Look for us in 2014 with something that looks similar, but is a whole lot lighter, makes more power, runs cooler, and perhaps rolls on those itty-bitty 10 in. wheels. We should be running by E-Day.

The pity is we can’t keep all the good ones. Roy Crump, Austin Gurley, Brian Keyser, and Greg Olin all graduated at MIS, earning Bachelors of Mechanical Engineering and Certificates in Automotive Engineering (Brian also earned a Bachelor of Electrical Engineering). Eric Lidvall and C.J. Milstead, fine fabricators both, have completed their degrees as Bachelors of Business Administration. Greg will join Mercedes in Vance, AL. Austin and Brian continue at AU as graduate students. Roy got hired right out of our paddock at MIS by Waltrip Racing. Eric and C.J. are still mulling over their options. Fair winds and following seas to all of our distinguished alumni.