SUN POWER

DARWIN TO ADELAIDE BY SOLAR VEHICLE

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TEXT BY PAUL MANN

IT IS an hour before midnight on 31 October 1987, the eve of the world's first solar car race. I am sitting in a camp chair in the cloying tropical darkness of a large, almost empty camping ground on the north-eastern outskirts of Darwin, watching a drama unfold. The theatricality of the situation is enhanced by the setting.

I am alone in the stalls. Thunder growls in the distance and, overhead, lightning flickers nervously around the pale underbellies of the clouds. In front of me is a brilliantly lit stage, a startling oasis of colour and movement. Normally it is a picnic shed built of concrete blocks, painted cream with a corrugated iron roof. Tonight it is a theatre. The star of the show, the sleek white pod and glittering black cape of the solar-powered car built by Team Marsupial, holds centre-stage, the focus of all attention.

The supporting cast fusses around the car like courtiers paying homage. Two are bent over the fuselage, tinkering with the electronics. Stage right, two more are welding a spare part for the chassis. Stage left, a man stripped to his shorts is grinding a metal component in a shower of silver sparks and stage front, a young woman with strands of damp hair clinging to her forehead is fashioning a foam-rubber headrest for the driver. Cables for the lights and power tools snake across the cement stage and coil around stacks of tool boxes painted fire-engine red.

Still more of the cast scurry barefooted amidst the chaos, fetching tools, digging out spares, lending a hand here, offering a suggestion there. Almost all are wearing shorts and T-shirts in the pale blue team colours and, if you can believe it, a couple are wearing matching pith helmets.

None of the 12 people in Team Marsupial has helped build a solar car before. This one wasn't even finished until the solar panels arrived a month ago, giving the technical crew only a couple of weeks for shakedown tests before hauling the car in its custom-built trailer from Sydney to Darwin for the start of the race on 1 November. Since their arrival at the Darwin camping ground a week ago they had seized every available minute to run checks and more checks. Even so, they were worried.

SIMON BRUTY

"Nothing was going wrong," complained mission director John Storey, 36-year-old professor of physics at the University of New South Wales. "And that always makes me anxious. You think you must be missing something and you know you're going to have a disaster as soon as you get a little way down the road."

Earlier that day they had their disaster. During stability trials on the Stuart Highway, the car almost burst into flames. Its space-age silver-zinc batteries, installed only two days before, were overheating. The batteries should tolerate a temperature of 70°C before the electrolyte (potassium hydroxide) becomes unstable, but according to the cockpit instruments it was bubbling over at 50°C.

"Potassium hydroxide is a very unpleasant chemical," said John. "Apart from burning your skin, its main danger is that it will blind you if it gets in your eyes."

To protect the driver from just such a drama the batteries had been sealed in a wooden box behind the driver's seat. The team's anxiety was increased by the presence of their sponsor, AUSTRALIAN GEOGRAPHIC publisher Dick Smith, behind the wheel at the time – they had visions of him going up in flames.

"Our first concern was to get Dick out of there safely, then to open the box and see how bad it was," said John. While the support crew stood by with a fire extinguisher, John and team manager Graham Allen, 30-year-old technical officer with the CSIRO Division of Applied Physics in Sydney, gingerly opened the box.

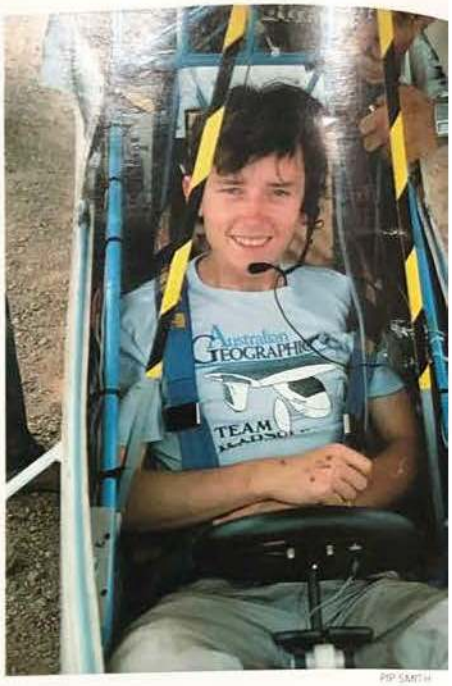
"This thing was sitting in there like a nuclear reactor melting down and there was a danger that the moment we opened the box the air would rush in and the whole thing would ignite," John said. "Fortunately it didn't."

Still, the electrolyte was foaming ominously, and the car had to be taken back to the camp site for repairs. It was just what Team Marsupial needed: a problem to solve! They arrived back at the camp site wreathed in smiles at the prospect of having to work all night – with race time less than 24 hours away.

The compulsory stability trials turned out to be a testing time in other ways. The trials required each car to

◀ ***Harnessing the red centre's*** *sun power south of Ti-Tree, Team Marsupial's car shares gunbarrel-straight Stuart Highway with its advance scout car. At right is the old red-dirt highway; at left a 3000 km-long trench holds an optical-fibre communications cable. The World Solar Cup* ***(above)****, a perpetual trophy of Australian gold and silver, provided by Broken Hill Associated Smelters.*

PHOTOS: JASON ALLEN



PIP SMITH

In the backyard garage *of his Sydney home, Team Marsupial manager Graham Allen (**top left**) works on the car that took the team 5000 man-hours of spare time to build. As work advances, drivers Dick Smith (**left**) and Jason Allen (**above**) try out the frame and the snug cockpit.*

> ***'Basically, you've got to find things that are too difficult to do... and then do them.'***
>
> Graham Allen, manager, Team Marsupial.

drive at full speed past a great road train travelling at 80 km/h. The speed achieved determined the starting order for the race. Ian McCurley was the team's driver for the trials, and Graham gave him the no-nonsense instructions: "If the car is unstable as the prime mover goes past, drive off the road and crash into the bushes. There are three trailers being towed by that prime mover and we can't afford to go under any of them!"

They watched anxiously as Ian sped towards the on-coming juggernaut, his foot pressed hard down on the accelerator, an ambulance following him at a discreet distance. Ian made it, and they raced to congratulate him when they saw he had clocked 85 km/h, which won him third place on the starting grid – the highest placed Australian entry. "By the way," said Ian, "the accelerator is jammed hard down. I had to turn the motors off to stop!" In his determination to get the fastest time possible he had pushed the accelerator past its limits.

IT IS now almost midnight. The team has been working for 10 hours with only a pause for tea. In five and a half hours they will have to present the car for race officials to check its fitness to start. John seems strangely calm. Despite the heat, the humidity, the mosquitoes and the strain, he is smiling.

"It's a brilliant omen," he says. "Everything was going a little too smoothly. The problem is that silver-zinc batteries are a totally new kind of chemistry to us. And we're not sure anyone fully understands them yet."

The batteries, imported from the US makers, cost $12,000 a set and are ideal for solar cars because of their light weight and because they can throw out 250 watts for 10 hours, enough to power the car at 30 km/h all day without sunlight. They weigh only 28 kilograms compared to conventional lead-acid batteries that would cost only $500 a set but weigh 120 kg. Using silver-zincs the total weight of the car is only 250 kg. In the US, similar

batteries are used in missiles and satellites.

Earlier this evening John scoured rival camps to glean further information on the batteries. "According to Ford they have to be fully flattened, then brought right back up before you use them," he said. "I don't think they're pulling our leg. When we installed ours, we poured in the electrolyte and they came to life fully charged. Apparently we should have discharged them, then re-charged them."

Nevertheless, in a bid to avoid further overheating the team has been busy installing a cooling system. They have been cutting vents in the plywood box encasing the batteries and will install a conventional 12-volt fan Graham bought from a hardware store. They will be on stage rehearsing all night, getting it just right. I remark on how happy they all seem to be at the prospect. They chuckle.

Team Marsupial was not formed for the Pentax World Solar Challenge. Most of its members have known each other for years and had worked together in successive Shell mileage marathons. John is married to Graham's sister Michelle, 28, a research fellow at the CSIRO's Division of Radiophysics in Sydney. Michelle is known as the team's spokesperson, a witticism on the fact that it was she who hit on the idea of using tougher wheelchair spokes for the car's wheels. Graham's brother Jason, 22, a mechanic and biomedical technician at Telectronics, is a driver and the team welder – with a latticework of burns on his legs to prove it. Other drivers are Simon Gibbons, 24 and Ian McCurley, 25, both technical officers with the Department of Defence, and Dick Smith, who described himself as "just a hanger-on".

The support crew includes Antony Schinckel, 27, an experimental scientist who took leave from the Max Planck Institute for Radio Astronomy in West Germany to fly home at his own expense to take part in the race; Graham's wife Georgina, 28, a systems engineer with IBM; Graham's father, Roy Allen, senior lecturer in physics at the University of Sydney; Horrie Kinnersly, technician, retired from the CSIRO Division of Applied Physics, Sydney, and his wife Marie, who cooked for the team all the way from Darwin to Adelaide.

The car was built in Graham's backyard garage at North Epping in Sydney. For the 18 months it took to build, Graham's Alfa Giulietta sulked in the driveway, exposed to the worst of Sydney weather.

"When the world's first major solar car race was announced it was something we all wanted to be in," says Graham. "But we looked at the money and realised we'd never be able to afford it. Then Dick rang up out of the blue and asked us to tell him about it. We sent in a proposal but then he went quiet and we thought he'd gone off the idea so we arranged a meeting and decided we'd better have a model. Jason and I built a model in three days, took it in and started rolling it around on Dick's desk and that's when his eyes started to glow."

AUSTRALIAN GEOGRAPHIC contributed $80,000 towards the cost of building the car. The team invested an estimated 5000 hours spread over weekends and late nights for 18 months – a massive contribution of volunteer labour. "It's the sort of thing you can't build in your spare time," says Graham. "But we did."

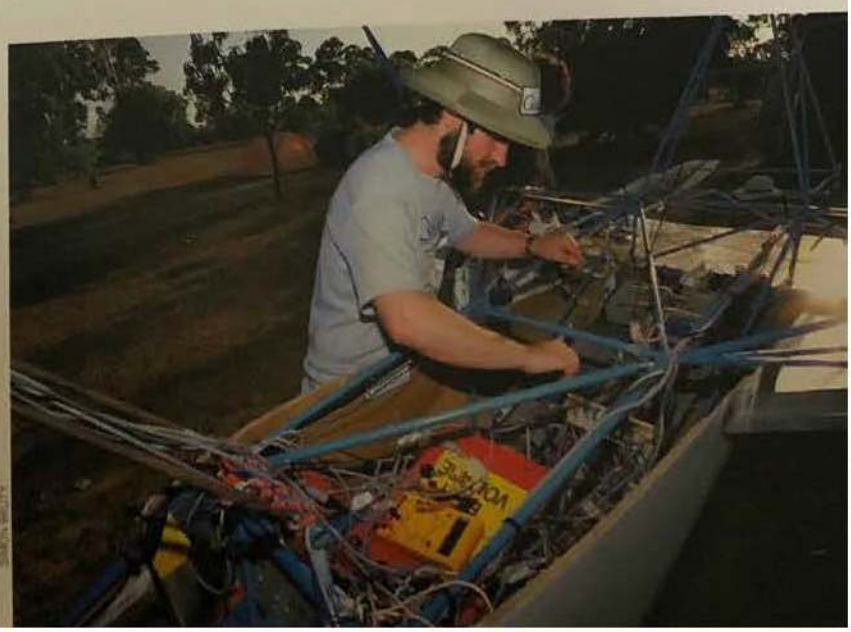
John and Graham designed the fuselage around the canopy of the Stratos ultralight aircraft. They used electronics from a small Brisbane firm called Australian Energy Research Laboratories, and the solar cells, specially made by BP Solar Australia, were derived from conventional industrial solar cells, though they were laminated to chemically toughened 1.3 mm Belgian glass for slicker aerodynamics.

For a year and a half John and Graham talked nothing but solar-powered cars.

"We couldn't go to each other's houses for dinner without it being taken over by discussions about solar cars," says Michelle. "The project took over our lives to the exclusion of all else."

When the race deadline rolled up they had remembered everything but a name for the car.

"We had exhausted the names of our favourite marsupials on cars built for the mileage marathons," explained Graham. "We decided Team Marsupial would cover everything."



***Darwin late on race eve**, John Storey gives the car's complex electronic circuits a last check. The team worked all night and right up to the 9 a.m. start of the race. Earlier, members stood by with a fire extinguisher after the car's space-age silver-zinc batteries overheated during road tests. The team's pith helmets – lightweight, waterproof and well ventilated – turned out to be practical in the outback, and overseas teams invariably asked, "Where did you get those hats!"*

SIMON BRUTY

IT IS 6 o'clock on the morning of the race at the starting grid in the grounds of Darwin's Casuarina Shopping Centre and Team Marsupial is all present and correct, though most have had no sleep.

A pink tropical dawn reveals too much cloud, but it's not considered ominous because coastal weather breeds clouds. Most entrants agree that the best tactic is to outrun the cloud-cover on the first day using battery power, then stock up through the solar cells farther south in the sunny outback.

As the 9 o'clock start draws near Dick is in the car, a 1-litre jug of water with plastic straw nearby to combat dehydration in a cockpit where the temperature usually hovers around 40°C. Ahead on the starting grid are two American entries, *Mana La*, built by an Hawaiian group of hippie shampoo tycoons, and the favourite, *Sunraycer*, built by General Motors. Dubbed "the flying cockroach" by the media, the GM car was built using the latest US aerospace technology and clocked 113 km/h during trials without her batteries breaking into a sweat.

"I don't think there's any doubt GM are going to win," says John. "On the other hand, just to finish this race means we've achieved something of significance."

By 9 o'clock the crowd has swollen to several thousand and tension builds. When Northern Territory Chief Minister Steve Hatton drops the flag, for the first time in the history of car racing the crowd's roar drowns out the sound of the cars. A total of 25 cars representing seven nations, ranging from the US *Sunraycer* built at a rumoured cost of $A8 million, to the Pakistani *Solar Samba* built for around $7000, are vying for the honour of winning the world's first solar car race.

It soon seems to those in Team Marsupial's support vehicles that the lead cars have vanished, but they have

All Darwin *(pop. 73,000) seems to be in the streets to see the solar challengers off on the 3000 km run south to Adelaide. As Team Marsupial's car crosses the line, the traffic jam is so severe it takes two hours for the support team to catch up with it. Under the race rules* ***(below)****, the cars race from 8 a.m. to 5 p.m. each day and have restricted times for maintenance. An official observer accompanies each car.*

The Rules of the Pentax World Solar Challenge

- Only solar power can be used. Even pushing or pedalling is prohibited.
- The car must be no bigger than 2 m x 2 m x 6 m. The solar cells and mirrors or lenses used to collect the light must all lie within a volume 2 m x 2 m x 4 m.
- Up to four drivers are allowed but each must be ballasted to 85 kg. Drivers must carry a certified lead weight in the car with them.
- The car must have friction brakes, rear-vision mirrors, a seat belt, brake lights and turn signals.
- The cars can race from 8 a.m. to 5 p.m. each day, stopping by the side of the road wherever they happen to be at 5 o'clock. They can charge the batteries from the solar panel from 6 a.m. to 8 a.m., and from 5 p.m. to 7 p.m., but from 7 p.m. until 6 a.m. each night the car must be put in a lightproof enclosure.
- Work on the car can be carried out only from 6 a.m. to 7 p.m. and defective batteries can only be replaced with a stiff time penalty.
- An official observer accompanies each car to ensure compliance with the rules.

to wait until the rest of the field crosses the starting line before they set off in pursuit. But all Darwin has turned out to see the race and the roads are jammed solid. They are doing 10 km/h in bumper-to-bumper traffic while Dick is out of radio range presumably doing about 60, and every minute they are falling farther behind.

The traffic begins to thin and they are driving as fast as they dare. They call Dick every few minutes but get no response. They pass two entrants already broken down, then other competitors each surrounded by its own little convoy of support vehicles. They pass all four Japanese entries, and wonder why they aren't farther ahead. They pass Melbourne's Chisholm Institute of Technology, fixing a problem with their student-built *Desert Cat*. They pass more cars and begin to wonder if Dick has gone under a road train. They are so anxious about his whereabouts that it is a long time before it dawns on them that since they have not heard from him he must be up there with the front-runners.

And so he is. By the time the support vehicles catch up with him two hours later they have passed every car but GM, *Mana La*, Switzerland's *Spirit of Biel* and Ford Australia. Dick has driven the car farther than anybody has before, all without benefit of any instructions from the support crew!

Yet by the end of this historic day it is clear something is wrong with Team Marsupial's car. They have camped by the roadside 20 km south of Katherine and 329 km from Darwin, and are still in fifth place with GM, *Biel*, Ford and *Mana La* ahead of them. But they had started in third place, and the car is not performing to expectations.

The strain of 48 hours without sleep is taking its toll. After dinner they stow the car in its trailer for the night and turn in, exhausted and worried. They have absolutely no idea why the car is not performing and the intermittent cloud is making diagnosis difficult.

Next morning, things go from bad to worse. They have been overtaken by one of the West German teams

***At Dunmarra**, 625 km south of Darwin at the end of Day Two, Graham checks the drive-chain and motor. Rear wheel and suspension swing above the body for easy maintenance. Although the car has now been driven farther in the race than in all its tests, nothing has gone wrong. Beside the highway (**below**) the panels are tilted to collect the last of the day's sunlight to store in the batteries, which can only be charged during the race and for the two hours before and after the race each morning and afternoon. This is the last blue sky they see for a week. In* Delta India Kilo, *which he flew solo to the North Pole only a few months earlier, Dick has just checked the rest of the field.*

JASON ALLEN

and the Darwin Institute of Technology entry. "We weren't sure about the West Germans," says John. "But when the guys from Darwin Tech passed us... that hurt."

By the middle of the day they work it out. Their sophisticated electronic circuitry has been acting up.

"When all the electronic units were switched on at once," says John, "they were talking to each other. That meant the unit taking power from the solar panels was getting interference and was drawing only about 30 per cent of available power from the panel. Once we discovered that, we reconfigured the car electrically, our speed jumped immediately from 30 km/h to 50 and we overtook the Germans, Darwin and the Hawaiians."

Then came the rain. And hail. And headwinds. And then thick, impenetrable cloud. In a frenzy of meteorological perversity the weather turned itself inside out. Instead of clear skies and blazing sunshine the outback dumped 100 mm of rain on the solar cars in 24 hours.

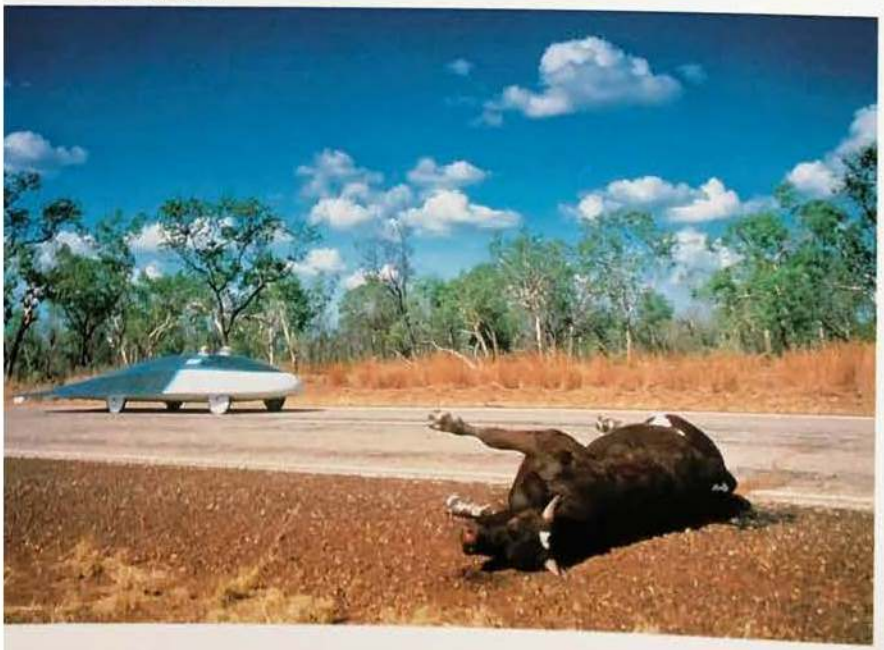
When he wasn't taking his turn in the car Dick was monitoring the race from the air in his helicopter. He put it in perspective: "Nobody could go anywhere. I landed in the rain where our team was camping. Most of them were in the caravan waiting for it to pass.

"The car was parked by the roadside with this soggy tarpaulin over it, looking really forlorn. As I walked past I heard a noise and lifted the tarpaulin. There was Simon in the cockpit, all alone under the tarpaulin writing postcards. And he'd been there a couple of hours. It takes about a minute to get a driver into the car and they wanted to be away the moment the sun came out so they just left him there... and he was happy. That is incredible dedication."

The team's plan was to have the car make only one stop a day, to change drivers. The changeover procedure is like a pit-stop on a racing circuit. The new driver gets early lunch and plenty to drink for the ordeal ahead. The scout car carrying Horrie and Marie pulls out of

PHOTOS: SIMON BRUTY

DICK SMITH



The glassy smooth surface *of the solar cells on Team Marsupial's car, here running at 35 km/h under clouded skies (**top left**), is important to the car's streamlining. In Alice Springs, the Swiss entry* Spirit of Biel *was damaged in probably the world's first collision between solar and conventional cars (**above**). Back in the race five hours later, it beat Team Marsupial into third place. GM's* Sunraycer *(**left**) averaged 66.9 km/h to lead all the way. Dead cattle and other animals dotted the roadside, casualties to the giant road trains that thunder the length of the transcontinental Stuart Highway.*

***The 25 cars** in the solar challenge were entered from seven countries – Australia (with 10), USA and Japan (four each), West Germany (three), Switzerland (two), and one each from Denmark and Pakistan. Some kept the cars simple, others built experimental space-age machines. The roadside "solar bowser" (**right**) at Larrimah, 488 km south of Darwin, raised a laugh.*

***The student-designed** Star (**above left**), from Missouri's Crowder College (USA), compares dramatically with Hawaii's corporate* Mana La *(**above right**). The full bubble canopy of the Japanese* Hama-Zero *car (**below left**) was cut away to keep the driver cool. The West German* Lichtblick 2 *(**below right**) used concave panels to collect both direct and reflected light.*

the convoy and finds a safe stopping place a few kilometres ahead. The solar car pulls in behind it, leaving a 20 m gap. Georgina drives the seven-tonne support truck into this gap, the crew opens its back door ready to get out spares if needed. Mission Control pulls in behind the solar car, with the team's V-8 with caravan in tow coming in behind them. Four people rush to the solar car and lift the wing and then the canopy.

The driver, usually very tired by now, struggles to get his seat belt off while someone unplugs his headset. The driver, often wet with perspiration, climbs out with his 1-litre drink bottle and lead ballast; in climbs the new driver, who buckles his seat belt, plugs in his headset and checks the radio. In goes his lead ballast, which the official observer checks and notes in his log. In goes the driver's drink bottle and the canopy is closed. John or Graham has been inspecting the car for potential problems. Down comes the wing. A check that the road is clear, and with a brisk command over the hand-held radio the solar car is off again. Elapsed time: less than two-and-a-half minutes. Ian was to take the laurels for the longest stretch behind the wheel – nearly six hours on a rough, bouncing trip from Port Augusta to Port Pirie when the car was jostled by crosswinds.

The race wasn't all problems and hard yakka however. During a stopover in a remote area south of Tennant Creek the team was visited by a few locals, one of whom was a telecommunications contractor. Dick's wife Pip jokingly asked if he could supply a TV so they could check the progress of the race on the evening news.

PHOTOS · SIMON BRUTY

***Television news**, outback style, somewhere south of Tennant Creek. A passing communications contractor obligingly provided the TV set and set up this satellite receiving dish for the team, who ate dinner under the stars while watching news coverage of the day's race. Fellow highway travellers were these South Australian and Northern Territory police (**left**), who rode camels from Darwin to Adelaide to commemorate the use of camels for police work in the outback.*

***More than 100 mm of rain** in 24 hours flooded long stretches of the Stuart Highway, adding to the problems of cars already disadvantaged by the lack of sunlight. This flooding was north of Alice Springs.* ►

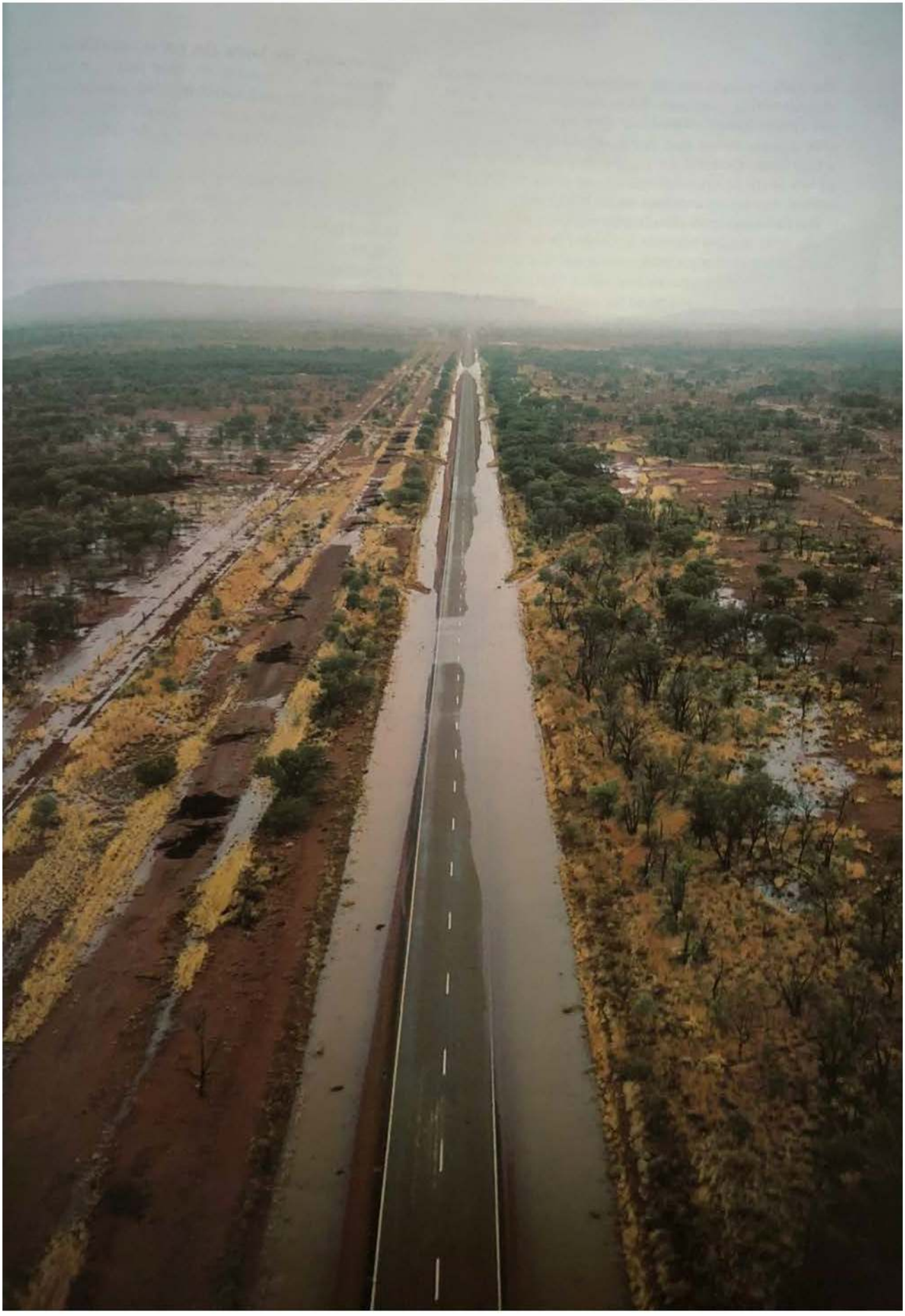
"He went into Tennant Creek and brought back a TV," says Pip. "He plugged it into our generator, turned the satellite receiving dish on the back of his ute to the right spot and picked up the ABC evening news. So we all pulled up our chairs and watched the news at the side of the road as Dick handed out Minties. I don't think the people driving past could believe their eyes."

The people along the route entered into the spirit of the race. Local radio gave special weather reports for the cars, and at Larrimah, 488 km from Darwin, the Top O'Town Roadhouse erected a plastic-and-cardboard "solar bowser" that offered "solar fuel at 50c a minute".

The downpour between Tennant Creek and Alice Springs forced the team to take their first big strategic gamble. They drove in the rain despite the risk that water might leak past the solar cells into the electronics and cause serious damage. "We decided we couldn't spend all day sitting by the side of the road waiting for the weather to improve," said John. "As it turned out we finished the day with the inside of the car totally dry. That was the first rain the local people had seen in three years. Farmers kept coming out and asking us if we would come back next year and bring the rain with us again."

When the rain stopped it was replaced by the solar-powered car's major enemy – low, thick cloud. The run to Alice Springs was made at 30 to 35 km/h, and this cloud helped decide the character of the race. Team Marsupial had anticipated camping close to other competitors each night to compare notes and share the spirit of the event, but by days four and five the cars were strung out over 2000 km of the 3004 km course – with gaps of up to 250 km between some. For *Sunraycer*, well ahead of the bad weather, it was not so much a race as a demonstration.

The thick cloud so exasperated the team at this point that Dick decided to take time out in his helicopter to visit Ti-Tree primary school north of Alice Springs, where the children had turned out in strength to watch the race. Team Marsupial spent a few morale-boosting minutes



(for both the team and the children) showing the car off and answering questions. When the time came to leave, the clouds hadn't cleared but they had a silver lining. One minute before that day's racing finished at 5 p.m. a tyre blew. Grateful for the timing, they made camp 45 km north of Alice Springs on one of those fine, cool central Australian evenings under bright stars.

But there was more cloud on the run from Alice Springs to the opal-mining country at Coober Pedy. The car got by on minimal charges from occasional snatches of sunshine and from the regulated two-hour charging sessions each morning and night when the car's lid could be tilted towards the milky sun.

The drivers' second biggest enemy was boredom.

"The car looks complicated but when you get on top of it, it's actually fairly simple," said John. "Once it's humming down the road it's really hour after hour of routine. The most frustrating thing about it is of course the weather. We know the car is capable of 85 km/h in trials and we wanted to see how fast it would go on long stretches in blazing sunshine. But sometimes we would go 1, 5 or 8 km/h." The cloud only began to show grudging signs of dispersing after Coober Pedy.

IT IS now a little after 9 p.m. on day eight. We are camped in sparse mallee scrub about 135 km north of Port Augusta in South Australia. John, Graham, Dick and I are squatting around the campfire. The tail end of a locust plague is passing through and while we talk, the fat insects blur between us, smacking into the canvas and pinging off the billy. The race may be only a week old but it feels like a month, so much has happened in this extraordinary sun-starved solar epic.

The Hawaiians dropped out long ago and the Swiss were almost knocked out in Alice Springs in the world's first collision between solar and conventional cars. They

How solar-powered cars work

A SOLAR CAR must derive all its power from the sun. The car carries batteries but their sole purpose is to store the energy obtained during sunny periods for use when it is cloudy or the car is climbing hills.

The amount of power available from the sun is surprisingly large. At noon on a bright day a patch of ground one metre square receives 1000 watts, about as much as a toaster would use. Unfortunately it isn't possible to convert all this power to electricity.

Unlike a solar hot-water service, which uses the sun's warmth to heat water, solar cars use photovoltaic cells (or solar cells) to produce electricity from sunlight. A solar cell is a thin wafer of silicon, treated chemically to give it the right electrical properties. When sunlight falls on the cell it produces about half a volt. A filigree of conducting paint screen-printed on both sides of the cell collects the charge and transfers it to the external circuit.

In the Team Marsupial car, 224 cells are connected in series to produce a nominal voltage of 100 volts, and there are 1960 of these cells distributed over the wing and sides of the car to produce a maximum of 1000 watts.

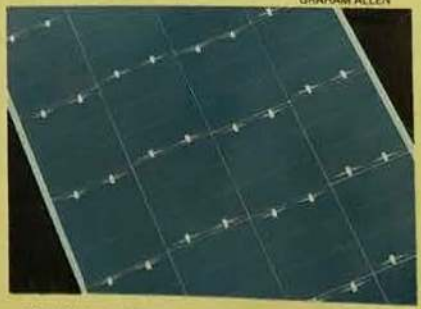
This output can be fed directly to the motors, or at the flick of a switch the driver can send it to the batteries, where it is stored for later use.

Only about 14 per cent of the sunlight falling on the cells is converted to electricity. By contrast, the drive motors are 90 per cent efficient, the electronic circuits about 95 per cent, and the chain drive from the motors to the wheels an astonishing 99 per cent. Clearly the major advances to be made are in the solar cells themselves!

While the drive motors are trying to propel the car, two forces are trying to slow it down. One of these – air resistance – is familiar to anyone who has tried to pedal a bicycle into a stiff headwind. The other is the rolling resistance of the tyres. Air resistance is kept low by making the car, and the frontal area in particular, as small as possible. Equally important are its streamlining and surface finish.

Rolling resistance is what frustrates you when you try to push your car on level ground, and is caused by the vehicle's weight and the tyres. Team Marsupial tested a wide variety of tyres by fitting them to a specially modified trailer and towing them thousands of kilometres around NSW roads. Their choice, an Avocet mountain-bike tyre, not only rolled well but was tough enough to last over 3000 km.

GRAHAM ALLEN



In this portion of one of the Team Marsupial car's solar panels, fabricated by BP Solar Australia, the fine conducting grid that collects the charge can be seen as thin white lines. The solar cells making up the panel are 70 mm x 70 mm-square thin wafers of silicon, laminated to chemically-toughened glass.

The car uses two 1.5 kW motors, one driving each rear wheel. In this way the car can be kept moving despite a failure such as the loss of a chain.

Team Marsupial's car is 5.5 m long, 2 m wide and 1.1 m high, and weighs just 250 kg without the driver. The chassis, of welded chrome-molybdenum steel tubing – a strong spidery latticework (see photo p 104) – supports an aerodynamic Kevlar/foam/fibreglass body. The solar panels are mounted on a wing built up from aviation-quality birch plywood reinforced with carbon-fibre tape. Like a Formula One racing car, the vehicle has a sophisticated suspension system that cushions bumps and maintains stability under most conditions.

So when will a practical solar-powered car be available for commuting? It won't be within the next few years for three reasons.

First, the solar cells are inefficient, requiring a large area to produce enough power. Next, the batteries are too heavy and have a limited life and finally, everything is too costly: Team Marsupial's solar panels cost $22,000, the two motors cost $1700 each and the silver-zinc batteries cost $12,000 for the set of 18.

The Darwin-to-Adelaide race was the world's first real solar challenge. The Tour de Sol has been an annual event in Switzerland for several years, but it consists of stages of about 60 km and the cars run just one hour a day. They are therefore fitted with big batteries and the event is really a test of electric cars with solar recharging.

John Storey

Spectators and cameramen *share Dick's celebratory champagne at the Seppeltsfield finishing line in the winegrowing Barossa Valley. The car's driving time for the 3000 km was 81.5 hours, mostly in overcast. The team agreed that the real satisfaction was that a car can be built in a backyard and driven across Australia on the energy from the sun.*

were overtaken by Ford but worked hard and have secured third place. Team Marsupial is now running fourth.

The unbeatable GM *Sunraycer* held first place all the way and crossed the finish line in Adelaide two days ago – the only car to have enjoyed bright sunshine for most of the journey. There's still plenty of cloud in the sky but the mood around the campfire is optimistic.

"The two leading cars are using extremely expensive aerospace-quality solar cells," says John. "We're the leader of all the backyard cars using conventional solar cells. And our car has a peak solar power of 1000 watts – half as much as GM's. We had hoped to finish in seven days but we'll do it in nine, and when you consider the atrocious weather we've had – that's quite an achievement." It's worth noting that 1000 watts is only about 1.3 horsepower.

Dick is equally optimistic: "What we have proved is that a group of enthusiasts can build a vehicle in their own backyard that can carry a man right across Australia using only the power of the sun. At the same time, I think this race has proved the limitations of solar energy in cars. But it's been well worth it because we have learned so much just by taking part. The lessons can improve the use of solar energy in other fields, like pumping water in the outback. But the best of it has been the adventure – the unpredictability – because you never know what's going to happen!"

Graham adds: "We have learned about the limitations of this generation of solar cells. Who knows what the next generation will be capable of?"

It is getting late and everyone prepares to leave. I ask if the silver-zinc batteries have behaved since Darwin and both John and Graham smile.

"It seems silver-zinc batteries always spit and foam a bit when you start using them," says Graham. "Then they settle. They've been fine since day one, holding a constant 30°C, not even a sign of overheating. The cooling system we installed wasn't needed at all. That whole night's work before the race started was a complete waste of time. Oh... but that's how you learn."

As expected, Team Marsupial crosses the line at Gepps Cross, Adelaide, in fourth place, nine and a half days after leaving Darwin and four days after GM's *Sunraycer*. Gepps Cross is not in fact the end of the race – although it's the point at which the official race times are recorded (and it is duly recorded that Team Marsupial covered the 3004 km in a driving time of 81 hours 26 minutes, at an average 36.90 km/h).

When I catch up with them next they are at Seppeltsfield in the Barossa Valley, the official finishing line. They look exhausted but exhilarated, and they are drinking champagne.

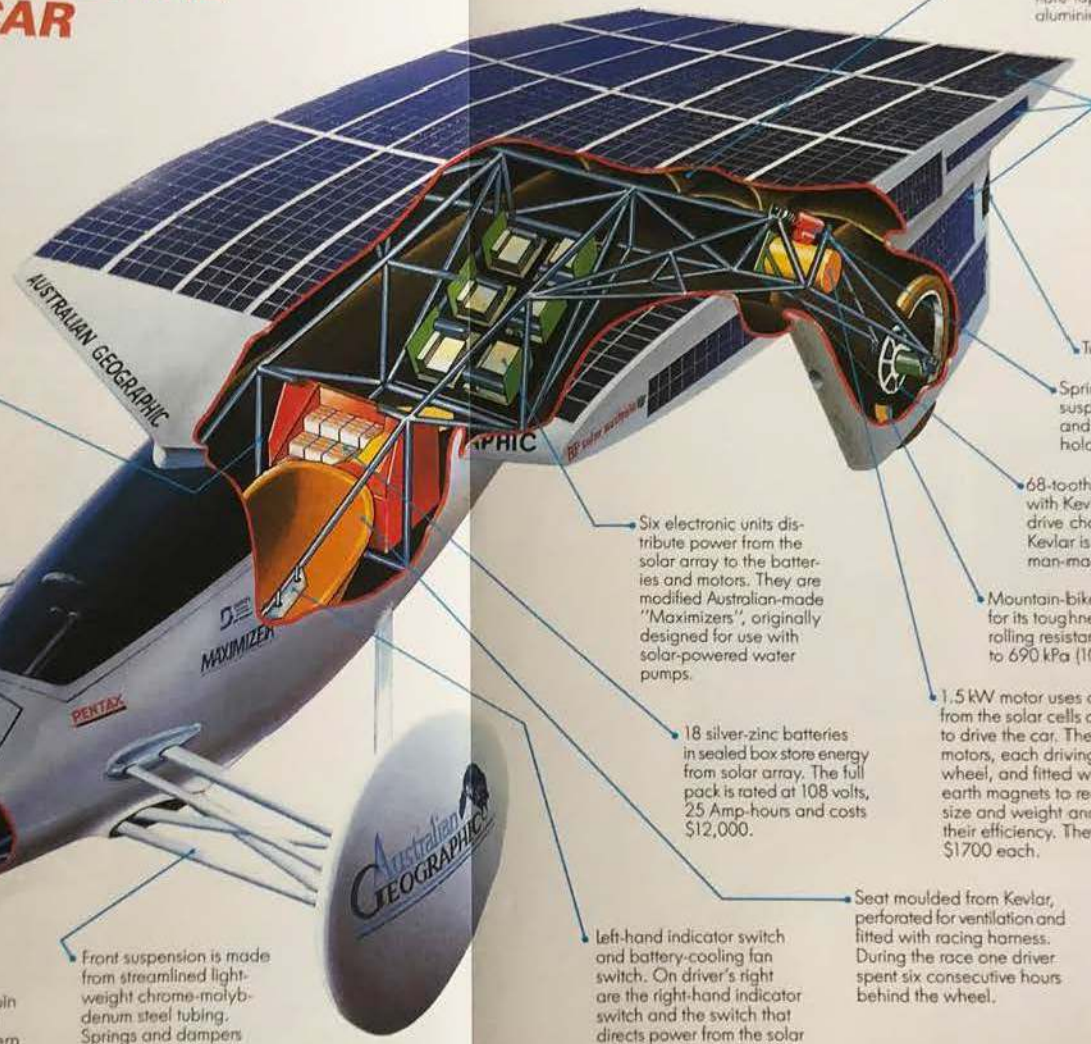
"We were the first to finish of all the cars made for less than $100,000," Graham says. "If we'd had better luck with the weather I think we could have given the more expensive cars more of a race too."

Then John leans forward with a mischievous grin.

"Tell you what," he says. "Tell GM we'll make it the best out of three!"

Team Marsupial wishes to thank the following for their support with its venture: AUSTRALIAN GEOGRAPHIC, Australian Energy Research Laboratories, BP Australia and BP Solar Australia, Boeing Trailers, M.B. and K.J. Davidson, GMH, and Viscount Caravans.

THE TEAM MARSUPIAL SOLAR CAR



Internal wing structure comprises lightweight aircraft birch plywood ribs, reinforced with carbon-fibre tape and tubular aluminium spars.

Solar array on the wing comprises 28 panels, each with 56 single-crystal silicon solar cells, laminated onto toughened glass. Side panels collect early morning and late afternoon light. The array cost $22,000 and produces a maximum of 1000 watts in bright sunlight.

Turn signal and stop lamp.

Spring and damper for rear suspension cushion bumps and contribute to road-holding and stability.

68-tooth bicycle sprocket, with Kevlar guide to prevent drive chain from falling off. Kevlar is a super-strong man-made fibre.

Mountain-bike tyre chosen for its toughness and low rolling resistance, inflated to 690 kPa (100 psi).

1.5 kW motor uses current from the solar cells or batteries to drive the car. There are two motors, each driving a rear wheel, and fitted with rare-earth magnets to reduce their size and weight and increase their efficiency. They cost $1700 each.

Seat moulded from Kevlar, perforated for ventilation and fitted with racing harness. During the race one driver spent six consecutive hours behind the wheel.

Left-hand indicator switch and battery-cooling fan switch. On driver's right are the right-hand indicator switch and the switch that directs power from the solar array to either the motors or the batteries.

18 silver-zinc batteries in sealed box store energy from solar array. The full pack is rated at 108 volts, 25 Amp-hours and costs $12,000.

Six electronic units distribute power from the solar array to the batteries and motors. They are modified Australian-made "Maximizers", originally designed for use with solar-powered water pumps.

Car is built around an exceptionally strong chrome-molybdenum steel frame weighing only 15 kg.

Streamlined lightweight fibreglass wheel spat reduces drag.

The aerodynamic body is made from a Kevlar/foam/fibreglass sandwich whose strength adds to driver protection. Car's overall dimensions are length 5.5 m, width 2 m, height 1.1 m. Weight is 250 kg without driver.

Brake and accelerator pedals. Brakes are dual-circuit hydraulic discs. Maximum speed during the race was 85 km/h, but the designers estimate top speed is 110 km/h.

Air inlet for driver. Cabin temperatures reached 48°C in tests on Northern Territory roads, but overcast skies kept them lower during the race.

Front suspension is made from streamlined lightweight chrome-molybdenum steel tubing. Springs and dampers are inside the body to reduce drag.

ILLUSTRATION BY OLIVER RENNERT
COMMISSIONED BY AUSTRALIAN GEOGRAPHIC

SOLAR RACE DIARY

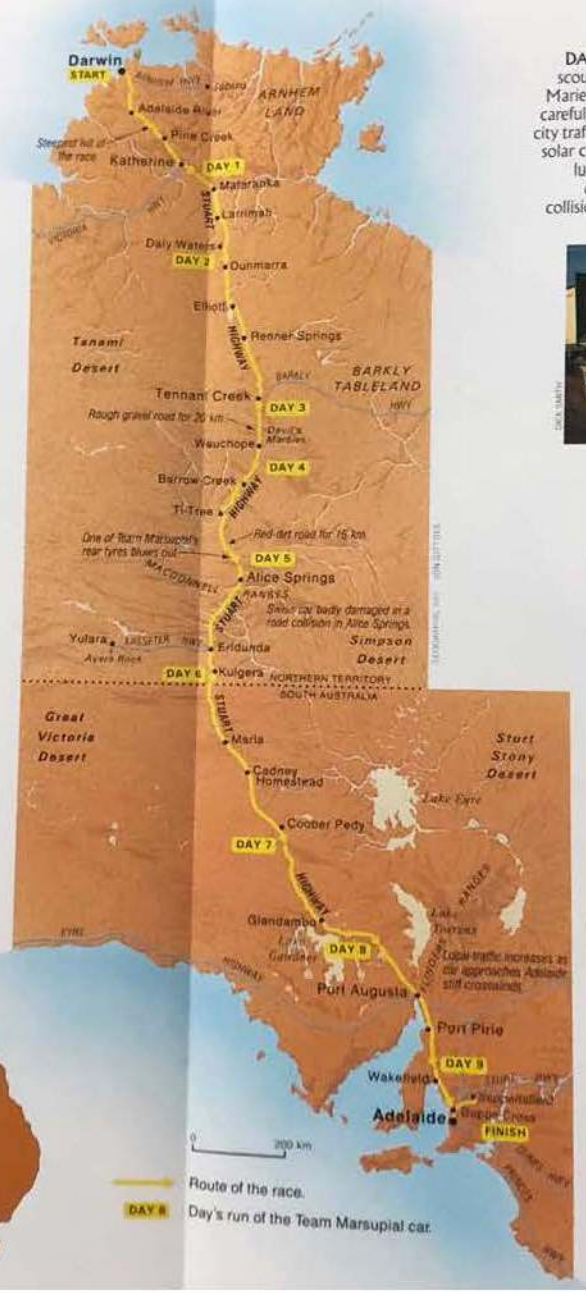
DAY 1: We're third on the starting grid as the flag falls and we head out of Darwin on our 3000 km sun-powered race across the continent. By day's end we have driven 329 km, and are running fifth.

DAY 2: Something is wrong with the car's performance. We're lying sixth and are about to be passed by Darwin Institute of Technology's *Desert Rose*. Feverishly we check our calculations and the car's systems in an effort to locate the trouble. Day's run: 295 km.

DAY 3: Spirits rise as we pinpoint the problem in the electronic circuitry, and our speed jumps from 30 km/h to 50. We are in fourth place at Tennant Creek, where these Aboriginal youngsters cheer us, but cloud is closing in. Day's run: 370 km.

DAY 4: Rain, hail and headwinds reduce our speed. We anticipate further problems when we negotiate a 20 km section of rough gravel near the Devil's Marbles, so Jason Allen welds a spare rear-supension just in case. Day's run: 156 km.

DAY 5: The rain behind us, we are exasperated by continual cloud. We run cautiously down this long stretch of red-dirt road north of Alice Springs at 30 to 35 km/h when the sunlight here could have given us 55 km/h without drawing from the batteries. Day's run: 282 km.



DAY 6: Alice Springs. Our scout car, which Horrie and Marie Kinnersly drive in turn, carefully clears a path through city traffic for Dick Smith in the solar car. The Swiss weren't so lucky: their car was badly damaged here in a road collision. Day's run: 337 km.

DAY 7: We cross the South Australian border after our best run yet, despite a missing wheel spat, which had been damaged. We fix it during the two hours allowed for day's end recharging, our solar array inclined to the setting sun. Day's run: 422 km.

DAY 8: The weather is improving. At tonight's camp, 135 km north of Port Augusta, the boys as usual cannily "discuss race strategy" while the girls prepare the next day's sandwiches. At the table are Georgina Allen (back to camera), Hayley and Pip Smith and Marie. Day's run: 365 km.

DAY 9: The crew inspects the car before we set off on a rough, bouncing run from Port Augusta to Port Pirie in increasing traffic and battered by crosswinds. Ian McCurley spends six hours at the wheel in a worrying day that is a severe but triumphant test of the car's stability. Day's run: 342 km.

DAY 10: The grand finish at Seppeltsfield. Michelle Storey has taken Dick's helmet while he answers the media's questions from the cockpit. We're exhilarated. We finish fourth, but we take the award for being first among the cars that cost less than $100,000. We averaged 36.9 km/h over the 3000 km.