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Automotive and transportation

Applus IDIADA

Automotive engineering firm uses Simcenter STAR-CCM+ to provide driving range of 250 miles for EV compact SUV

Product

Simcenter

Business challenges

Develop concept EV compact SUV with record drag coefficient (<0.2)

Identify most aerodynamic design digitally without building a prototype

Increase driving range of EV compact SUV

Keys to success

Use Simcenter STAR-CCM+ to optimize vehicle shape

Deploy CFD to discover new, innovative active flow systems design

Conduct virtual design exploration with automated workflow

Use Simcenter STAR-CCM+ to simulate over 600 design proposals in six months

Results

Delivered concept EV compact SUV with driving range of 250 miles on one charge

Designed outstanding aerodynamic concept with a drag coefficient of only 0.19

Reduced time for design and testing of new active flow control systems

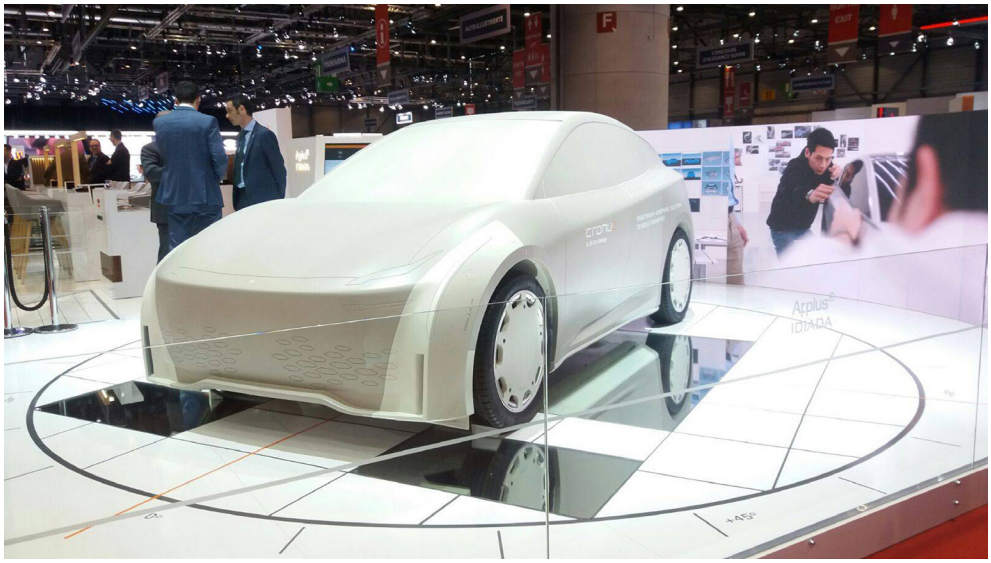
Siemens PLM Software solution enables Applus IDIADA to deliver excellent aerodynamics in shape-shifting CRONUZ concept vehicle

Range anxiety is all the rage

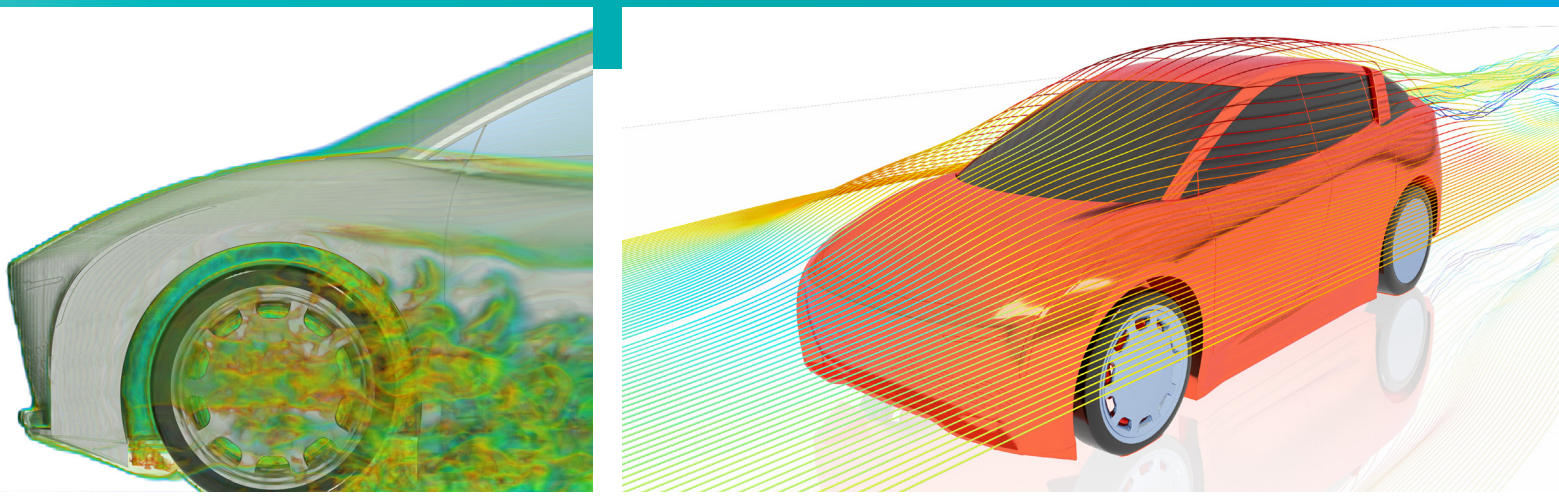
"Range anxiety" is the fear of running out of a battery charge and being stranded miles from an electric vehicle (EV) recharging station. Although it is a new term, it is hardly a new concept.

Range anxiety existed since the dawn of automobiles in the early 1900s, when there was no network of gas stations and people drove around with gasoline cans strapped to their cars. Today the average person drives only 40 miles per day, yet a recent Forbes study found that due to highway driving, two-thirds of potential EV consumers want a range of at least 300 miles per charge.

As EVs go mainstream, achieving greater range will be a deciding factor for consumers. A recent Tesla study notes that a 10 percent improvement in aerodynamic performance gives a 5-to-8 percent increase in range for EVs. Aerodynamic performance becomes even more critical for highway driving. At speeds over 130 kilometers (km)/



CRONUZ at the Geneva International Motor Show (GIMS) 2018.



Flow streamlines and vortices around the CRONUZ from Simcenter STAR-CCM+ analysis.

"I can't imagine conducting a project like this without Simcenter STAR-CCM+. By building a digital twin, we were able to try out various design possibilities with simulation early in the process. Simulation is the key to design innovation."

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Fluids Engineering Product Manager
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per hour (h) (78 miles per hour), around 80 percent of the power is used to overcome aerodynamic losses. Clearly, better aerodynamics provides increased range.

An electric powertrain and the small number of moving components already enable EVs to have a flat underbody and a closed off front side with no grill, offering aerodynamic benefits. Most internal combustion engine (ICE) losses come from the engine/drivetrain, while wind resistance is the major contributor for EV performance losses, meaning aerodynamic improvement is twice as important for EVs compared to ICEs.

Hence, continuous aerodynamic innovation is needed to reduce the EV drag coefficient (Cd), the driving force behind aerodynamic performance and efficiency. The most aerodynamic cars currently on the market – including Tesla Model S, Mercedes CLA, BMW 5-series and Audi A4 – all have Cds hovering between 0.22 and 0.24, depending on engine types and features.

Can an electric vehicle design have a Cd lower than 0.2 without sacrificing form and functionality? Applus IDIADA, a worldwide leader in design, testing, engineering and homologation services to the automotive industry, used Simcenter STAR-CCM+™ software from Siemens to help them achieve that.

"As far as we know, this is the first concept electric SUV on the market with a Cd below 0.2," says Enric Aramburu, fluids engineering product manager at Applus IDIADA.

Breaking the 0.2 Cd barrier with Simcenter STAR-CCM+

Applus IDIADA unveiled the CRONUZ project, an EV compact sport utility vehicle (SUV) concept car with a Cd of 0.19, at the Geneva International Motor Show (GIMS) 2018.

The design was a result of seamless cooperation between Applus IDIADA's designers and aerodynamicists. The designers produced an attractive initial surface attuned to EV design sensibilities, an aesthetically pleasing style, a minimalist aerodynamic design and a streamlined SUV type body.

The aerodynamicists then used a virtual wind tunnel created with Simcenter STAR-CCM+ for analysis of the vehicle aerodynamic performance using numerical simulation. Simcenter STAR-CCM+ is a premier computational fluid dynamics (CFD) tool and is a part of the Simcenter™ portfolio.

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"Simcenter STAR-CCM+ is easy to use," says Aramburu, who has been with Applus IDIADA for 15 years and has used the software all along. "It is robust and good for automation. That is why we have been active users since the very first version of Simcenter STAR-CCM+ came out 12 years ago."

Applus IDIADA simulated more than 600 design proposals over six months, progressively incorporating drag-reducing concepts into each design. This allowed a streamlined and optimized upper body design while retaining the basic design concepts. With Simcenter STAR-CCM+ simulations, the final optimized design delivered a drag coefficient of 0.17 in free air without attempting to model the wind tunnel and in steady-state conditions. The final assessment of the wind tunnel testing provided a Cd of 0.19, confirming the simulate-innovate-test approach and the CRONUZ's place as the most aerodynamic concept EV compact SUV.

For comparison, based on simulations the first CONUZ model had a Cd of 0.27, helping highlight the areas that required improvement.

Aramburu adds, "We knew from Simcenter STAR-CCM+ that we could achieve a record drag value even before building a prototype."

Simulation ushers in aerodynamic innovations

Two innovative features on the CRONUZ are key in driving down the drag – active systems and an optimized wheelhouse/underbody design.

Aerodynamic performance of cars is always a classic tussle between the aerodynamicists and designers, between performance and aesthetics. Active aerodynamic systems refer to parts of a car moving in operation to positively affect the airflow around the car. Introduced, quickly banned and now resurfacing as drag reduction systems (DRS) in Formula 1™ racing, active aerodynamics is the next breakthrough in achieving fuel efficiency, reduced drag and increased downforce in the automotive industry. These systems ensure optimum aerodynamics for every driving situation, be it low drag in economy mode or high downforce in sport mode, while maintaining the design sensibilities and styling requirements from the designers.

CRONUZ features active systems for the front fairing and an active rocker, which are hidden at low speed and while parking. At high speeds or on-demand, the active systems are deployed, changing the airflow around the car (and the car's shape, in fact) to stay attached from front to rear while minimizing turbulence around the wheel well, one of the key drag contributors.

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Forty percent of aerodynamic losses come from wheelhouse and underbody areas, offering significant room for optimization. An optimized rim design, low undercarriage (deployed after 80 MPH) and an almost completely closed wheelhouse from underneath minimize wheelhouse turbulence and ensure attached flow from front to rear – a major driver for drag reduction.

Steady-state simulations in Simcenter STAR-CCM+ showed the active systems reduced drag by 20 (one drag count equals a Cd of 0.001) counts. Even accounting for wind tunnel mounts and unsteadiness, which were not included in the simulations, this confirmed the huge reduction in drag from active systems. Wind tunnel tests eventually showed a 14-count reduction.

These innovations were made possible by iterating various designs for the active systems, rims and underbody wheelhouse covers in Simcenter STAR-CCM+ to find the best performing combination. These design improvements reduced drag by 55 drag counts prior to building the only prototype.

The most aerodynamic concept EV

Electric SUVs have a signature look – a hatchback shape and a greater height compared to sedans and coupes – features that increase drag, making it challenging to optimize aerodynamics. With as many as nine electric SUVs slated to be introduced to the market, 2019 may as well be the year of the electric SUV. Aerodynamic innovations in this space are critical and CRONUZ provides a solution to the increasing need for breakthrough aerodynamic solutions that offer drag reduction in this market space.

The car was developed from a clean slate to fulfill best-in-class aerodynamic values in 18 months with collaboration between the company's teams in China and Spain. The concept vehicle also offers Applus IDIADA a platform to deliver a master class in record-breaking aerodynamic design. Designed with a battery pack of 200 liters and weighing 1,500 kilograms (kgs), the four-seater C class SUV runs on two electric motors and is designed for a range of 250 miles (400 kms).

For a concept car, the CRONUZ looks a lot like a production vehicle. There's a reason for this. Applus IDIADA set out to deliver innovative drag-reducing aerodynamic features that would be feasible on a production-type electric SUV. A streamlined, appealing design and vehicle functionality were core requirements for the CRONUZ.

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Solutions/Services

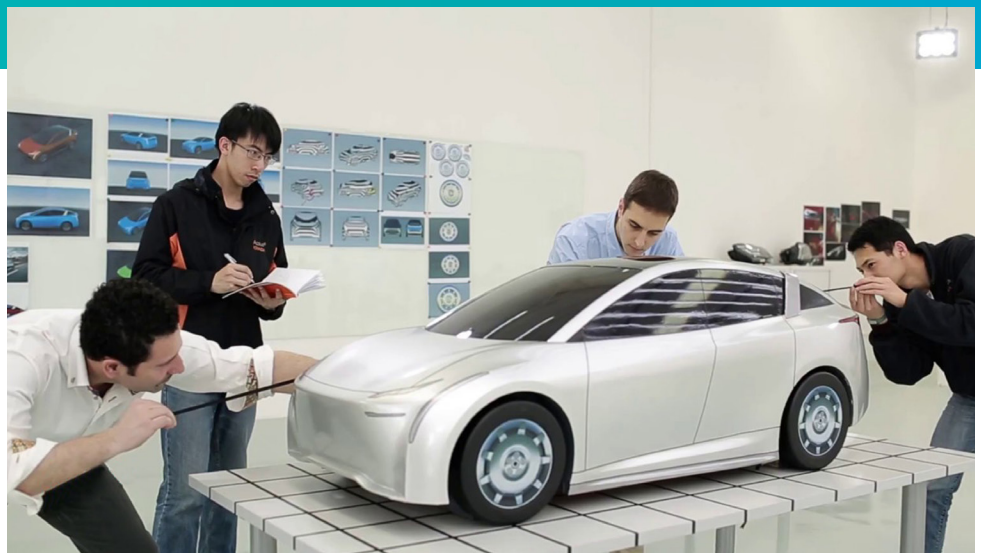
Simcenter STAR-CCM+
www.mdx.plm.automation.siemens.com/star-ccm-plus

Customer's primary business

Applus IDIADA offers design, testing, engineering and homologation services to the worldwide automotive industry. The firm has an international team of more than 2,450 engineers and technical experts, and an international network of subsidiaries and branch offices in 25 countries, ensuring customers receive fast and personalized service.
www.applusidiada.com/en/

Customer location

Tarragona
Spain



Applus IDIADA engineers and designers working on the CRONUZ design.

Using simulation to optimize the design is the key to achieving perfect harmony between design and aerodynamics.

With just steady-state simulations that aligned well with wind tunnel results, the engineers quickly identified a design that would break the 0.2 Cd barrier.

"I can't imagine conducting a project like this without Simcenter STAR-CCM+," says Aramburu. "By building a digital twin, we were able to try out various design possibilities with simulation early in the process. Simulation is the key to design innovation."

The aerodynamic innovations in the CRONUZ stand to help both major original equipment manufacturers (OEMs) and EV startups in reducing drag and increasing range. Such shape-shifting cars with active systems, which have become prominent in the last decade, seem to be the future of automotive aerodynamics.

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