GABRIEL CABANA
ELECTRIC MOTOR DESIGN • UNIVERSITÉ DE SHERBROOKE, ROBOTICS

# Shell Eco-Marathon: The drive for green

## A team of engineering students embraces environmental technologies in yearlong car build for international competition.

Energy plays a critical role in our world. As populations grow and prosper, we are faced with the realization that we must meet the ever-increasing energy demand while remaining environmentally conscious. A transition is needed.

A team of 27 students at the Université de Sherbrooke studying engineering  mechanical, software, electrical and robotics — is working on this transition. They had one year to accomplish their Bachelor's final project and ideas were flowing regarding an entry for a race to be held in April 2023.

### THE PROJECT

To represent the Universit  de Sherbrooke in Quebec, Canada, and their community at the Shell Eco-marathon international competition, the team chose to compete in the "Urban Concept" class: The vehicle must be designed for city driving and take human needs into account (four wheels, one passenger).

The team was registered in the battery-electric category. The transition toward green technologies and their development are core beliefs shared by the whole team.

Shell Eco-marathon is one of the largest international university competitions for engineering students in the world. The academic program brings together students of many disciplines to design, build, and operate vehicles. The goal is to travel the greatest distance possible on a limited, predetermined amount of energy. Collaboration, innovation, competitive environment, students bursting with bright ideas — that's what the Shell Eco-marathon is all about.

### THE VALUES

The team project is based on three values: innovation, excellence, and commitment.

- **Innovation.** The team had to overcome obstacles with imagination and creativity. For them, innovation is more than an improvement; it is a state of mind.
- **Excellence.** Aim higher; go further. They aspire to be the best they can be.
- **Commitment.** To themselves, to their project, to us, to our society.

As future engineers who want to build the world of tomorrow, the members of the team are 100 percent committed to energy-efficient vehicles.

### KISSSOFT: A KEY PARTNER

As the main goal of the competition is efficiency, it was critical to make sure there was no excess weight. One of the possible sources of excess weight is the transmission. There are a multitude of factors that can influence the efficiency of the transmission. As one might suspect, some of these factors are the type of transmission, the tooth thickness if not optimized adequately, and the overall geometry of the tooth. Generally, the easiest type of transmission to design and to manufacture is a simple gear train or even a compound gear train.

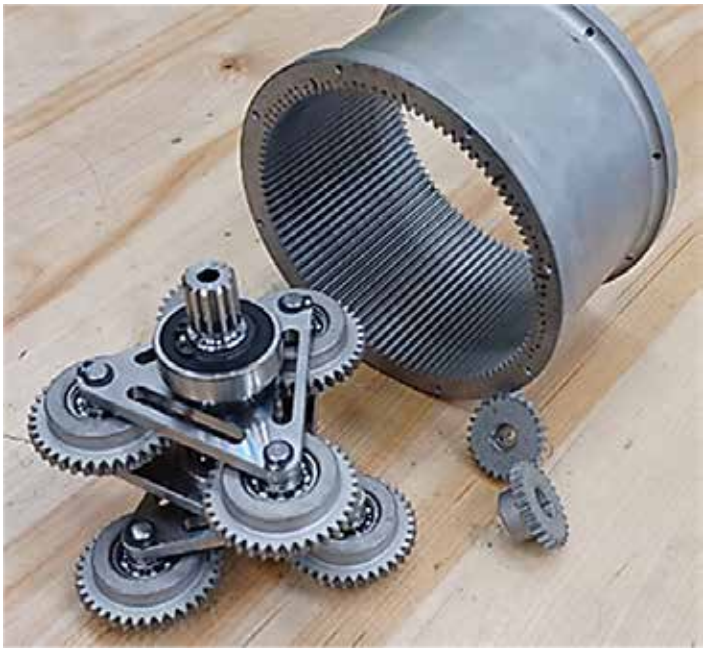

**Figure 1: Planetary gear train. (Courtesy: KISSsoft)**

As we discovered in our research, the gear train that would be optimized for its drivetrain was an epicyclic gear train. At first, that was a concern for us because the design is much more complex than other types. The one thing that made us choose this concept was the KISSsoft software suite. The multiple training offered within the software suite and the overall functionality gave us the confidence to design a planetary gears system. Typically, the thicker the tooth is, the higher the torque it can transfer. The team thus needed to optimize for the maximum anticipated torque, with a considerably lower safety factor than what is commonly used in the automotive industry since the vehicle doesn't need to function for more than a few dozen hours.

To achieve that goal, the team used the KISSsoft software to design the sun, planets, carrier, and ring of the transmission. They input the design parameters and constraints of their application — speed, desired gear ratio, torque — and the software generated various solutions, slightly tweaking the parameters for each. It was then easy to filter results by overall dimensions, overall weight, efficiency, and safety factor. With a solution selected, they then move to modeling optimization, still within the KISSsoft software. The design of the gear teeth was tweaked to further refine the desired characteristics as well as making sure that the final product could be produced with the available tooling and equipment. At the end of the process, a very detailed report of the solution can be exported to run it against other models for further validation or provide useful data for the quality assurance process after manufacturing. The solution can also be


**A team of engineering students worked hard to represent the Université de Sherbrooke at the Shell Eco-marathon international competition. (Courtesy: Université de Sherbrooke)**

> **As we discovered in our research, the gear train that would be optimized for the vehicle's drivetrain was an epicyclic gear train.**

exported as a STEP file for machine code generation, assembly validation, technical drawings, and more. The team used these features to run the design against analytical models available in the scientific literature, provide all necessary files to the manufacturer, and validate the assembly of the transmission with the rest of the drivetrain. With this entire process under their belt, the members of the team were confident to deliver a lightweight and very efficient transmission, a key step in winning the competition.

Furthermore, the team was genuinely proud of the final product. A picture of the final design is shown in Figure 1. As can be seen, the general concept extracted from the KISSsoft software is visible. An attentive reader might notice that the final transmission is a two-stage planetary gear train. This was a choice made to ensure that the overall dimension of the gear train would fit inside the vehicle. Some adjustments had to be made to respect the manufacture capabilities. For example, the outer ring is the full length of the system. This was to make the manufacturing manageable. That ensures that the geometry of the tooth of the outer ring is compatible with both stages. That way, the manufacture was able to produce multiple examples of the same planet to fit both stages. Also, it serves as the casing for the gear train.

As this is a bachelor's final project, it is accomplished alongside other projects of other students. As you might suspect, this gear train might have made some students envious. This is in part because of the complexity of it. That would not have been possible without the help of the KISSsoft software with our timeline and knowledge at the beginning of the project. In fact, the software made it possible to have an early idea of the overall concept and dimension of the gears train. That gave us crucial information to design the other parts related to the transmission (motor, chassis, wheel axle).

The team showed off a working prototype and its digital twin at the MégaGÉNIALE exposition, the largest exposition of undergraduate engineering projects in Canada. The next steps for the project included validation testing to optimize the car's driving cycle and integration of the telemetry software to guide the driver. After that, the team was ready to compete at the April Shell Eco-marathon Americas.

Editor's note: Unfortunately, the team was unable to compete in the competition due to mechanical problems (unrelated to transmission). But the story of how they got there and the creation of their innovative gearbox design is a good one.

## ABOUT THE AUTHOR

Gabriel Cabana is recently graduated in robotics engineering at the Université de Sherbrooke. He has experience ranging from firmware development to industrial automation all the way to heat exchanger and electric motor design. He is now pursuing a career as a simulation engineer in the automotive sector.