Delft University of Technology takes great pride in its so called ‘D:DREAM’ (Delft: Dream Realisation of Extremely Advanced Machines) teams, and rightly so. As one of these teams, the Eco-Runner Team offers students the opportunity to bring theoretical knowledge obtained during their studies into practice.

The Eco-Runner Team was founded in 2006 and since then has built three cars: the Eco-Runner 1, the Eco-Runner H2 and the Eco-Runner 3. This year, the team is building the Eco-Runner 4 where knowledge from various fields of dynamics, structural analysis and aerodynamics finally comes to life in the design and production of this new vehicle. “Actually holding the parts you designed in CATIA in your hands for the first time is a great feeling,” says Pieter (Student, Bachelor Aerospace Engineering), responsible for the suspension of the Eco-Runner 4.

The slogan, ‘Eco-Runner: the most fuel efficient vehicle in the world’ of the Eco-Runner Team Delft says it all: designing and building the most fuel efficient vehicle in the world. The Eco-Runner Team is a ‘D:DREAM Team’ where students from various faculties work together to design and build extremely efficient, hydrogen powered vehicles and conduct research in the fields of aerodynamics, structures, electronics, hydrogen fuel cells and driving strategies.

As in the Aerospace industry, the Eco-Runner Team strives to build their vehicles as lightweight as possible, using high-end composite materials for the monocoque and wheels, and high quality aluminum alloys for the suspension.

For the Eco-Runner 3, this resulted in an impressive total vehicle mass just shy of 40kg, yet still strong enough to transport a person of 50kg at an average speed of 25km/h. The EcoRunner is yet to be finished while writing this article, but the mass is expected to be reduced by at least 7kg with respect to the Eco-Runner 3. This significant weight reduction was achieved through extensive finite element modeling of the body structure.

The team competes in the hydrogen category. Fuel cells converting chemical energy from hydrogen into electrical energy have been around for several decades now, but are gaining immense popularity only in the last few years. Several major car manufacturers (e.g. Hyundai and BMW) have already developed hydrogen powered road vehicles. The Eco-Runner Team sees the hydrogen category as the greatest challenge and wants to prove the potential and capabilities of hydrogen as energy source for future vehicles.

The fuel cell for the Eco-Runner 4 is developed in Germany, at the German Aerospace Laboratory (DLR), in close cooperation with the powertrain team. It is a state of the art fuel cell, able to convert more than 60% of the available energy in hydrogen into useable electrical energy. “Being able to cooperate with such a high tech institution on such a unique, custom product is a pretty cool experience”, says Enzo (Student, Bachelor Electrical Engineering), Chief Electronics. The brushless in-wheel DC motor is capable of achieving efficiencies of over 90%, that leads to the total efficiency of the Eco-Runner 4 (from chemical to kinetic energy) exceed by 50%.

The electronics in the Eco-Runner 4 will be more sophisticated than before. A good data acquisition system has been developed to make sure parameters such as speed, fuel cell voltage and fuel cell cur-
rent can be measured and analyzed afterwards. The analysis of these parameters is important because, besides having an extremely efficient vehicle, the driving strategy of the Eco-Runner 4 during the competition plays a large role as well. In order to find this driving strategy it is important to know how the car and in particular the fuel cell will behave during the race. Together with the measured data, a simulation program, developed by the team, calculates the most efficient driving strategy. The next challenge is to bring this theoretical strategy into practice. A good communication with the driver is therefore vital.

Besides analyzing data afterwards, real-time data communication is needed to implement the correct driving strategy. Right now, the team is trying to implement this data communication into the Eco-Runner 4. This is a big challenge since the distance that has to be covered by the data is around 600m, with buildings in between the transmitter and receiver, and probably a lot of interference from other signals.

MINIMIZING RESISTANCE
To achieve extreme mileages, keeping the total resistance to a minimum is crucial. The factors that contribute most to the total resistance are rolling resistance and aerodynamic drag (approximately 50% each).

To reduce rolling resistance, special low-resistance tyres are used and the mass is kept to a minimum. The aerodynamic drag is reduced by keeping the frontal area small and by shaping the Eco-Runner like an airfoil, increasing the amount of laminar flow over the body and reducing drag. The frontal area of the Eco-Runner 4 is only 0.25m² (compared to a Renault Twingo series, with a frontal area of 2.315m²). The aerodynamic design is tested and optimized using CFD software that was made available to the team. Besides that, the Eco-Runner Team was able to use the university’s excellent facilities, such as the low speed, low turbulence wind tunnel and the open jet facility, to optimize the aerodynamic design even further. All this effort lead to an approximate total resistance of less than 3N at a velocity of 25km/h.

COMPETITION
The Eco-Runner Team builds their vehicles to compete at the annual Shell Eco-Marathon. In the European edition of this global competition, almost 200 teams from over twenty countries compete for prizes. In 2013, the team was runner-up in the hydrogen prototype category with a mileage of 287km/kWh (2914km/l of petrol).

The vehicles are split up into prototype (very futuristic) and urban concept (conventional car inspired) vehicles. Teams also have a choice of the energy source they use. A few examples are: petrol, solar power, battery electric and hydrogen.

The Shell Eco-Marathon is a large event, challenging young engineers to think about solutions for future mobility. “Even though it is a competition, you can feel that teams are not only there to win, but also to share ideas and find solutions to common problems together”, team manager Alexander says.

In the end, the greatest challenge might be for the drivers. Evelijn (Civil Engineering), who drove the Eco-Runner 3 at the Shell Eco-Marathon 2013, explains: “It can get pretty hectic. A lot of vehicles are on the track together at any given time, and the visibility from the cockpit is pretty limited. Good communication is really important.”

FUTURE PROSPECTS
The challenge of designing and building the most fuel-efficient vehicle in the world is never ending. In the future new technologies may arise that can be used to improve designs and vehicles.

If the Eco-Runner Team sounds challenging and fun to you there is also a possibility to join the team. There are both part-time and fulltime positions and it is also possible to do your minor as part of the team.