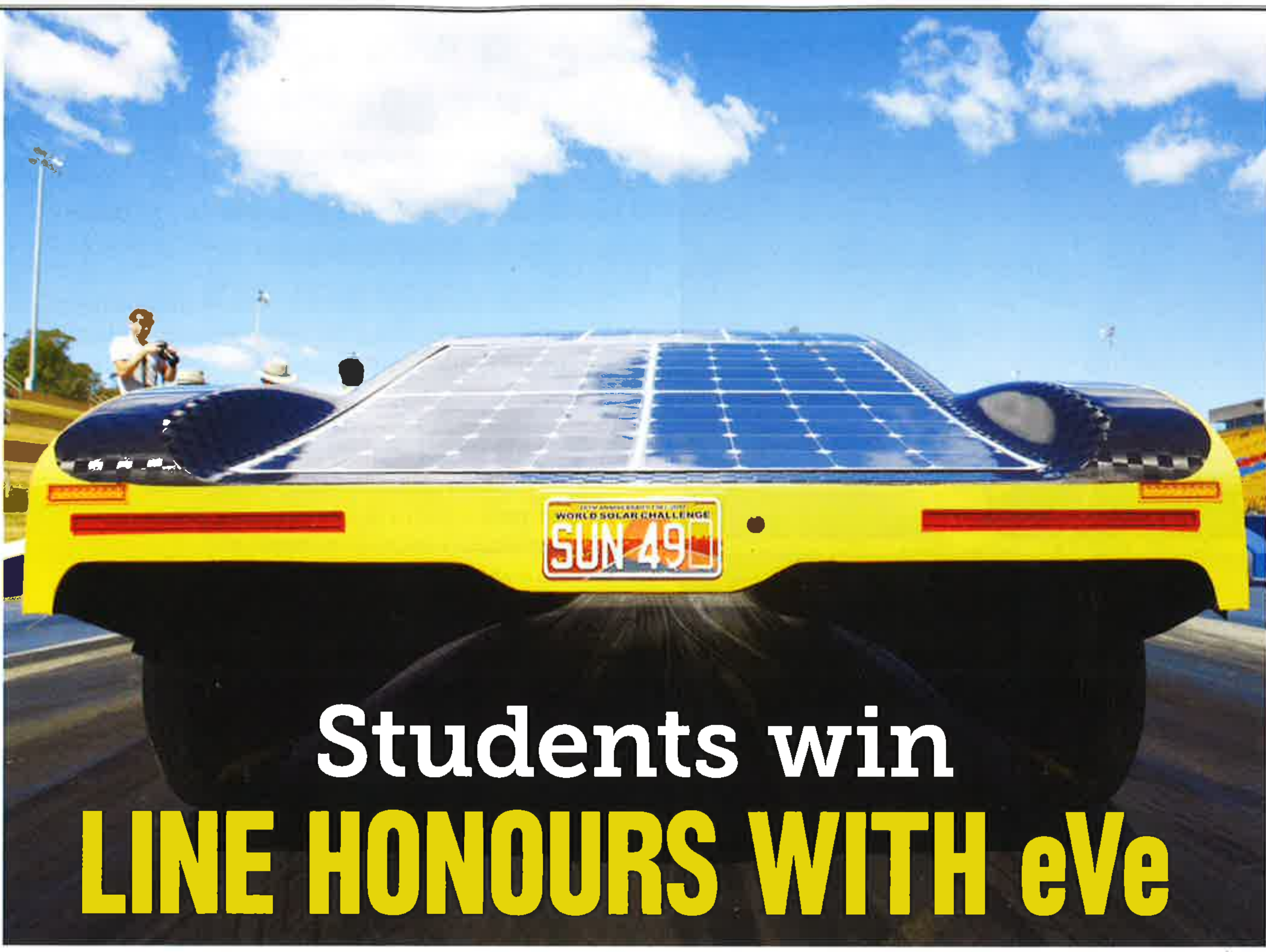


Students win LINE HONOURS WITH eVe

While electric and hybrid cars are seen on our roads, developing a practical solar powered car for mass production is still proving elusive. A new design from the University of New South Wales may bring mass production of solar cars closer to reality, writes Joshua Hoey.

Until recently, solar cars were useless for everyday use. A wide, flat, PV-cell-covered wing, wheels that look fit for a bicycle, and an egg-shaped cockpit for a single occupant is not a car with mass appeal.

As part of a move to see marketable solar cars developed for everyday use, the World Solar Challenge launched a cruiser category in 2013 for practical solar cars that could carry passengers.

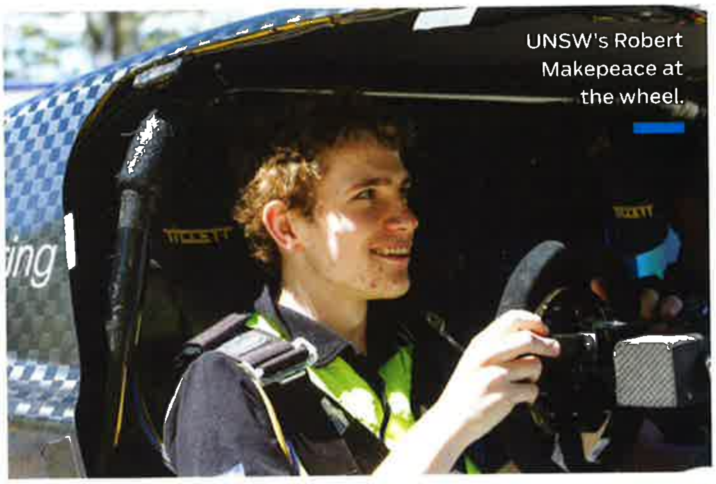
Sunswift's eVe won line honours in the inaugural category, finishing more than an hour ahead of the next car. Robert Makepeace was one of the UNSW engineering students that developed eVe, and now works for Provecta Process Automation in Sydney.

eVe being tested at Eastern Creek raceway in Sydney.

"eVe is a two-seater sports car, and we only had one driver," Makepeace says. "Our aim from the beginning was just for speed. We wanted to be the fastest."

The team from Eindhoven University of Technology in the Netherlands ended up with first place, receiving extra points for carrying an average of three people across the six-day race.

Yet Sunswift's eVe is still pushing, and breaking, boundaries. In July 2014 the car broke the Fédération Internationale de l'Automobile World Record for the fastest electric vehicle over 500 km on a single charge, averaging 107 km/h over the distance. The previous record had stood for 26 years, and was held by GM with a solar car they designed in the 80s.


UNSW's Robert Makepeace at the wheel.

"We were actually averaging 112 km/h, but we had a flat tyre during the record attempt, so the average dropped down a bit," Makepeace says.

In designing the two-seater sports solar car, the UNSW student team focused on two core ideas: looking good and going fast.

"We wanted a car that boys could have on their bedroom walls and get excited about, a car that people could identify with and want to drive. And we wanted to make it as fast as possible," Makepeace says.

To make the car as aerodynamic as possible, the team didn't use a wind tunnel, and instead turned to computational fluid dynamics (CFD). Cross winds and strong gusts – both a regular feature of the Darwin to Adelaide race – can be hard to simulate in a wind tunnel.

> *"Cross winds and strong gusts can be hard to simulate in a wind tunnel."*

Using CFD allowed the team to run multiple wind scenarios and refine the car's overall design. "We spent about six months going through about 100 different models and adjusting little bits of the shape to see if it made improvements," Makepeace says.

In the end they achieved a drag coefficient of 0.16, below that of the world's most aerodynamic production car, Volkswagen's XL1.

The team's achievements with eVe are impressive, especially considering that limited funding means they typically use standard, commercially produced components for much of the car. The budget for the car was around $500,000, with half of the money from UNSW and half from sponsors, largely in the form of free parts.

HOW STELLA BEAT eVe

While Sunswift's eVe was the first car across the line in the 2013 World Solar Challenge cruiser class, it was Stella from Eindhoven University of Technology in the Netherlands that came first after points for practicality and the number of passengers were added in.

"They carried more people, and used slightly less energy, recharged their battery slightly less than us, so they ended up winning on points," Makepeace says.

Stella is a solar family car rather than a sports car; it can carry four people and has more of a typical sedan shape, allowing for six square metres of PV cells compared to eVe's four.

According to Makepeace, the technology used by the teams participating in the race overlaps significantly: the same solar panels, the same motors, the same batteries.

So what gave Stella the edge? "Because of the extra solar power, they were able to keep up even though they had the extra weight of a family car and more people in it," Makepeace says.

He also says differences in funding and how the two teams work meant that Eindhoven was able to develop a more reliable car that didn't break down.

At Sunswift, the whole team still studies full-time at UNSW, whereas at Eindhoven students take two years off and receive scholarships to work on their car full-time. Makepeace also estimates their build budget at over $1 million.

"They have a lot more money and a lot more resources. The car is probably built to a higher quality; it looks almost professionally produced by a major car manufacturer."

Rival car Stella showing off her internal capacity. Image: Bart van Overbeeke

"The university has tried to cut its contribution down a lot in the past couple of years," Makepeace says. "Often you try to buy what you can, focus on a few things, and try and make do with something else.

eVe uses go-cart brakes. "They are the closest thing we could buy commercially, but they're not quite appropriate for the car," Makepeace says.

Cars are required to have independent braking systems, a hand and foot break. Aligning these correctly on the same wheel has proved difficult, and so they've had problems with the brakes not fully releasing.

The car's two motors are from CSIRO, and are located one inside each rear wheel.

Despite being designed over a decade ago, Makepeace says they're still the standard in most solar cars. "They're very efficient, about 97% to 98% efficient, some of the most efficient motors in the world." ⊠

Above, eVe on the HART test track in Sydney and right, the battery technology.

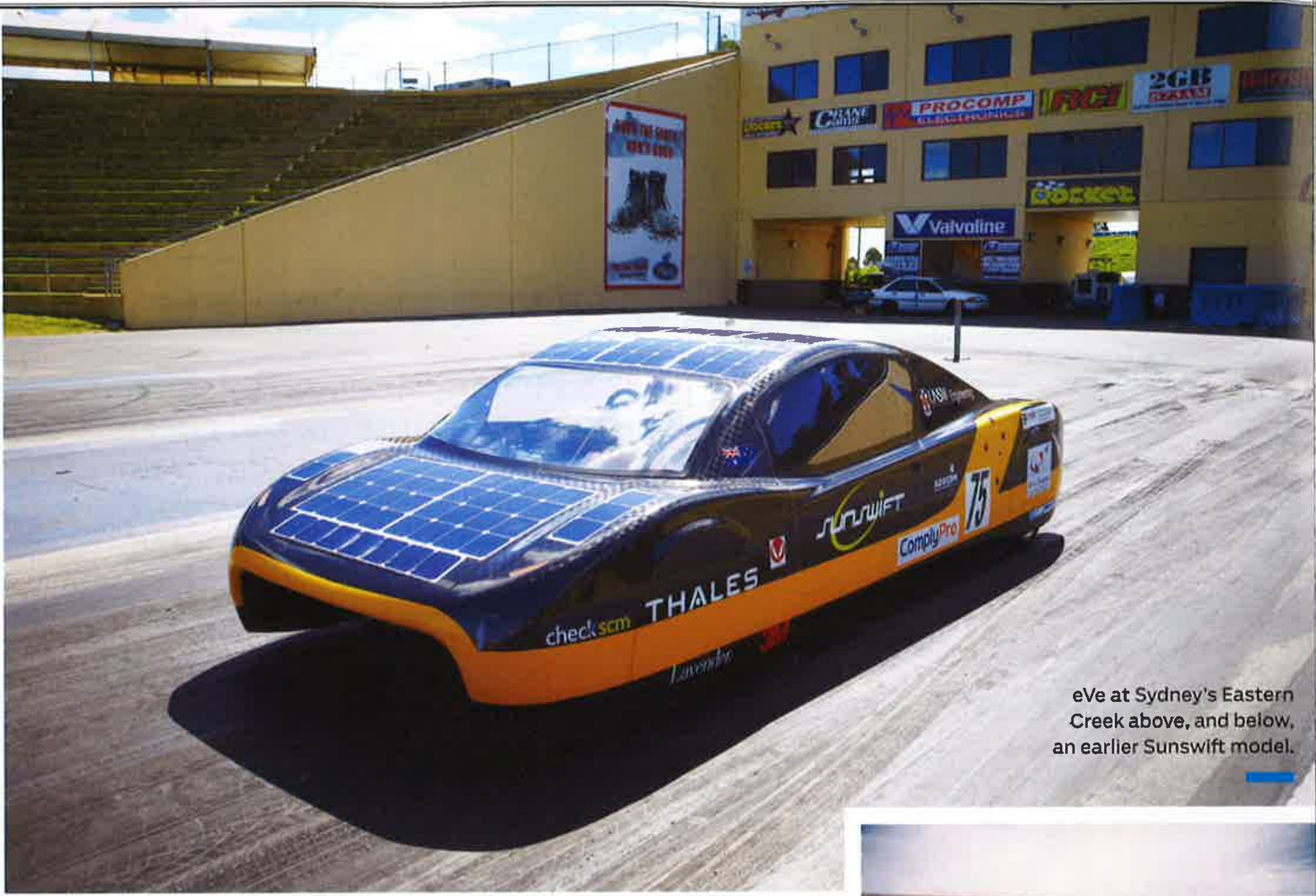
To ensure they get maximum efficiency from eVe, the team custom built a battery monitoring system to manage heat and voltage output from around 1000 Panasonic lithium-ion cells that make up eVe's battery pack. "It monitors cell voltages and switches on fans if they are heating up, and can balance out cells that are getting a higher voltage than others," Makepeace says.

The team also used MATLAB to predict battery performance in various states of charge and under various loads to determine eVe's optimal speed for maximising battery usage.

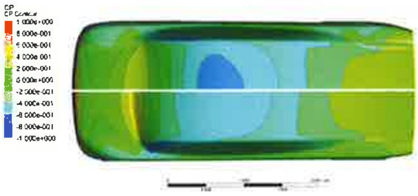
The software also allowed the team to monitor eVe's performance while on the road and adjust it accordingly. The team quickly picked-up on that brake problem by analysing battery discharge rates. Similarly, by using baselines for cell outputs in various conditions, the team was able to rapidly locate faulty photovoltaic cells.

Four square meters of photovoltaic cells produced by SunPower cover eVe's boot, roof, and bonnet. Explains Makepeace: "They're mono crystalline cells and they get about 22.5% efficiency, so potentially they're the best silicon mass-produced calls available."

Makepeace says that research cells, such as transparent cells, are an exciting possibility for solar car developers, but that their poor reliability makes them currently impractical. ⧐



eVe at Sydney's Eastern Creek above, and below, an earlier Sunswift model.



FOR eVe IT'S ALL ABOUT SOFTWARE

The Sunswift teams used a range of software to design eVe to be as efficient as possible.

ANSYS computational fluid dynamics software from LEAP Australia was used to design the shape of the vehicle. It allowed the students to rapidly evaluate pressure gradients on the car from one design iteration to the next.

MATLAB from MathWorks was used to measure the nonlinear behaviour of the lithium ion batteries so they could model battery performance in various states of charge and under various loads. This enabled the team to maximise battery performance.

> *"All the changes have added weight, but the team has been able to lose some elsewhere, partly through redesigning the suspension."*

"They are hard to mass produce, even to get enough to cover a car. Even though you have higher efficiency, we just don't have the set-up to get them reliable enough," he adds.

For this year's World Solar Challenge race, the Sunswift team are keeping the same basic design of eVe, but have included creature comforts to make her more practical.

"We got a bunch of interior designers to completely redesign the cabin – there's a whole dashboard and more driver controls," Makepeace says.

The car now has windscreen wipers and a large touch screen for navigation.

With added reinforcing to the carbon fibre body, and a more robust battery compartment, eVe now also meets roadworthy requirements and is currently going through the registration process.

All the changes have added weight, but the team has been able to lose some elsewhere, partly through redesigning the suspension. There's now also an added metre of PV cells that fold out of the boot when eVe is stopped to increase charging capacity.

The team has updated the electronics, adding in additional sensors around the car to get more data on performance. "You're more likely to pick up if something fails," Makepeace says.

Maybe even solve that faulty brake issue. ●