SIEMENS
Ingenuity for life

Automotive and transportation

Nissan Motorsports International

Manufacturer uses Simcenter STAR-CCM+ to design distinctive low-drag cars and win 2014 Super GT Series

Product

Simcenter

Business challenges

Reduce reliance on expensive and time-consuming wind tunnel tests

Develop a full understanding of the complete flow field

Use motorsport technology to drive design of high-performance road cars and increase brand value

Keys to success

Facilitate faster turnaround and more insight by using Simcenter STAR-CCM+ to complement wind tunnel tests

Provide full-scale vehicle analysis that is not possible in the wind tunnel

Capture pressure and flow features that might not be seen experimentally

Results

Won 2014 Super GT Series

Achieved low-drag specification

Achieved synergy between CFD results and wind tunnel testing

Enhanced performance of the rear wing

Siemens Digital Industries Software solution helps Nissan Motorsports International achieve synergy between CFD results and wind tunnel testing

"An indispensable tool"

In spite of three decades of excellence on the race track, Nissan Motorsports International (NISMO) is always seeking ways to run faster. It has recently employed the unique capabilities of computational fluid dynamics (CFD) to help the firm's aerodynamic engineers improve their aero-packages during the development process. Yoshitaka Yamamoto, the chief aerodynamicist of the development division of NISMO GT-R grand touring (GT) cars, believes that "CFD serves as an indispensable tool in development aimed at bringing visibility to the invisible dimension of flow."

Super GT Series

The SUPER GT, an International Automobile Federation (FIA) sanctioned race, has regulations known as the GT500 for the top-class racing category and the GT300 for the privateer category (entrants with no manufacturer backing). The GT500 class consists primarily of vehicles developed and

Figure 1: The front mask engineered to reduce drag (photographed at the NISMO showroom).

"As a result of the CFD analysis, we realized that the front fender is an effective area for reducing drag. Under the regulations, the only means of expanding that area was to widen it vertically. When we attempted that, the results were favorable as expected."

Yoshitaka YamamotoChief Aerodynamicist, Development Division
NISMO GT-R GT

manufactured by the big three Japanese automakers, Nissan, Toyota and Honda, and their affiliated companies. The GT300 class is mainly for amateurs, with the majority of participating teams comprised of privateers.

In the race, vehicles from these categories compete on the same course. The speed differences translate into even more complex and exciting race conditions. Cars compete fiercely to outstrip each other as they roar around the circuit, creating a compelling spectacle. The NISMO team develops and produces vehicles for both of these categories. The GT500 class vehicle, which the company staked its reputation on, is based on the GT-R.

In 2013, the GT regulations became more aligned with those of the German Touring Car Masters (DTM) Series, which stimulated new mechanical and aerodynamic changes for the 2014 Nissan GT-R NISMO GT500. Simcenter™ STAR-CCM+™ software from product lifecycle management (PLM) specialist Siemens PLM software was used to develop it.

Juggling wind tunnel tests and CFD
In race car development, the traditional approach is to run wind tunnel tests on scale models, and visualize them with pressure measurements at specified points, smoke, tuft, particle image velocimetry (PIV) and other methods.

However, with these methods it is almost impossible to visualize the entire domain of the aerodynamic flow. On the other hand, the recent advances in CFD software, hardware and computing capabilities has enabled engineers to simulate a complete race car in a highly detailed CFD model from scratch, and to gain deeper insight into their designs, which would not be viable through any other means.
Using Simcenter STAR-CCM+ substantially helps with understanding the phenomena involved in fluid flows, permitting accurate display and analysis of the information with a level of detail that is hard to provide experimentally. It enables engineers to test the car virtually prior to any wind tunnel session, so as to pre-evaluate various configurations and what-if scenarios, and to test only the most promising solutions. This makes Simcenter STAR-CCM+ a widely accepted tool for the design and development of racing cars, complementing wind tunnel tests. Given the rapid growth of computing resources, it seems likely that CFD holds the promise of offering itself as the digital wind tunnel that can replace the physical testing in coming years as the science behind CFD improves and computers become even more powerful.

Yamamoto explains the contributions of Simcenter STAR-CCM+ and the advantages this method offers in comparison to wind tunnel testing in aerodynamic development: "When attaching small parts to the

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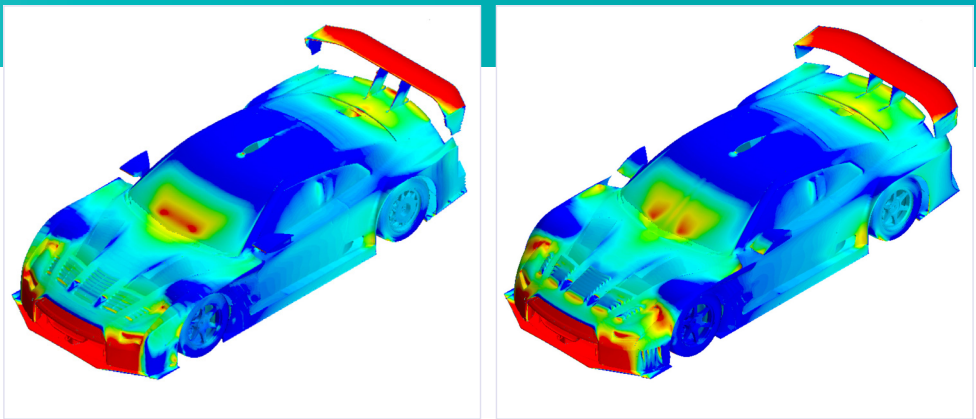

Figure 2: CFD results using Simcenter STAR-CCM+ show reduced pressure on the front fender for the 2013 design (right) compared to the previous design (left).

car, for example, wind tunnel testing alone is not sufficient to determine the impact of these parts on the backside, especially where the effects occur, and whether or not downforce has been obtained. However, using Simcenter STAR-CCM+ offers valuable insight into the flow behavior. GT cars are growing more complex every year. The number of intricate devices is also on the rise, making it increasingly tough to get the job done on the strength of experience alone. This is where Simcenter STAR-CCM+ becomes necessary."

CFD inspires NISMO

Every aerodynamic engineer in race car development has two major concerns: the creation of downforce to help push the car's tires onto the track and keeping it from sliding off in corners due to centrifugal forces, and minimizing the drag that is caused by turbulence and slows the car down. The harder and faster you drive, the more low-pressure air (higher speed) goes underneath the car, and the more downforce will be created.

On the other hand, with an increase in speed comes an increase in drag, which is not desirable. Normally, the ideal setup is to generate the maximum amount of downforce for the smallest amount of drag. However, the decision on whether to create an aero-package that is balanced or leans toward one of these two forces is highly dependent on the track and condition. A track with tight turns requires a car with higher downforce configuration to navigate the turns. But on tracks with a long straightway and wide and banked turns such as speedways, less downforce is required.

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Higher speed can be negotiated, and hence the drag reduction is of greater importance. At NISMO in 2011, Yamamoto started developing an aero-package with low-drag specifications that improved the high speed, while prior to that year, all the improvements were carried out to increase downforce while maintaining the drag level. One of the initiatives behind selecting the low-drag specification was to prepare an aero-package specifically designed for the Fuji speedway in 2012. Because of its long straight course, lap time could be decreased significantly by reducing the drag.

Under the low-drag specifications for 2013, the front fender was configured along the lines of a steep wall (figure 1). That resulted in an extremely distinctive front mask for the vehicles. Yamamoto's team conducted an initial CFD simulation using Simcenter STAR-CCM+ to find the potential areas for reducing drag, and they found out the pressure on the fender section was lower compared to their previous design in 2012 (figure 2). Yamamoto explains: "As a result of the CFD analysis, we realized that the front fender is an effective area for reducing drag. Under the regulations, the only means of expanding that area was to widen it vertically. When we attempted that, the results were favorable as expected."

Prior to that, they had attempted to eliminate the drag by rounding the configurations, but with the help of CFD, the NISMO team understood that it was possible to reduce such drag without streamlining the shape in that way. They featured this so-called approach as "aerodynamic harnessing modulation" in their 2014 model. This refers to raising performance through the adept use of pressure differences, which can only be performed with CFD.

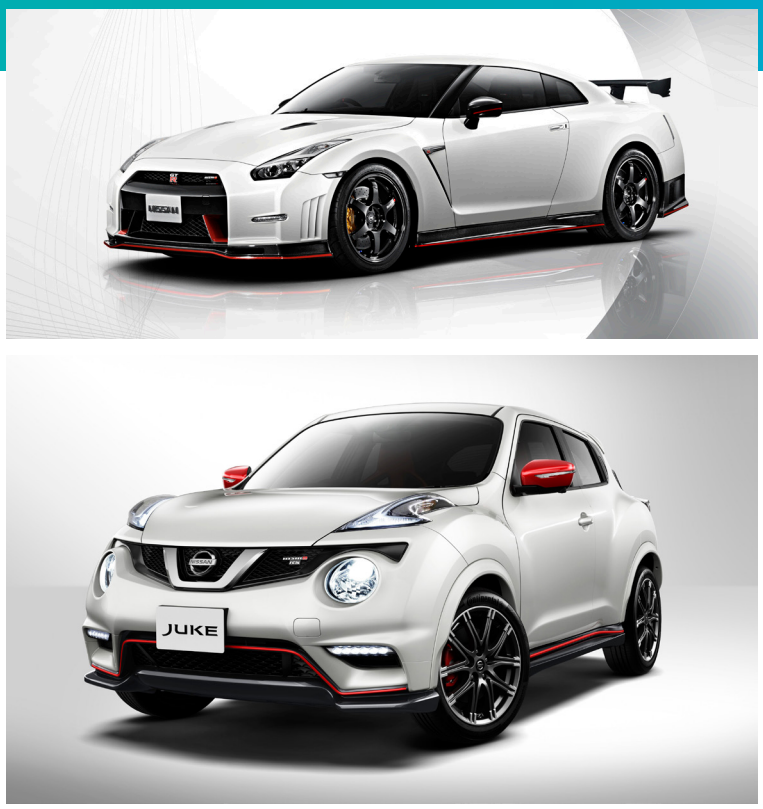

Figure 3: GT-R NISMO (above) and JUKE NISMO (below)

Yamamoto highlights the impact of CFD in their new achievement, as he continues, "Measurements may be carried out in wind tunnels as well, but the visualization that becomes necessary is difficult to achieve over the entire vehicle. CFD is an effective tool to view the body as a whole."

Although CFD has led Yamamoto's team to a better design by offering a valuable insight on the entire design continuum, it has been used until now in a supplementary role, rather than as a replacement for the work in the wind tunnel. As he explains: "One of the areas that still has room for improvement lies in evaluating portions that bear the wake of the parts in the front. As a case in point, I still regard assessments of tire wake as posing a stiff challenge. In addition to the wake, we have also failed to get 100 percent satisfactory results with the rear diffuser and other reverse pressure gradients. If we can achieve that, I feel confident that the time will arrive when we no longer need wind tunnels."

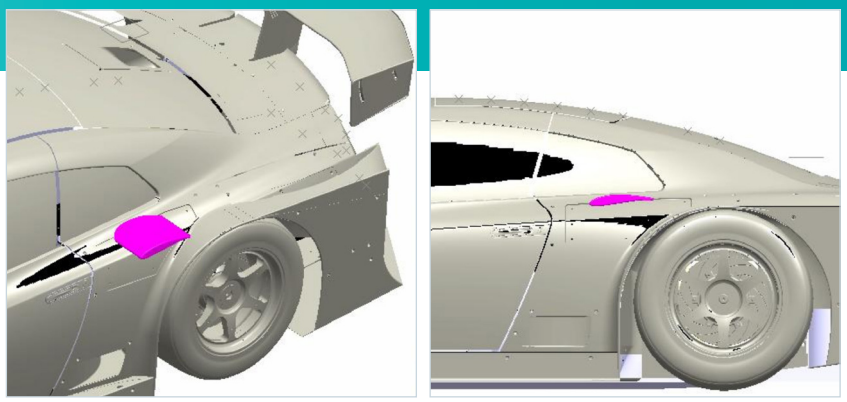

Figure 4: The shape and position of the rear fender turning vane.

Applying technologies cultivated through motor sports

The GT500 vehicle development work involves pooling the essence of various technologies. NISMO channels know-how cultivated through motor sports into the development of commercially marketed cars like GT-R NISMO, JUKE NISMO and other Nissan high-performance vehicles as the automaker's self-styled performance brand.

"With sports-oriented models that bear the name 'NISMO,' we instill our race car expertise into the development work. The key selling point in these vehicles is high performance," says Yamamoto. "Any car carrying the NISMO name is supported by development on the aerodynamics side by NISMO engineers, which means that I am also personally engaged in the work."

In 2014, SUPER GT vehicle regulations were aligned with the German Touring Car Masters, and broad revisions were carried out. For that reason, it became necessary to coordinate the development work with each of the new regulations.

"Because 2014 necessitated the first-ever use of regulations integrated with the DTM, we couldn't tell which of the various rules offered advantages or disadvantages for GT cars," says Yamamoto. "Today we've generally ironed out the details in that regard. For example, we understand that the know-how for the upper side of the exterior is generally uniform, meaning that there were actually no differences linked to the amended regulations."

Rear fender turning vane makes a brief appearance[1]

The regulation for the second Fuji race in 2012 stipulated that engineers were at liberty to tweak the design of the rear fender. From that time onward, this has become a standard measure for all Formula (F) 1 races. Following the rule change, NISMO attached turning vanes that had winged cross-sections mounted on the rear fender (figure 5). According to Yamamoto, the primary goal was to create an eye-catching external appearance that could be presented in the Formula One (F1) Series.

In addition to its distinctive appearance, it also contributed positively to the rear wing performance. As can be seen in figure 5 (top), CFD results showed the air flow churned up from the wheel arch lip on the front fender alleviated the breaking away at the rear fender and top surface of the trunk lid. As shown in figure 5 (bottom), the addition of the rear fender turning vane changed the flow pattern and improved the flow attachment towards the trunk lid. This ultimately helped reduce the drag and improve the efficiency of the rear wing.

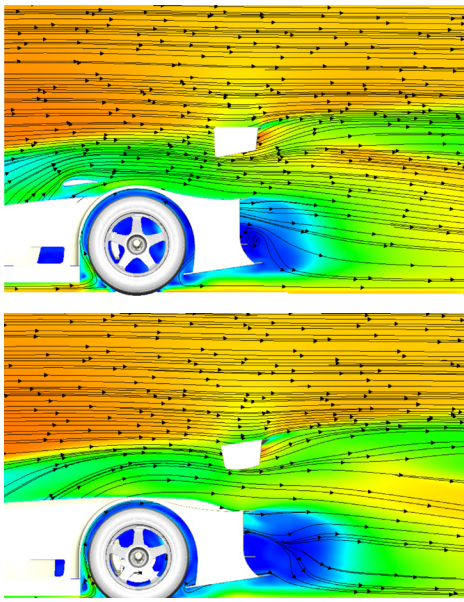

Figure 5: Flow patterns with (top) and without (bottom) the rear fender turning vane.

Solutions/Services

Simcenter STAR-CCM+
siemens.com/simcenter

Customer's primary business

Nissan Motorsports International Co., Ltd. (NISMO), located in Yokohama, Japan, is sacred ground for Nissan GT-R enthusiasts. NISMO is the development site of the SUPER GT and other premier racing cars. Launched in 1984 as the Nissan works team, NISMO has compiled an illustrious track record.
www.nismo.co.jp/en

Customer location

Yokohama
Japan

But it is notable the upside-down winged cross section profile of the turning vane generated lift in specific locations near the front, back and center of the vehicle. Therefore, the turning vanes did not improve the downforce. But the aerodynamic team approved its addition since it reduced drag, and hence improved the overall performance of the rear fender. However, the ruling authorities such as the Grand Touring Association (GTA) had a different interpretation of the newly mounted turning vanes. Although the rules stipulated only one wing, GTA considered the rear fender turning vane a second wing. Therefore, it was shelved after having been installed for only 10 minutes during the open inspection, and became little more than a memory.

Competing at the highest level

NISMO was crowned series champion in 2014. The aerodynamic engineers at NISMO used the synergy between Simcenter STAR-CCM+ results and wind tunnel testing to reach the optimum low-drag specification. The race car developers at NISMO continue using Simcenter STAR-CCM+ as an indispensable tool in their development process because it provides accurate pre-evaluation, deeper insight into a full-scale model and the ability to assess as many configurations as possible.

Following the interview for this article, the company announced its plans to participate in the Le Mans 24 Hours Race, further fueling the need for CFD in vehicle development. Hence, once again, Simcenter STAR-CCM+ will be used by NISMO to compete at the highest levels of the sport.

1. "Motor Fan Illustrated Special Edition", Kota Sera, Motor Journalist

Siemens Digital Industries Software

Americas +1 314 264 8499
Europe +44 (0) 1276 413200
Asia-Pacific +852 2230 3333

siemens.com/software

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