VERTUAL | Chalmers Vera Team Driving Simulator

Conceive | Design

PORTFOLIO

Implement | Operate

An Eco Marathon *project at* Chalmers University of Technology



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Introduction

Humanity's need of transport has led to an immense consumption of fossil fuels; a consumption which according to scientific reports may be greater than what our planet can handle. More fuel efficient vehicles in the transportation sector is a major piece in the green puzzle, but without proper driving their advanced technology may never be used to its full potential.

The international competition Eco Marathon invites teams of upcoming engineering students to design vehicles with the sole purpose of covering as much distance as possible on every drop of fuel. Chalmers Vera Team is one of the world's ten best teams in the gasoline class and is continuously exploring new ways to increase fuel efficiency. This project aims to aid them in that endeavour.

Racing disciplines such as Formula 1 heavily relies on excessive amounts of testing. Simulators have therefore existed in this sector for a long time and are now making an entrance in the automotive industry; however, mainly for performance purposes. They are a great tool when testing different configurations and allows for instant feedback from the driver; a source of knowledge incomparable to any other data output.

By utilizing technology used in simulators to optimize fuel efficiency this project aids Chalmers Vera Team in their work to achieve the most fuel efficient vehicle possible. This will act as a complement to their already advanced technology and offer the ability to develop and practice new driving strategies. It will also be a valuable tool when developing future vehicles, since it enables early testing of important parameters.

Creating a realistic environment requires visual and physical authenticity. By covering the windows of the vehicle with monitors the driver is visually immersed on a virtual track. Leaning the driver, vehicle and monitors then recreates the forces experienced when turning. The latter part is achieved by placing six linear actuators in a configuration known as a Stewart platform. This allows for translation and rotation along all three axis based on real-time data provided by the simulation software. Apart from supplying information about forces acting on the virtual vehicle the software also renders the virtual environment.

Five students from Chalmers with competences ranging from programming to manufacturing attained the challenge of designing the simulator during the spring of 2014. By utilizing tight communication with the team and close collaboration with industrial partners, a simulator with focus on authenticity and immersion has taken shape. It has been designed and built by the project group with inspiration from scientific articles and reports. This includes adapting the software to control the simulator and suit the graphical needs.

Interfaces and documentation have been designed to allow for use and further development by Chalmers Vera Team and in related education.
This will ensure that engineering students at Chalmers University of Technology have a platform for further development towards a sustainable future.

May 2013



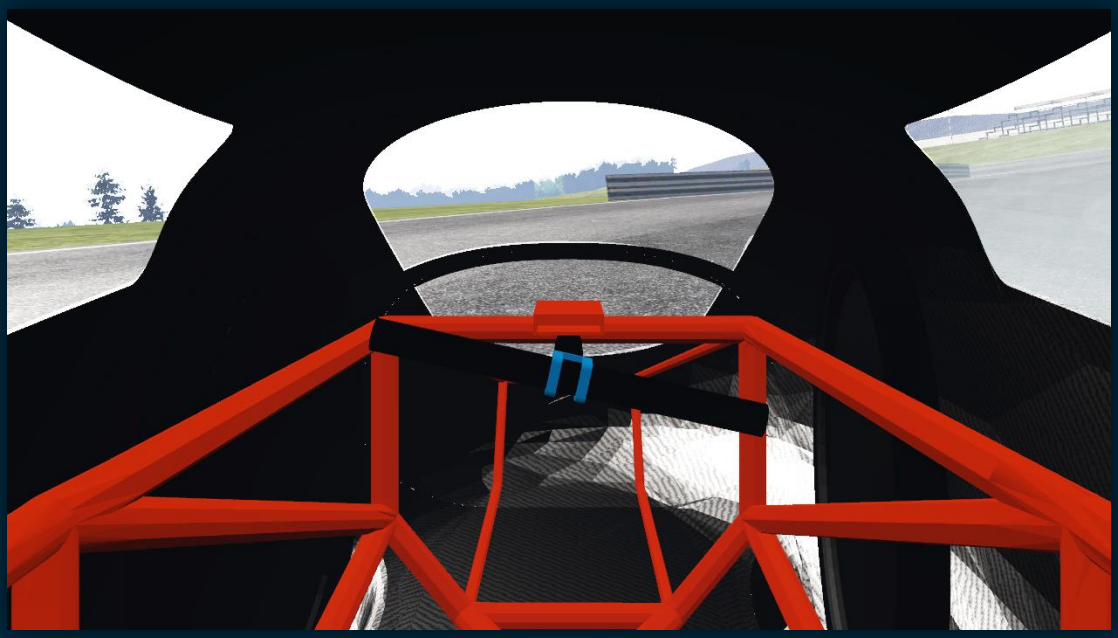




Every year in May the group of engineering students that is Chalmers Vera Team travel to Rotterdam to compete with their vehicle. 2013 marked the start of a new team generation and with the majority of the team, including the driver, being unfamiliar with the environment, focus was top priority. The effort the team had put into the construction of Vera paid off.

With a staggering 1011 km/L gasoline the team achieved the ever so desirable four-digit number. However, settling down is nothing the team is known for. During a dinner after the competition, the driver and a member of the team chat about the difficulties that comes with only having access to the track once every year. The driver expresses her desire to practice and learn the track in beforehand; a desire which would become the foundation of the project this Portfolio will cover.

June 2013



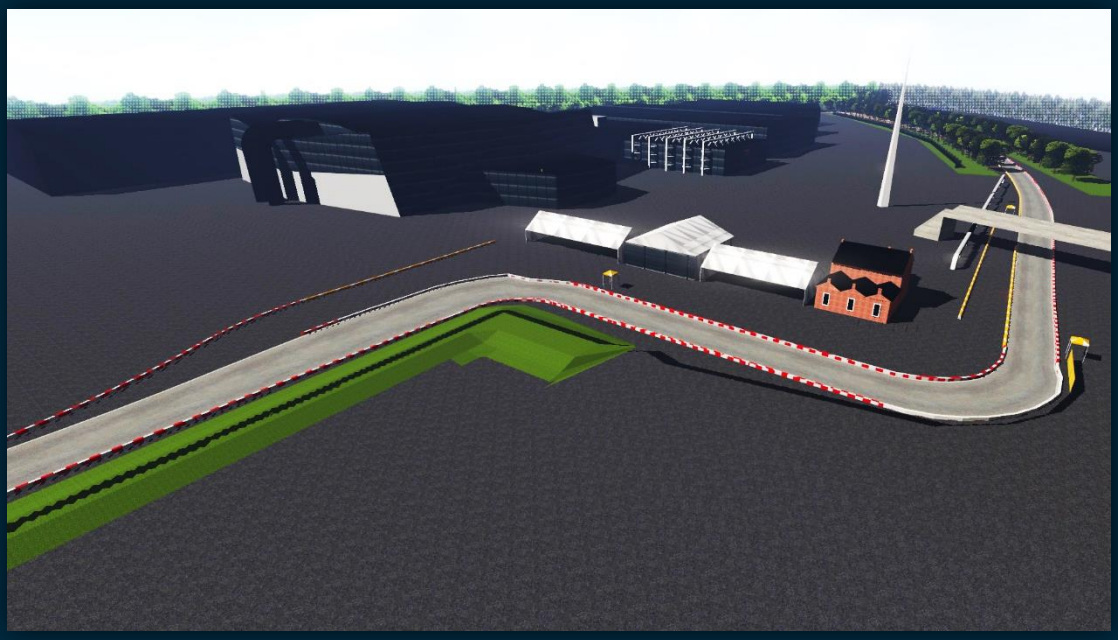




A member of the team acquires the challenge of creating a tool which the driver could utilise to practice the layout of the competition track and develop strategies for improving fuel efficiency. Recreating Vera in a drivable graphical environment was the first step. This required refining of the 3D models for rendering in real-time, but also acquisition of textures for the different materials used in the vehicle. Many baby steps later the nose was pointing in the right direction, the wheels were inside the chassis and the handling was setup to mimic the real thing.

With the camera positioned where the head of the driver would be, it was apparent to the team how limited the vision was; yet another reason for driver practice!

July 2013







With a virtual representation of Vera in place, development of the virtual track was initialised. The track is found is found in the Netherlands, next to a convention centre in Rotterdam. Information about the layout was acquired from logged data, online map services, photos, competition hand-outs and on-board videos which all came together to form a realistic representation of the Ahoy track.

Every detail which makes the track more true to the real world is costly in the form of computation power. Finding a balance of which details to exclude and which to include became a matter understanding what the driver is using to make decisions while driving.

The very characteristic Z-shaped corner, the long straights and the sweeping corners were all included and surrounded by significant buildings, barriers and signs.

August 2013







Taking it to the track once more! With the early success in May, the team was eager to improve their result as they headed to compete in Nokia, Finland. Some slight modifications had been done since Rotterdam and after 11 nail-biting laps they delivered what the team wished for. The new result of 1178 km/L proved that the hard work had paid off once more.

The graphical interface with the virtual representations of Vera and the Ahoy track was demonstrated to the Eco Marathon community and received a lot of positive feedback.

This marked the end of the season and planning of improved which were to be made in the near future was initialised.

September 2013







With the result from Nokia in the backpack, a virtual track with the same layout took shape. While the same methodology as the one used for the Ahoy track was used, new challenges as such surroundings in the form of forest and elevation of the track were encountered.

New data sources such as laser scans of the area were used in conjunction with the acquired log data from the actual race. Getting the details of the track correct is important since the major challenge for the driver on the Nokia track is to plan the race in relation to the hills and long straights. This offers a valuable contrast to the tighter track in Rotterdam and a new kind of engineering challenge to the team.

October 2013







Two tracks were now produced to allow the driver to practice in familiar settings. However, in order to recreate the challenge faced during an actual race, opponents were modelled which would run the same track and interact with the driver. Some attempts were successful and some were not, but this gave an insight in the challenges faced with Artificial Intelligence.

The graphical interface was now at a good level and future improvements were discussed. Stepping away from the keyboard and driving with a realistic handlebar was an interesting idea. Maybe the real car could be used and surrounded by monitors?

November 2013







Taking the simulator to the next level would require high ambitions and a lot of work, but being late autumn, the start of new Bachelor theses was only weeks away. With a vision of creating a downscaled version of a real driving simulator, a project plan was derived and published for students to see.

To aid creativity, the specification was relatively loose and the instructions were closer to suggestions than requirements. The overall concept was presented as an actuator configuration known as Stewart Platform and on top of that, a driver immersed by monitors which would display the virtual environment.

December 2013



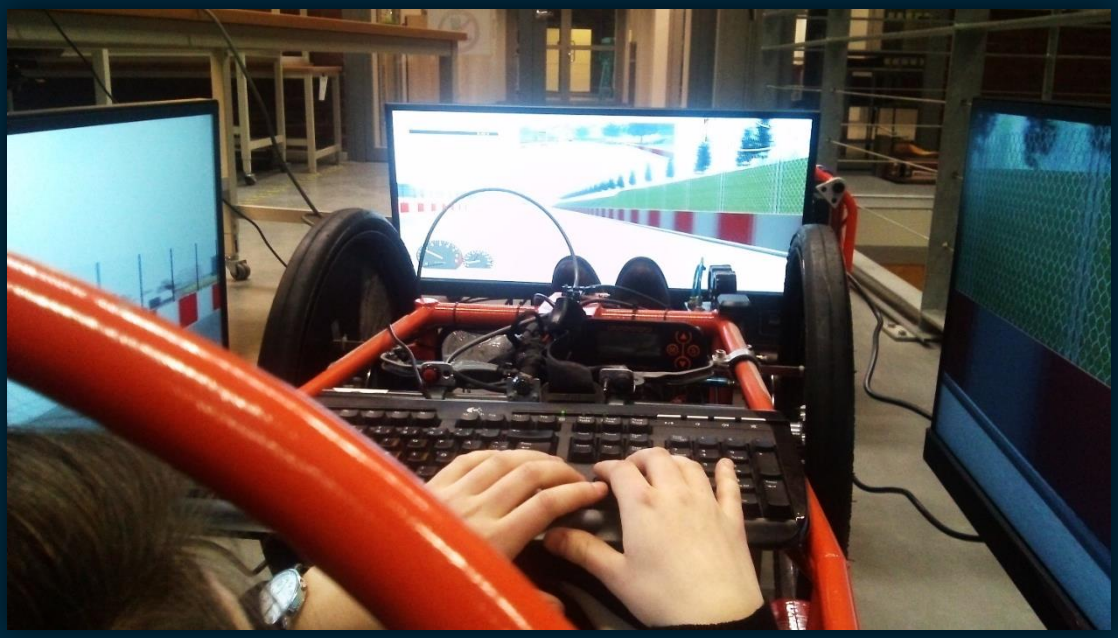


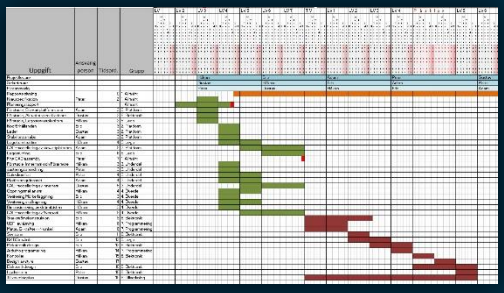


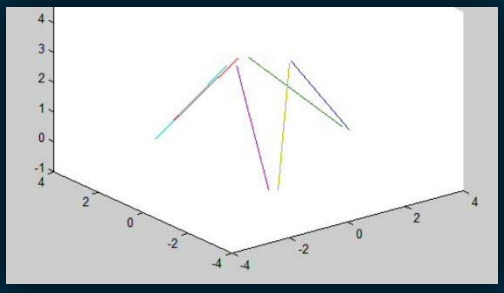
Four additional students with competences ranging from welding and machine design to programming and mechatronics joined the project and an initial planning took shape. It was apparent that the ambitions were at the desired high level.

The graphical interface developed during the past half a year was presented and the ideas of how this could be complemented started to arise.

January 2014





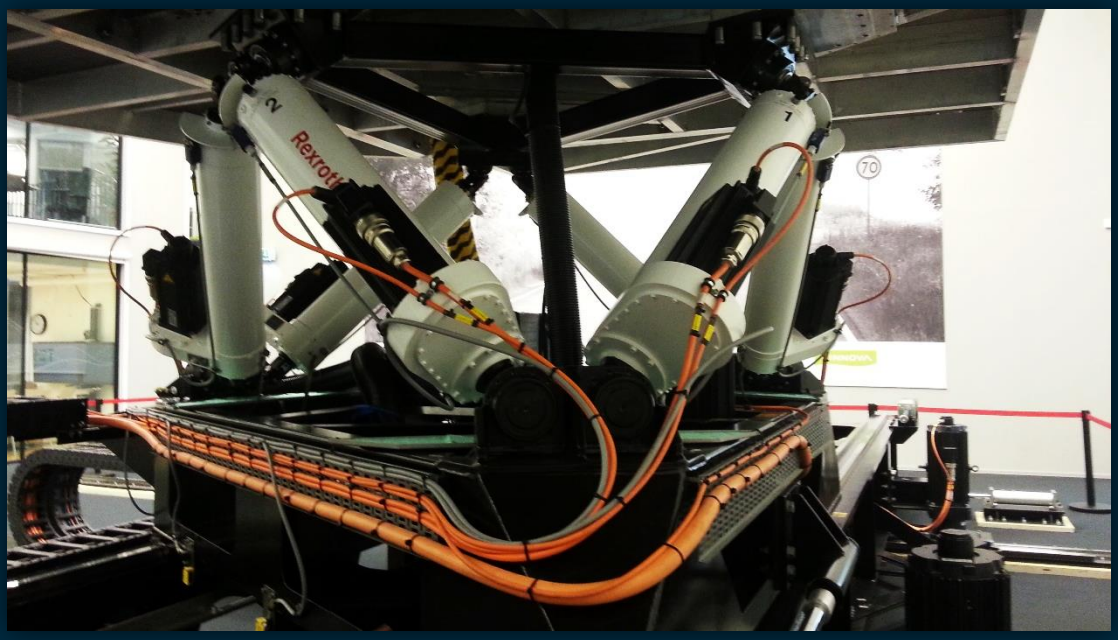


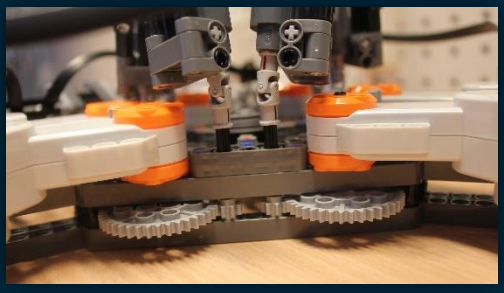
The students had six months to complete the project and a thorough planning was therefore established. As the complexity of the project became more apparent, so did the need of finding existing products and solutions which could be used for the simulator.

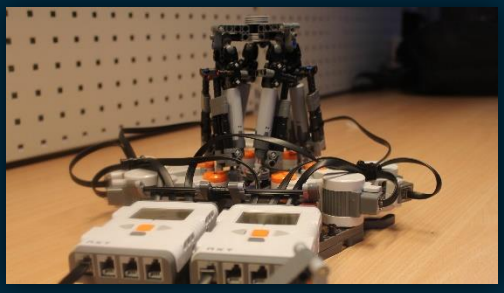
The car was used to test how the monitors could be positioned in order to display the correct perspective for the driver. A keyboard was then used to get an idea of what the final experience could be like. It was immediately apparent that there was a lot of potential in a simulator.

Computer models of the Stewart platform were tested and the tasks were divided amongst the students to cover both the hardware and software aspect.

February 2014



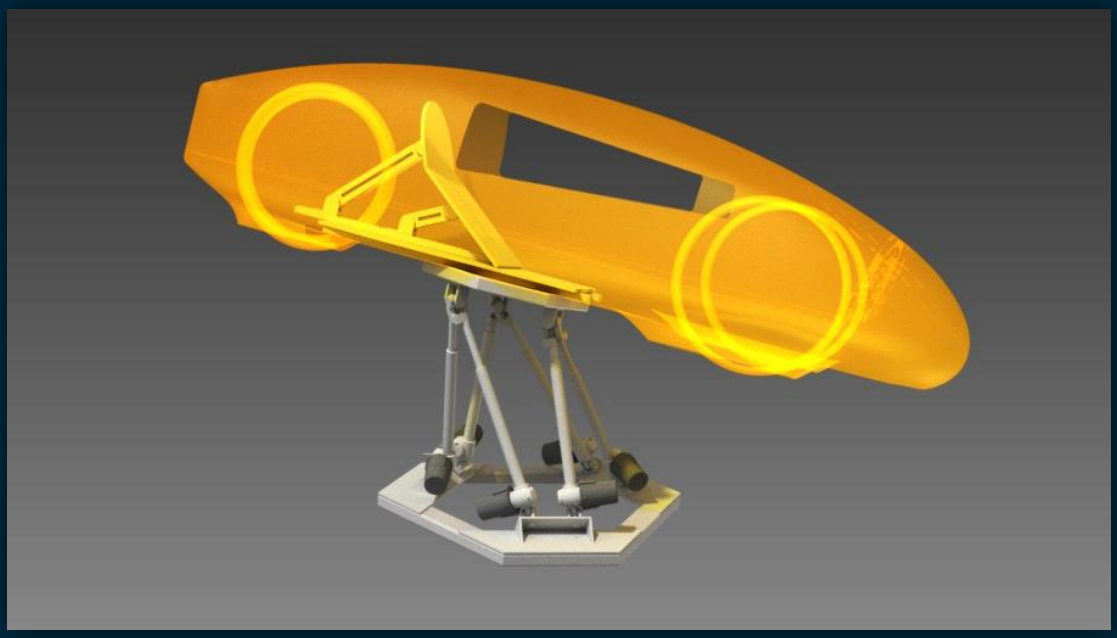




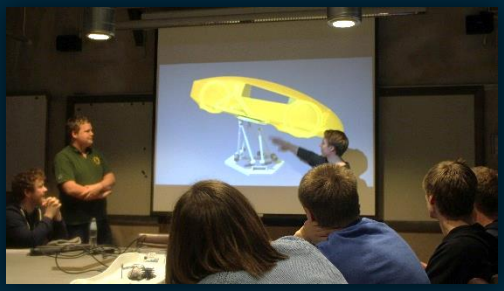
As driving simulators were relatively new to the team members, benchmarking and reverse engineering of similar systems was carried out. VTI, the Swedish National Road and Transport Research Institute, houses a full-scale driving simulator located in Gothenburg. The team visited them and got a lot of valuable advice on what to look out for in the process that was ahead of them. Much of the design came to be inspired by what was seen during this visit.

Lego was used to create a prototype of the simulator, in which the plan was to test the software. Based on the literature studied in the early phase of the project, the relation between the size of the upper and lower platform was critical to achieve the desired behaviour. A platform constructed out of building blocks could then be used to test different configurations.

March 2014







The design phase was now up to speed and initial 3D models were assembled. The upper platform was still in an early stage and a copy of the model used to build the original car was used to get a feeling of how the final result could look.

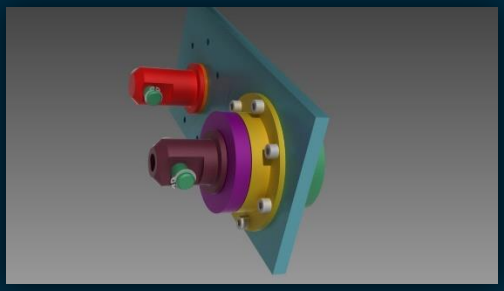
To maximise stability, the lower platform was constructed in steel, but for the movable upper part, aluminium was chosen.

Frequent presentations were organised to get feedback and to interact with other upcoming engineers. This served as a great forum in which necessary design changes were brought up, ensuring that the final result would reach its maximum potential.

April 2014







The design phase was slowly fading out and manufacturing began. Half of the team spent their time in the workshop producing the metal parts and the other half started the process of putting the software together. A lot of effort was spent on ensuring that the interfaces between the software and hardware would work well, but also on ensuring that both manufacturing groups were up to date with the current status of the project.

The deadline of the project was approaching and the invested a lot to ensure that the desired result would be reached. The welds came together and the actuators started to move; one at the time.

May 2014







It was again time for competition and this time the car was accompanied by the simulator. The construction was close to finalised and the software made the whole thing move.

Being the first of its kind, the project caught the attention of both officials and engineers from other parts of the world who all wanted to hear about how it all came together. Flyers containing information about the partner products and the technology behind the system were handed out and demonstrations of the system were frequently carried out.

As soon as the simulator returned to Sweden, the final adjustments were carried out to make the experience as smooth as possible.

June 2014







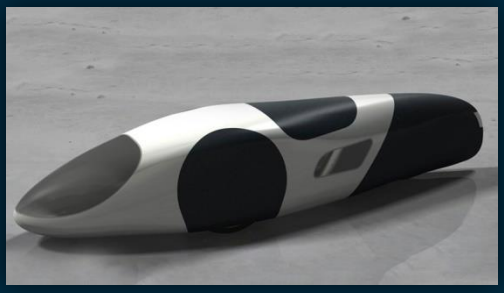
The high level of engineering caught the attention of the Mechanical Engineering programme and the simulator got nominated to compete in the international CDIO Academy Award. The offer was welcomed and the final touches were done before the team headed to the competition in Barcelona.

The judges performed a thorough investigation of the system to ensure that there was a fundamental understanding of the technology behind the orange façade. The result came out positive and the driving simulator won both the award for best Bachelor thesis and the great CDIO Academy Award. This was a tremendous success for the team and a great way to end an intense and interesting project.

Outlook 2015







Since the project was finished in 2014, the Chalmers Vera Team has initiated the integration of the simulator in their development cycle. It's an important part of their ever-growing arsenal of engineering development tools and will be play a great role in the computer model based and more driver-centric development process.

As of 2015, the team has finished the third generation of the Vera car and will be facing a new set of challenges as they push the limits of fuel efficiency. The new car is a lighter one, featuring a carbon fibre monocoque and large amount of innovative solutions in the powertrain.

With the amount of interest the Eco Marathon community has given to the simulator, the team hopes that it will initiate a new trend and open the eyes of other engineers to follow the same path.

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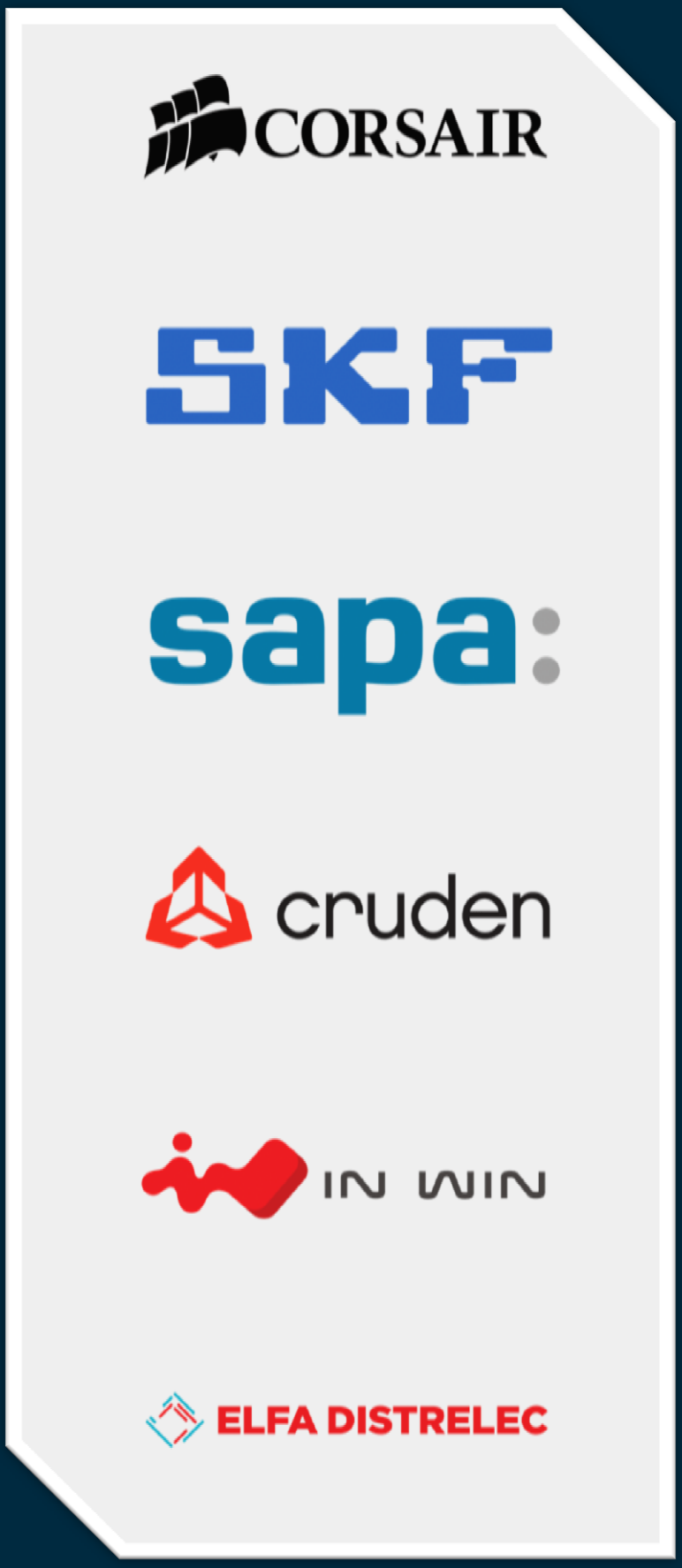
Exposure

The attention which the project has acquired did exceed the expectations. It has offered valuable exposure, but also led to several great discussions with upcoming and existing engineers. The feedback has often included compliments, but also a great deal of input on how the system could be improved. The step towards utilising the power of simulations was seen as a clear indication of how Chalmers Vera Team aim to be one of the world's best teams.

The simulator has been shown on several places in Europe including competitions, conferences and demonstrations. When back at Chalmers, it has been used to demonstrate to younger students what the possibilities are when becoming an engineer.

Below is a list containing some of the media coverage done on the simulator.

- *MathWorks Racing Lounge Episode*
  https://www.youtube.com/watch?v=63-d7jdHoMs
- *CDIO Results*
  http://www.cdio.org/node/6014
- *Shell official Flickr*
  https://www.flickr.com/photos/shell_eco-marathon/14017714089/in/photolist-9M8hoN-nCJXPc-nC3BJ2-nmH6iA-nmH6g1-ejp8Np-ekzPfw-ek3rpE-nmGs2F-ejkof4-nnsjuE
- *Shell Eco Marathon Twitter*
  https://twitter.com/shell_ecomar/status/467665871792394241
- *The Tekniikan Maailma magazine - Nr 16/2014*
  https://www.dropbox.com/s/v7fpvlgvzttwlrs/tm1614s24.pdf?dl=0
- *Chalmers Article*
  http://www.chalmers.se/sv/institutioner/am/nyheter/Sidor/Chalmerister-vann-pris-for-basta-kandidatarbete.aspx



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