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UMSAE Polar Air Post-Competition Report

SAE International
2023 Collegiate Design Series

Prepared By: University of Manitoba

Pilot: Don Hatch

Faculty Advisor: Dr. Paul Labossiere, P.Eng

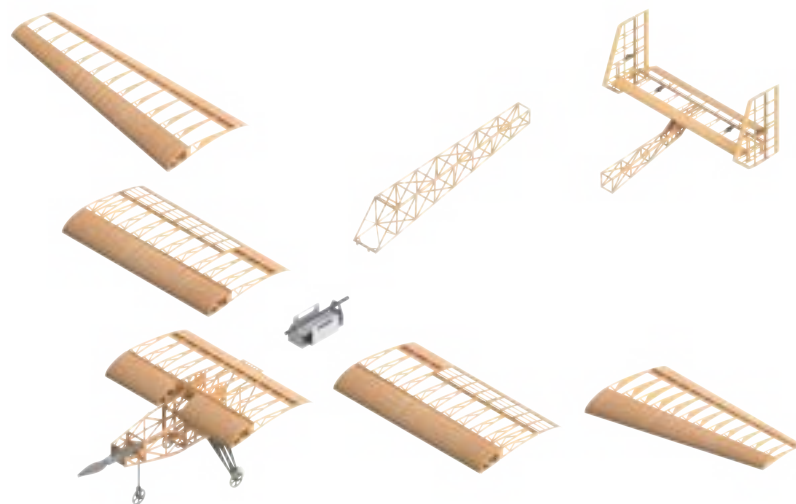
Prepared For: UMSAE Executive Committee

Design Background

2022-2023 was the first season of a brand-new ruleset for the Regular class of SAE Aero Design. The challenge set out for us was to build a large-wingspan, heavy-lift aircraft that could be parted into 4 [ft] sections. Our scoring was based on a design report, a design presentation, wingspan of the aircraft (more wingspan up to an 18 [ft] maximum = more points), and payload carried. Polar Air developed a clean-sheet design for our competition aircraft, with many tried and tested features from past years and some new developments aimed at improving manufacturability and performance.

Aircraft Design

The 2022-2023 ruleset was released in the first week of September. Polar Air held brainstorming sessions to develop our initial design over the next three weeks, eventually settling on a high-wing aircraft with a tricycle undercarriage and H-tail empennage. The 18 [ft] wing was sectioned into five parts, with the center section permanently attached to the forward fuselage. Ailerons were placed on the second sections towards the wingtips to keep the outboard sections free from wiring. This decision was driven by a requirement to assemble the outboard sections of the aircraft on the flight line as a practical consideration due to the size of the wing.



Exploded view of the 2023 plane

A boom fuselage section connected the forward fuselage to the rear section including the empennage. The undercarriage was a completely new design that was taller than past undercarriages to accommodate a massive 27 [in] propeller. That prop was driven by a Scorpion motor hooked up to a 3000 *mAh* battery. We returned to our classic H-tail after last year's T-tail design due to different aerodynamic considerations for the new aircraft. Connecting the sections proved to be a challenging design problem, and different joints were developed for the fuselage sections and the wings. Extensive testing was carried out to validate the strength of those connections.

Manufacturing and Testing

Polar Air used levelled construction tables and 3D-printed jigs to lay out and construct our aircraft. Each section was mostly built individually, but the section interfaces were built with the sections together to achieve tight fits. We started with a $\frac{1}{3}$ -scale prototype to test the aircraft configuration. Stability issues caused several failed test flights before we were able to complete a smooth circuit near the middle of October. We then delivered our Preliminary Design Presentation in the first week of November and moved on to full-scale prototype construction.



Crash-landed prototype plane after flight test at Steinbach South airport

It took a while to gather momentum on that build, but we were well underway by the end of November. We completed the plane during Christmas break, load tested the wing on New

Year's eve, and then test flew on January 2nd. Organizing the test flights presented an unexpected challenge when the Model Aeronautics Association of Canada put a ban on RC flying, invalidating Don Hatch's (our longtime mentor and pilot) RC licence. We instead received permission to fly at the Steinbach and Morden regional airports, and the aircraft was piloted by our fuselage lead Michael Kehler under a Transport Canada RC licence. Our first flight at the Steinbach South airport resulted in a soft crash after the aircraft proved uncontrollable. The issue was identified as insufficient aileron control, so we installed bigger servos and tried again. We completed two successful flights at the Morden airport in sub $-20^{\circ}C$ temperatures.



Repaired prototype plane in action

Competition Preparation

With flight tests complete, we moved on to report writing, preparation for our design presentation, and construction of our two competition aircraft. All section leads contributed to the design report throughout January, and we submitted the report shortly before the deadline on January 30th. We then began practicing and refining the design presentation roughly four weeks prior to our scheduled presentation date. Jazzy, Michael, Tony, and Ben delivered the 10-minute long presentation to a group of aerospace engineers from Lockheed Martin on March 3rd. Throughout, construction of our full-scale aircraft was underway. We underestimated the challenge involved in building these huge planes, and some details were incomplete by the time we left for competition on March 6th. Leaving the university proved to be a scramble, as we had to organize a rental truck the day after we discovered the dealer truck we had on loan had very limited insurance.

2023 SAE Aero Design East Competition

Once on the road we drove overnight to Chattanooga, TN and then arrived in Lakeland, FL on March 8th. We received very welcome news on the way to our AirBnB when the competition released scoring for the design report and presentation, with us placing 2nd in both. We flight tested the next day with mixed results, as our novel reverse thrust set-up proved finicky and the prototype aircraft flew poorly. We attributed the poor control to worn and mismatched aileron servos and trusted that our competition aircraft (with matched sets of new servos) would fly better. We worked late into the night on each of Wednesday, Thursday, and Friday to prepare our planes.



Plane A flying over Lakeland, FL

Our work first paid off on Friday as we passed technical inspection with no issues, and then again on Saturday as we completed multiple successful test flights. However, before those successful flights we had several mishaps with the aircraft overshooting or rolling off the runway, and at one point a wind gust blew the plane on to its wing. It took most of the afternoon to fix the damage and re-certify the plane, but then we achieved two high-scoring flights in the last two hours of operations. By the end of the day we were leading all flight scoring but continued to struggle with teething troubles in our reverse thrust system. Our closest competitors were teams from Puerto Rico, Brazil, Poland, and Mexico. On Sunday we attempted two flights but both overshot the

landing zone. Fortunately for us, our competitors similarly struggled to nail their landings on Sunday. We remained in first place in flight round scoring while Universidade Federal da Bahia of Brazil, the 2nd-place team, was a few points behind. Combined with our success in the technical report and presentation, we achieved first place overall in the competition.



2023 UMSAE Aero Competition Team

Tony Liang	Michael Kehler	Ani Kalia	Ga-Young Kim
Jazzy Kostelnyk	Maria Youssef	Ben Fransoo	Lucas Audette
Luc Maxwell	Brandon Dreger	Anh Nguyen	Haley Hwang
Darian Chakhmouradian	Joseph Nardella	Eric Crooks	Avery Barsalou

Special thanks to Don and Louise Hatch, this team wouldn't be what it is today without you. And thank you to all of our sponsors for supporting UMSAE and allowing us to compete against schools from around the world.



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UMSAE Formula Electric Post-Competition Report

SAE International
2023 Collegiate Design Series

Prepared By: University of Manitoba
Faculty Advisor: Dr. Paul Labossiere, P.Eng
Prepared For: UMSAE Executive Committee

The team started off the year excited for attending the June 2023 Formula Electric competition after the team's success the previous year. Unfortunately, part way through the year the team decided to pull out of the competition due to various unexpected challenges around the midway point. The decision was not an easy one to make, but the team felt it was the right path to take.

To help remedy this lost experience, Formula and Formula Electric decided to team up again, this time with Formula Electric members helping Formula get their car to competition. Members who had not been to a competition before were selected to have the opportunity to help the Formula team build their car and accompany them to Michigan!



Fig. 1. Formula and formula electric members beside the formula vehicle

If you are interested in what our members experienced in Michigan, you can read about it in the Formula report!



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UMSAE Formula Polar Bear Racing Post-Competition Report

SAE International
2023 Collegiate Design Series

Prepared By: University of Manitoba

Faculty Advisor: Dr. Paul Labossiere, P.Eng

Prepared For: UMSAE Executive Committee

Competition: Formula SAE - Brooklyn, MI (May 17-20, 2023)

Competition: Formula SAE - Brooklyn, MI (May 17-20, 2023)

Competition Rules:

The scoring system is based on a combination of static and dynamic events. The static events include a cost analysis, business presentation and design evaluation. Every team participates in this event as it is only necessary to have a car to be evaluated. The dynamic events consist of acceleration, skid pad test, autocross and endurance; cars that finish endurance also are evaluated on fuel efficiency. In order to participate in the dynamic events, the team must first pass four safety inspections: technical inspection, the tilt test, noise test and brakes test.

Competition Summary:

In the weeks leading up to the competition, the team was hard at work putting together the finishing touches on the car. One week before competition, the team held a mock technical inspection with some faculty members and alumni to help discover potential problems in passing this inspection. As the team has not built a car and attended competition since 2018, one of our big goals was to pass the technical inspection. As the day neared to leave for competition the car was just about finished, however, we were experiencing difficulties with the engine idle and the electronics system. We figured these problems could be solved with a bit of dedicated time and effort before technical inspection.

Wednesday, May 17 - Day 1

The first two days of the competition are dedicated to the static events, and the second two days are when the dynamic events take place. On the first day of competition, the team was busy tying up loose ends to get the car ready to pass technical inspection. Unfortunately it took quite a while to get the car into the paddock, resulting in us starting work on the car later in the day than we would have liked. The paddock is only open until 7:00 pm and the team was hard at work all day.

Thursday, May 18 - Day 2

Work continued on day two of competition and after a considerable effort by the team, the car

was ready to go for technical inspection by late morning. Although we did not pass on the first try, the team was encouraged as there were only minor changes necessary to complete the inspection.



Fig. 2. Members working on the car to pass the technical inspection

After this, the team participated in the design event, where design judges talk to each of the section leads and ask questions pertaining to their knowledge of the functionality of their section and how it is integrated into the whole car. This event went well, and the team learned a lot. Since the team has not attended competition in 5 years, there was a significant loss of knowledge and our score reflected this.

Once the design event was complete, the team headed back to the paddock to fix the issues from the first technical inspection. After a few hours we brought the car in to get reinspected, and we managed to pass! This was an exciting moment for the team, and a few members received mullets as a result of this success. To close out the day, we also participated in the cost event, where our cost report is compared to the final car. This went smoothly, and the team was ready to finish the safety inspections.

Friday, May 19 - Day 3

First thing in the morning, the team went to the fuel station to fill the car for fuel and test for leaks in the tilt test. The first time the car was filled with fuel we discovered a leak. We were able

to fix it and the second attempt there were no leaks. We immediately proceeded to the tilt test, where the car is tilted to 60 degrees to check for leaks and to make sure the car will not roll. We passed this event on the first attempt, and as a result we were now allowed to run our engine in the paddock. However, when we returned to the paddock, we noticed a very slow fuel leak. Upon further investigation, we discovered fuel leaking from the fuel pump electrical connector. This was a significant issue, and we spent the rest of the day resolving it. As a result of this setback, we were not able to complete the rest of the safety inspections and not able to participate in the dynamic events.



Fig. 3. PBR 23 on the tilt test

Saturday May 20, Day 4

Since we were not able to participate in the endurance event on day four, most of the team spent the day talking to other teams, gaining knowledge and watching the events. Even though it was disappointing that we were not able to participate, there were some positive aspects to this competition. We passed the technical inspection which was a major goal, and our car ended up being the sixth lightest out of 120 teams! We were encouraged to know that we had a fundamentally good car. Our goal for the coming year is to use the knowledge we gained to make small tweaks on our design and complete the car much earlier to allow for testing time.

Post-competition Activities

Even though this car will not be able to compete in a competition, we still wanted to validate our current design and see what would happen when we drove the car. We got everything sorted and

managed to test the car in one of the parking lots at the university on June 17. The car performed well, and proved to be a solid foundation for the years to come! Thank you to all our sponsors for their support, we would not be able to develop valuable engineering skills and experiences without your help. We brought our car to the DRIVEN Car Show on July 15 and the car won the Judges Choice Award!



Fig. 4. Award from the DRIVEN Car Show

2023 UMSAE Formula Competition Team

Aaron Loewen	Von Hanesiak	Daniel Penner	Murray McBain
Matthew Kolody	Austin Huynh	Araz Sadrzadeh	Riley Zacharias
Tyler Wiebe	Aayush Vij	Harleen Gill	Ethan Kolmel
Austin Smith	Jordyn Mailey	Jazmin Calumba	Hannah Dunlop
Micah Bartel	Harsharan Kaur	Kaya Jones	Isabelle Skonberg



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UMSAE Baja Red Lion Racing Post-Competition Report

SAE International
2023 Collegiate Design Series

Prepared By: University of Manitoba
Faculty Advisor: Dr. Paul Labossiere, P.Eng
Prepared For: UMSAE Executive Committee
Competition: Baja SAE Oregon 2023

Pre-Competition:

This year, the team faced the challenge of having very few returning members, but gained a wealth of new members early on, including members from Red River College Polytech. Many section leads were designing parts for the Baja for the first time, and so much of the fall term was spent learning and researching various designs and design methodologies, as well as understanding the design of the previous year's Baja and testing it in various ways.

The design phase was completed in early January, culminating in a formal design review, and manufacturing kicked off with the upcoming term. This year, the members from Red River were involved in manufacturing parts, as well as providing valuable insight in terms of designing parts for manufacturability.

Competition Details and Online Events:

The competition took place in Washougal, Washington, in Washougal MX Park, with an international competition roster of 86 teams from the US, Canada, Mexico, India, and Saudi Arabia.

This season the Business Presentation and Cost Report events were completed online, prior to in-person competition. In these events students presented the cost breakdown of the vehicle for mass production and presented the business case of selling 4000 units annually with a kit style 'Build-Your-Own-Baja.'

Wednesday, May 31 – Day 1 of 4:

Upon arrival, registration, and setup, the team utilized the day to engage with sponsors and establish connections with fellow teams. Exploration of the various dynamic event setups, finalization of vehicle preparations, and securing a position in the line for engine technical inspection occupied the team's efforts throughout the day.

Thursday, June 1 – Day 2 of 4:

Day 2 began bright and early with the team passing Engine Technical Inspection (sponsored by Kohler) first thing in the morning. Subsequently, the team members presented at the Design

Presentation (sponsored by Polaris), allowing the members to present all the hard work the various sections put into designing, testing, and validating the vehicle.



Fig. 5. The Team Lead Paolo Endrinal converses with the judge during the design presentation

Later that day, the Baja team attempted the Technical Inspection, resulting in a “Fail” due to 3 minor issues which were quickly corrected allowing the team to come back for reinspection and subsequently pass on the first day – this is a major achievement and was met with enthusiasm and excitement. Included in this, the team was able to pass the dynamic brake check and the 4WD component – the latter a new requirement for the competition this year. Passing Technical Inspection early proved to be huge, allowing the team to spend the rest of the day scoping out the dynamic events and strategizing for the next day.



Fig. 6. Team Lead Paolo Endrinal and Powertrain Lead Sebastian Kapustka look on as the Baja passes tech inspection

Friday, June 2 – Day 3 of 4:

Early in the morning, the team lined up to compete in the dynamic events which included acceleration, hill climb, maneuverability and rock crawl. Because the team had spare time between the events, we were able to have drivers tackle the practice track to gain a feel for the vehicle on the local terrain.

Acceleration:

This event measures the time in which it takes the Baja to accelerate from a standing start to cover a 100 ft stretch. It was found the vehicle performed best with 4WD engaged to start followed by turning it off approximately $\frac{1}{4}$ of the way into the track. The team was able to cover this distance in 5.14 seconds.

Hill Climb:

This event tests the vehicle's ability to climb high grades and rough, rocky terrain; the time in which it takes the driver to complete the course is measured as the parameter of interest. The team placed 27th in this event, with the Baja easily clearing the obstacles along the track.



Fig. 7. Powertrain Lead Sebastian Kapustka maneuvers the Baja over rough terrain during the hill climb event

Maneuverability:

This dynamic event quantifies the Baja's agility and speed to maneuver around various obstacles and challenges (sharp corners, pylons, hay bales, inclines, and drop offs). Despite being disqualified early in the first attempt for straying from the course, the team was able to secure 29th place with a time of 66.41s and no major penalties.



Fig. 8. Go-Pro footage from the maneuverability event

Rock Crawl:

This event pushes the Baja vehicle to its limits, where the driver must cross gates while traversing a challenging rock garden. Penalties of time/distance are given if cones or hay bales are contacted during the run. If the course is completed, the time with which a team does so is measured. Otherwise, the distance is measured. This places teams according to who went the farthest the fastest, emphasizing finishing the course over speed.



Fig. 9. Precariously bouncing over the rock gardens

Practice Track:

The teams were free to take runs on a designated practice track set up at the event. While this track did not score the team any points, it did allow the drivers time to familiarize themselves with the local terrain and get a feel for the vehicle before diving into the main events. The team was fortunate to have sufficient time to take a few runs on the track which helped the drivers gain confidence in the handling of the vehicle and allowed for a few last-minute adjustments to the shocks.

Saturday, June 4 – Day 4 of 4:

The final day was the Endurance Event, where all Baja vehicles race wheel to wheel on a 2.2 mile loop for a grueling 4 hours. Teams are able to stop and refuel in the pits, and are able to repair their cars if they break down, as vehicles are towed off the track to the team's paddock in the event of damage. The team placed 24th in the event, with two minor breakdowns in the steering system that were quickly repaired.



Fig. 10. The Baja (far left) traversing woops near the end of the track

Competition Results:

Competition Event	Distance	Time [s]	Score	Placement
Business Presentation	-	-	46/70	36/86
Cost Report	-	-	31.6/100	46/86
Design Presentation	-	-	50/150	48/86
Acceleration	-	5.14	-	50/86
Hill Climb	150 ft	23.32	-	27/86
Maneuverability	-	66.40	-	29/86
Rock Crawl	48 ft	24.55	-	45/86
Endurance	23 laps	4:15:59	-	24/86
Overall				33/86



2023 UMSAE Baja Competition Team

Ariel Lezen	Ethan Hornick	Avery Barsalou	Jenny Tran
Braden Weber	Katrinna Heppner	Bronwyn Rempel	Oluwalonimi Ajayi
Cadin Giesbrecht	Paolo Endrinal	Caelum McConnell	Rosemary Wilson
Davis Peters	Savan Panchal	Ethan Froese	Sebastian Kapustka

Message for our Sponsors, Alumni and all whom support us

We thank you very much for your support. It has allowed us to participate in this wonderful event, which has – and will continue to – immensely contribute to our knowledge and understanding of engineering, business, and professionalism. It brings joy and drive to our respective programs and forms lasting memories and connections.

We hope to be able to continue the relationships we have developed over the past few years and look forward to doing so with all whom support us. Keep an eye out for emails to organize tours, networking, and events with the UMSAE organization.