

TECHNION STUDENT PARTICIPATION IN SAE FORMULA DRIVERLESS INTERNATIONAL COMPETITIONS

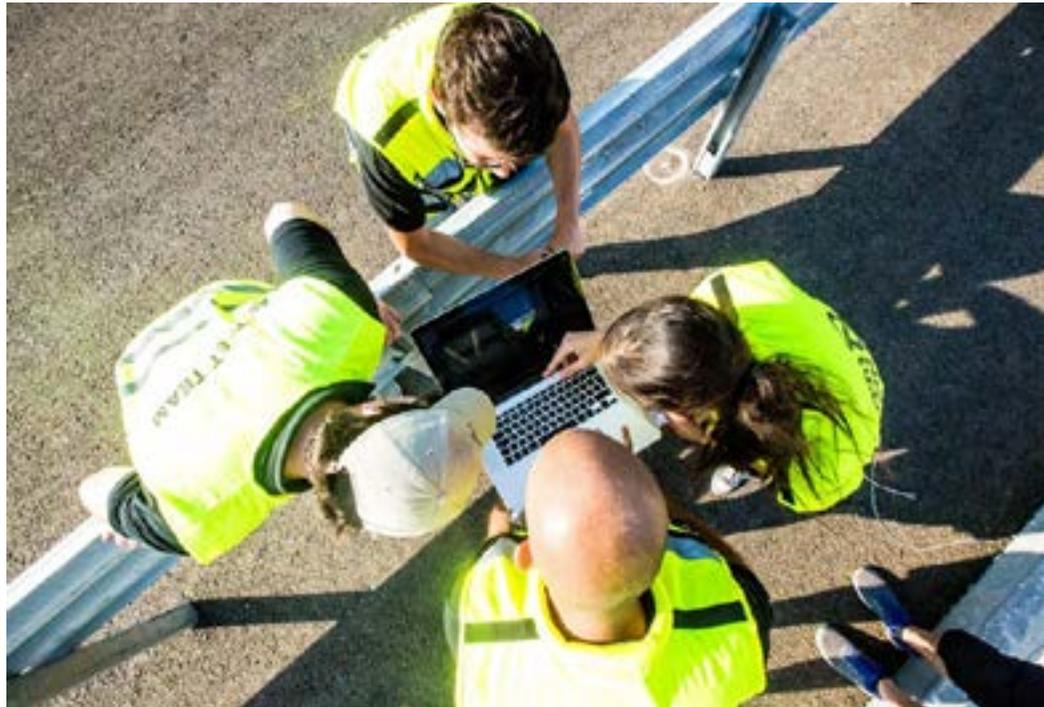


Executive Summary

Because Israel is such a small country, attending international contests such as those organized by the Society of Automotive Engineers (SAE), in which students design, build and race a small formula-style race car, are especially important ways for Israeli students to gain hands-on experience, to measure themselves against their competitors in the global marketplace, to build networks, and to ensure that Israel remains at the forefront in highly dynamic fields.

The Technion is proud that its formula student team, founded in 2013, has participated annually in Formula SAE (FSAE) since 2013 and plans to continue to participate in the regular competition. However, the team was inspired by the first Formula Student Driverless (FSD) race which was conducted in Germany in 2017 with fewer than six teams successfully competing and only one able to finish the entire competition. The Technion team decided to gather a second group of leading students from across the campus who share the dream of competing in the driverless event and being part of the autonomous revolution.

In 2018, they began a pilot project that consisted of converting the Formula Technion's 2016 car into a driverless car. A successful [test drive](#) was completed at the Ayalon Highway's autonomous vehicle testing area, where the car drove 300 meters without a driver. The car was also presented at the [NVIDIA GTC](#) Israel artificial intelligence technology conference in October 2018. The Technion team



plans to compete against leading universities from across the globe in FSD 2020 with an electric-autonomous vehicle. The project is dependent on economic and professional support from industry as well as mentoring from the team's advisors.

As Israel's first and leading institute of science and technology, the Technion recognizes the value and importance of encouraging students to take on the kind of challenge set by FSD. Israeli universities are constantly facing the threat of isolation and boycott, which heightens the importance of fostering international

links such as this competition. For many of the participants from other countries, these competitions will provide their first opportunity to meet Israeli students and learn to appreciate their ingenuity and spirit of comradeship. For Technion students, such competitions are an opportunity to serve as ambassadors of the Technion and Israel, and to establish new friendships that will last for many years. The **Fund to Support Technion Participation in the Formula Student Driverless International Competition** – will ensure the team's ability to compete and collaborate with their peers from the best universities in the world. Your generous contribution

will enable Technion students to take their place on the international stage and help keep Technion, and Israel, on the map.

Contribution requested: A \$200K expendable fund is required to support Technion participation in FSD.

Introduction

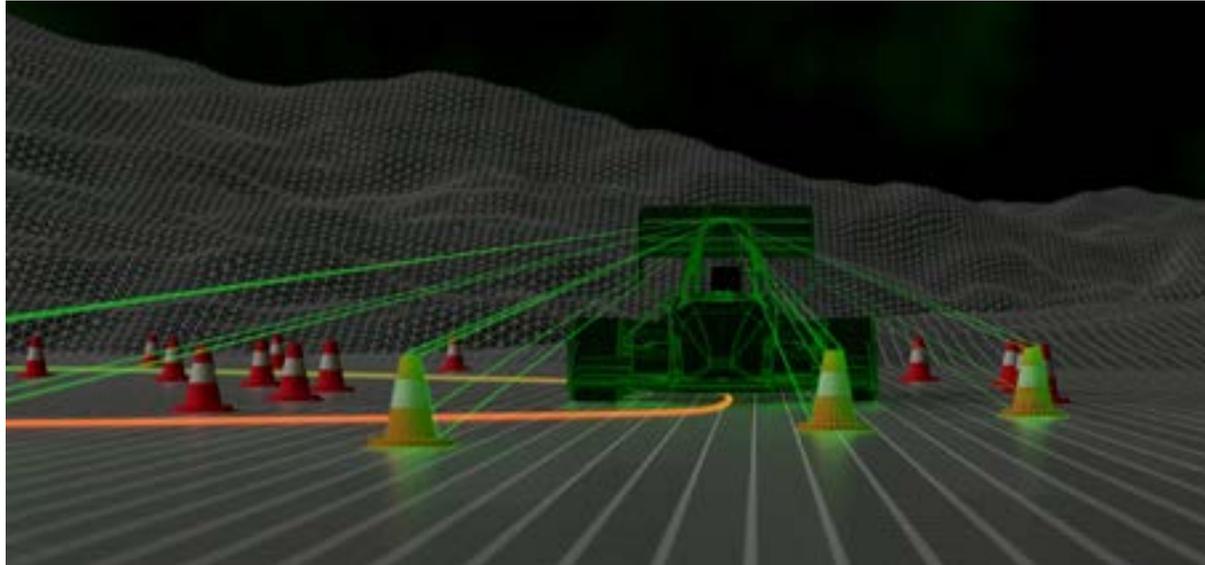
The Society of Automotive Engineers (SAE) has organized events and competitions for engineering students for decades. The most prestigious competition is Formula Student (known as FSAE or as Formula Student in Europe), established in 1979, in which students are required to research, design, and build a real formula racecar in competition with students from around the world. In 2017, a driverless competition was introduced.

The FSAE competition takes place annually in 10 worldwide race track events (US, Italy, Germany, UK, Japan, Australia, and other locations). Today, some 600 teams participate in the Formula Student competitions, and each competition includes between 25 to 100 competing teams. Each student group chooses in which competition(s) to participate (it is possible to compete more than once in a year).

Lasting an entire week, each competition involves dozens of FSAE teams from around the world who compete against each other in a series of static and dynamic events in which their car is tested, evaluated and ranked by the industry's highest profile engineers and designers from leading companies in the automotive industry such as Audi, BMW, Siemens, SKF, Continental, Porsche, Mercedes, Daimler and many others.

The concept behind the competition is that a fictional manufacturing company has contracted a student design team to develop a small formula-style race car.

The prototype race car is to be evaluated for its potential as a production item. Each student team designs, builds and tests a prototype based on a set of rules whose purpose is both to ensure on-track safety and to promote clever problem solving.



The competition starts with a series of technical inspections to check the vehicle for safety and determine whether the vehicles meet the requirements defined in the rules. The static events focus on the team's creativity, design, cost calculations and business plan. The dynamic events consist of several races that take the cars to the limits of their performance. The prototype race car is judged in a number of different events:

the Design Event, Cost & Manufacturing Analysis Event, Business Presentation Event, Acceleration Event, Skidpad Event, Autocross Event, Fuel Economy Event, and Endurance Event.

Apart from developing engineering and scientific skills, the competition sparks innovation and creativity in the young future engineers, who not only gain hands-on, real-world work experience, but also have the privilege of taking part in a once-in-a-life-time experience that includes teamwork, budget planning, fundraising, design, manufacturing and racing the car they built by themselves.

The students are unanimous about the most important thing they gain from participating in FSAE: experience. Upon graduation, they will be able to bring much more than a diploma to prospective employers.

Project Description

The FSD team is part of the Technion's flagship "Formula Technion" project and will leverage the years of experience acquired by students participating in the regular FSAE competition. The FSD team includes undergraduate and graduate students from mechanical, aerospace, electrical and industrial engineering, as well as computer science faculties.

In the competition, the team must develop and deliver a comprehensive business model that demonstrates their product, exhibit their understanding of the manufacturing processes and costs associated with the construction of a prototype race car, and prepare for the evaluation of their vehicle design and engineering process.

The dynamic events in which their vehicle must compete include:

- Skid pad, which takes place on a figure-eight layout (the average of the right and left circles is taken to determine the time)
- Acceleration, a drag-type event consisting of a timed 75-meter acceleration
- Autocross, a 1 km technical timed course requiring navigation between cones
- Track drive + efficiency, 10 laps of the autocross track and measurement of the energy required during the event



The Technion driverless vehicle that competed in Germany in 2018

The Timeline

The team is currently working to develop electric and driverless concepts including the electrical schematic, writing the “system requirements” document, ordering items that have a long lead time, and recruiting new team members from various Technion faculties, particularly mechanical engineering, electrical engineering and computer science.

During the spring semester (March-July), they plan to complete the design of the electric vehicle, develop the algorithms for steering, acceleration, and braking in simulation, use lidar and cameras to build a simulation of cone navigation, and develop a start-to-finish plan for the event.

The team’s aims for the summer semester (August-October) include manufacturing an electric car which is rules-compliant and can drive with a driver and adapting the PX2 autonomous car development platform and simulation to the new car.

The winter semester (November 2019-February 2020) will be devoted to running the car hardware and Controller Area Network (CAN-Bus) communication actuators, registering for the competition, assigning team members to static

events, and implementing the car algorithms.

The last stretch of development during spring semester (until mid-June) will focus on ensuring that the car is completely rules-compliant (to pass mechanical, electrical, and driverless inspection), making improvements, testing calibrations and visiting sponsors.



Students and Advisors

The FSD team's major challenges can be divided into two categories: building an electric race-car and developing an algorithm for fast and efficient autonomous driving. These challenges include the following components:

- **Motors and batteries:** To develop a powertrain with motor power of 30-60 kWh at 320V. The powertrain is controlled by the Vehicle Control Unit and is capable of regenerative braking. The motors have a water-cooling system and a temperature-controlled battery pack.
- **Cone detection:** To detect cones in different weather conditions, separating cones by color and route prediction to reduce runtimes and increase efficiency.
- **Stereo camera:** To detect distance to cones using one camera case with two cameras inside and synchronize the points between the two cameras after cone detection to reduce runtimes.
- **Mapping:** Integration of data from various sensors to draw a map with the cones. The vehicle must log the number of cones on the course and the log must be submitted to the competition.



The Technion 2018 FSAE vehicle (left) and the 2016 vehicle that was converted into a driverless car in the pilot project (right)

- **Path planning:** To find areas of the track where the car can drive and optimize the track based on the car's dynamic model.
- **Simulation:** Development of a simulation to virtually test the driverless algorithm.
- **Dynamic model:** To predict vehicle performance using a physical model.

- **“Learning” algorithm:** To develop an algorithm which receives an image input from cameras and sensors and “learns” to navigate between cones. Last year our pilot racecar drove at a constant speed of 15 km/h between cones using a learning algorithm. This year the team is aiming to improve the performance and drive faster with acceleration and braking with the goal of winning the competition.

- **Live mapping:** The team's first attempt at a driverless car last year only allowed for map development after driving since the algorithm was not fast enough to develop the map in real-time. The goal this year is to develop an efficient algorithm

which can create a map in real-time.

A brief [video summary](#) of the team's work on the pilot version of the car last year has been uploaded to YouTube.

The Technion FSAE Team

Founded by students in early 2013, the Technion's very first formula student team struggled to gain recognition and resources in its initial few months. During that time, a core of 15 students worked with great devotion in order to fulfill two dreams – to build the first-ever Technion FSAE racing car, and to set a precedent for Israel's first and best technology institute by participating in the 2013 Formula Student competition in Italy. The students succeeded in addressing two major challenges: studying and researching automotive systems and dynamics (engine, suspension, chassis, aerodynamics, etc.), and, equally difficult and important, acquiring the funding and technical resources needed

for a project of this scale.

The entire project was dependent on the students' success at obtaining financial as well as academic support. The team reached out to everyone who might have potential interest. Scrambling to find corporate sponsors, the students succeeded in making valuable personal connections with top industry fabricators, suppliers, engineers and consultants who generously donated raw materials and services including parts, labor, professional knowledge, software tools, logistics, clothing, and much more. This response to the students' huge efforts proved to the team itself, and to the Technion, that the project was feasible and that the students were capable of meeting the challenge.

In October 2012, the Technion's Faculty of Mechanical Engineering recognized the great potential and decided to support the project by officially recognizing it as a final-year project for its BSc students. This decision marked a turning point for the project, and participation in FSAE has become a Technion tradition ever since.

The vision is to encourage automobile engineering at the Technion and in Israel by establishing a lasting tradition of having a first-rate student team of formula car experts. The first stage of the effort is to annually build a car (and beginning with the 2020 competition, a driverless car as well) to participate in the international competitions. In the future, the hope is to host the competitions in Israel.



The intangible benefits of participating in FSAE include the experience of working with excellent teammates and the immense pride that comes from accomplishing so complex and challenging a task.

The primary makeup of the FSD team is as follows, and recruitment of additional students is underway:

1. Mechanical Engineering – 15 students are developing the actuators, battery pack, electric motors, dynamic model and integration. In addition, during the summer of 2019 until early 2020, more members will join to help manufacture and assemble the racecar. The chassis, suspension and aerodynamics will be heavily based on the 2019 combustion car with the adaptations required to meet the driverless and electric requirements.

Advisors: Dr. Naftali Sela – advisor (design), Prof. Reuven Katz – head of design program, Dr. Roman Shamsutdinov (control)

2. Electrical Engineering – 12 students are developing the algorithms, cameras, lidars and image processing.

Advisors: Dr. Eli Appelboim – advisor, Dr. Israel Berger – advisor, Johanan Erez – head of image processing lab

3. Computer Science – developing algorithms and autonomous software (currently recruiting)

Advisor:

Dr. Kira Redinski – advisor

Conclusion

Participation in FSD provides a unique opportunity for Technion students to carry out end-to-end development of an electric driverless vehicle while gaining valuable experience working with industry. The team brings together students from all backgrounds and a variety of academic interests. This year 25% of the team is female.

One of the team's goals is to promote the Israeli automotive engineering industry. To this end they partnered with high schools nationwide, conducting workshops for pupils and teachers showcasing the FSD

initiatives and engaging them in the fields of automotive engineering.

The team is eager to represent the Technion and Israel in international competitions. Corporate sponsors' names will be featured on the car, team shirts, social media and other platforms which promote the team nationally and internationally.

With your support, the Technion FSD team will be able to continue and expand its activities, with emphasis on establishing strong personal and professional partnerships, and creating a lasting legacy that will benefit the participants, the Technion, and Israel for many years to come. Success in the FSD competition depends on funding, and your generous donation will help the Technion reach the finish line.



Funding and Donor Recognition

Participation in FSD is dependent on funding by the Technion and external corporate sponsors, and all the external sponsor recruitment is carried out by participating students. Funding is required for the purchase of parts, materials, machining, experiments and tests, and the direct and indirect costs of participation in the competition.

The total cost of participation in the **Formula Student Driverless International Competition** is \$270,000, spread over a two-year period, with the bulk of the funding required in the first year, mainly for the purchase of parts. Of this sum, the team expects to raise ~\$70,000 in corporate sponsorships.

The donor's name and size of recognition appearing on the vehicle will depend on the level of funding provided (starting with the highest level appearing on the vehicle's nose, thereafter the rear wings, front wings and sides).

Option 1: A \$200K expendable fund.

Donor Recognition

1. The donor's name will get exclusivity in naming on the vehicle and will appear on the vehicle's nose and rear wings, in addition to the corporate sponsors.
2. The donor's name will appear in Technion publications and websites, as well as on the TSA Facebook page, in articles related to the FSAE competition.
3. The donor will be given the opportunity to meet with the FSAE team members before and/or after the competition.
4. The donor's name will appear in the "President's Report," the official annual report of the Technion.

Option 2: A Fund to Support between \$100K and \$200K.

Donor Recognition

1. The donor's name will be placed on the vehicle's nose and rear wings, in addition to the corporate sponsors.
2. The donor's name will appear in Technion publications and websites, as well as on the TSA Facebook page, in articles related to the FSAE competition.
3. The donor's name will appear in the "President's Report," the official annual report of the Technion.

Option 3: A Fund to Support between \$50K and \$100K.

Donor Recognition

1. The donor's name will be placed on the vehicle's rear wings, in addition to the corporate sponsors.
2. The donor's name will appear in all Technion and publications, websites, etc., as well as on the TSA Facebook page.

Option 4: A Fund to Support for under \$50K.

Donor Recognition

1. The donor's name will appear on the vehicle's rear wings, in addition to the corporate sponsors.
2. The donor's name will appear in Technion publications and websites, as well as on the TSA Facebook page, in articles related to the FSAE competition.



