Blue Sky Solar Racing

Academic Case Study

BLUE SKY SOLAR
RACING

Challenge

The University of Toronto's Blue Sky Solar Racing team needed to design and build its seventh-generation solar vehicle in just two years to compete in the *World Solar Challenge's* 2013 race across the Australian continent.

Solution

The student-led team chose Dassault Systèmes' **3D**EXPERIENCE Platform for Academia, using CATIA for virtual product design, DELMIA for digital manufacturing and SIMULIA for realistic simulation, to develop and manufacture their state-of-the-art, solar-electric vehicle.

Benefits

The **3D**EXPERIENCE Platform helped the team improve work flow, significantly reducing development and production time into a tight thirteen-month cycle. The suite of server-based tools improved collaboration, integration of major car systems, and visualization and virtual testing of design concepts.

Crossing Australia has always presented challenges. The interior is vast, harsh and mostly unpopulated. It took six expeditions and more than three years before the first inland explorer established a route across the continent in 1861.

In more recent history, university-student teams race along much of the same route in sci-fi-like vehicles designed and built entirely by them and powered only by the sun. On their modern-day pioneering journey—from concept to finish line—they encounter their own set of trials.

The *World Solar Challenge (WSC)* is a unique event that began in 1987 and is now held every other year. It starts in Darwin on the north coast and ends 3,021 kilometers (1,877 miles) later in the southern coastal city of Adelaide, splitting the island continent approximately in half. The route, for the most part, follows the Stuart Highway, a road named for the early explorer and known by Aussies simply as "The Track."

The student-built, solar-powered vehicles entered in the competition are strangely-shaped, sleekly aerodynamic, and cutting-edge: "arguably the most efficient electric vehicles" on the planet, according to the race website. Covered on their upper surfaces with a space-age layer of photovoltaic arrays that convert incoming photons into electricity for power, the leading cars average speeds of 80-90 kph (50-56 mph). Traveling at that rate, the cars complete the course in about 30-40 hours, with driving limited to daytime (from 8 a.m. to 5 p.m.).

Solar-car success in this noteworthy race depends on the relationship of power to drag. In pursuit of the optimal ratio, teams strive to find a winning combination of aerodynamic profile, lightweight composites, photovoltaic advances, vehicle dynamics, and more. This is no trivial academic engineering exercise.

No matter which car wins, for everyone it is the adventure of a lifetime. The *WSC* might also be the ultimate testing ground for the solar-car technologies of the future.

The making of a racing team

In the summer of 2011, the 50 students of the Blue Sky team from the University of Toronto began work on the school's seventh-generation solar car ("B-7") and entry in the 2013 *WSC's* most popular *Challenger* class. (In 2007, an earlier vehicle placed fifth overall in the race's *Adventure* class.) The students have a wide range of backgrounds and abilities: from first-year through graduate level and from virtually every engineering discipline—electrical, mechanical, civil, chemical, mineral, even biomedical.

"We don't discriminate among those who come knocking at our door," says Ahthavan Sureshkumar, chief engineer for the team, who has been a participant for 10 years. "We are looking for people who are willing to commit their time to get the job done. And the time demands are huge."

According to Paul Park, a six-year veteran and the team's managing director, "Everyone is somewhat clueless when they join. But they all come out at the end with really strong technical knowledge. Basically, this is where they cut their engineering teeth."

When work on the B-7 started, the group had approximately two years before the race's October, 2013 starting gun. At first they could only focus on research and theoretical design discussions because all-important regulations weren't released by race organizers until much later. This gave the student engineers only a year or so to design and build their entry. Past design-build cycles have typically been four years.

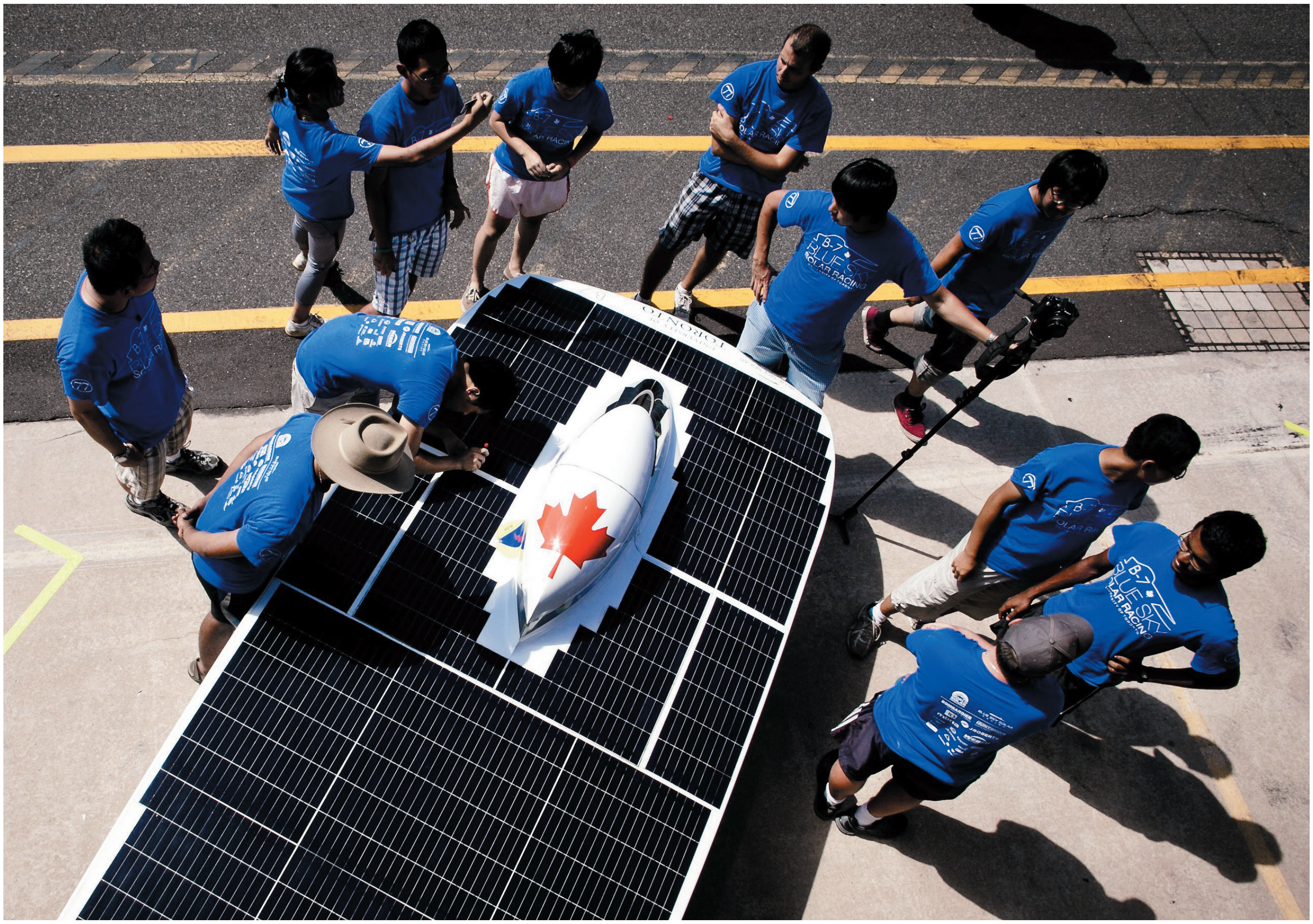
Meeting car requirements

Specifications for this year's *Challenger* class were many: for the photovoltaic arrays (a limit of six square meters), batteries (lithium ion that can provide no more than 10-percent of the total power), and others. Two new design constraints were also thrown in. For the first time, four wheels were mandatory. And there was a very stringent stipulation about driver vision combined with upright seating.

"These new regulations posed a very difficult design challenge for us, mainly in the area of aerodynamics and driver packaging," says Blue Sky Chief Advancement Officer Tiffany Hu. "In recent years the *World Solar Challenge* has been shifting towards more practical designs, which is very exciting."

"At team meetings we would project CATIA files on the screen, where we could check minute details, modify the design, and verify whether everything was okay in real time."

Paul Park, Managing Director



Blue Sky team and solar car during race preliminaries in Australia.

To meet the 2013 requirements, the students divided themselves into small work groups: aerodynamics, chassis, roll cage, suspension, electrical, and solar array technology. Team coordination and speed were critical concerns. And prior inefficiencies had to be addressed, such as the inability to virtually test the design before fabrication, and the need to exchange and validate files between two different CAD-based systems.

Enabling collaboration and integration

Aventec, Canada's leading provider of Dassault Systèmes Product Lifecycle Management (PLM) technology and services in nearby Markham, Ontario, recommended that the Blue Sky team use Dassault Systèmes' **3D**EXPERIENCE Platform for Academia—including CATIA for virtual product design, DELMIA for digital manufacturing and SIMULIA for realistic simulation—to collaborate efficiently and visualize design performance. A Dassault Systèmes business partner since 2001, Aventec's knowledgeable and experienced team helps implement, educate, and support solutions that enable organizations to exceed engineering requirements and business goals. "When we visited Aventec, they showed us a series of CATIA features and videos," says Park. "They just wowed us with how the software could help us with all aspects of design."

"The server-based collaboration features in CATIA really attracted us," says Sureshkumar. "We were also quite impressed with the way it modeled vehicle dynamics and the flexibility you get from using its multiple workbenches." Aventec further assisted by providing week-long training in the use of CATIA for a dozen members of the Blue Sky mechanical and aerodynamics groups.

The **3D**EXPERIENCE modeling tools allowed the team to work on all their car's systems under one interface—including mechanical, electrical, and aerobody—from starting concept all the way through to manufacturing. As Sureshkumar put it, "The software helped us make trade-offs early on and guided us in how best to build the plug and mold for composite fabrication."

The **3D**EXPERIENCE Platform was also instrumental when the team confronted several critical design problems, especially where the driver was concerned. "DELMIA's Human Builder tool with its virtual manikin allowed us to visualize ergonomics and driver comfort for a very tight cockpit," says Sureshkumar. "It even identified a flaw in our driver-vision calculations and helped us rectify the problem."

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>
> **Ahthavan Sureshkumar, Chief Engineer**

As hoped, the software helped the team improve its workflow, too, according to Park. "At team meetings we would project CATIA files on the screen, where we could check minute details, modify the design, and verify whether everything was okay in real time."

Opening virtual windows on performance

As the project advanced, the team employed SIMULIA's finite element analysis (FEA) software, Abaqus, with its seamless interface to CATIA, to further verify robustness of the design. Student designers had previously used only rudimentary hand calculations to analyze how their model would perform under real-world conditions.

"In the past we used a liberal amount of intuition as well as back-of-envelope calculations in order to estimate how many layers of carbon fiber would be needed," says Sureshkumar. "Using the SIMULIA solution, we were able to perform stress analyses that helped us optimize the composite aeroshell and chassis for weight while keeping them strong."

These calculations helped the team improve the car's stiffness and rigidity while ensuring it was as lightweight as possible. SIMULIA also provided some insights that would have been missed in prior years. When FEA showed that certain bulkheads experienced more buckling stress than expected, Blue Sky was able to adjust its design and reinforce these areas.

A new day for solar transportation technology

As race day dawned in Darwin, design decisions had all been made, composite layups completed, decals applied, and test drives logged. After countless all-nighters, the gleaming B-7 stood poised, reflecting the sun, ready for the starting gun. It was a proud moment, a remarkable achievement for a volunteer group of students, 19 of whom had been chosen to travel to Australia to support the car.

How the race was run depended on more than just sunny skies. "There's a remarkable amount of strategy," says Park. "Tactics depend not only on the weather, but on road conditions, other teams that impede your speed and, yes, even the occasional kangaroo crossing your path. We go as fast as possible but take every precaution to make sure that two years' work doesn't break down in the middle of the Outback."

While more than half of the entries in the competitive *Challenger* class did break down during the race, the Blue Sky team's entry performed exceedingly well according to Sureshkumar. "The car was robust," Park adds. "We designed every component to withstand the harsh conditions. We had a solid, perfectly aligned suspension that refused to give out. My heart was pounding throughout the race. I loved every minute of it."

Blue Sky team and their entry in the 2013 World Solar Challenge.

B-7 and driver racing towards Coober Pedy on the fourth day of the 2013 Bridgestone World Solar Challenge.

The B-7 completed the course in 45 hours, 38 minutes for an average speed of 65.7 kph (40.8 mph) and an 8th-place finish—second among North American entries and achieving the team goal of a spot in the top-10.

"The race was the climax of an incredible two-year engineering journey," notes Sureshkumar. "This was the first generation car on which we'd used multiple tools from the Dassault Systèmes' **3D**EXPERIENCE Platform. It helped us collaborate better and improved work flow tremendously. We used the software to really great effect."

"The suite of tools helped tremendously," concludes Park. "CATIA allowed us to fully integrate the systems in the vehicle and gave us the flexibility to design a world-class aerobody. SIMULIA highlighted potential problems early in the design process and helped us avoid over-design."

While the student teams competed (40 teams from 22 countries), interested entrepreneurs looked on, studying the latest in advanced sustainable-transportation technologies. Solar-powered cars have yet to make real commercial inroads in the auto industry's green markets. But the dedication and insight of teams like Blue Sky might help change that at some point in the very-near future.

Focus on Blue Sky Solar Racing

University of Toronto's engineering students are chasing the goal of a sustainable transportation future. The school's Blue Sky Solar Racing team built its 7th-generation solar vehicle called the B-7, which placed 8th in the 2013 World Solar Challenge.

Products: Solar car
Headquarters: Toronto, Ontario (Canada)

For more information
www.blueskysolar.utoronto.ca

Focus on Aventec

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