



# University of Waterloo Midnight Sun Solar Car Project



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Welcome to the home page for the Midnight Sun Solar Race Car Project. Midnight Sun is the largest student project in the history of the University of Waterloo. The challenge is to design and build a solar powered race car to compete against other university teams in a variety of races. Currently we are working on the fifth UW solar car since 1988. Join us as we progress toward our goal of competing in Sunrayce 97.

## What's New

### Husky upgraded to platinum sponsor

[Husky Injection Molding](#) was recently upgraded to a platinum sponsor. Their last minute funding provided the necessary funds to send us to Sunrayce 97. The Midnight Sun team would like to express their thanks for Husky's last minute contribution

### Destination: Australia

Midnight Sun, fresh off its excellent finish at Sunrayce 97 is looking to compete at the World Solar

# Table of Contents:

- [Executive Summary](#)
- [The Challenge](#)
- [The Car](#)
- [The Races](#)
- [The Public](#)
- [Mission Statement](#)
- [The Team](#)
- [Why Sponsor?](#)
- [Marketing Opportunity](#)
- [Sponsorship Packages](#)
- [Project Budget](#)
- [Project Needs](#)
- [Conclusion](#)



## Executive Summary

Solar car racing has recently emerged as a high profile event in North America. Since the first World Solar Challenge held in Australia in 1987, solar car racing has captured the imagination of the public as a demonstration of environmentally friendly technology. As the world's fossil fuel supply diminishes and atmospheric pollution increases, electrical vehicles are gaining public support. Solar cars offer the promise of non-polluting, renewable energy alternatives.

Sunrayce is a unique automotive competition in which university teams race solar cars of their own design. This exciting event encourages the creativity and ingenuity of university students, promotes further technological innovation, and educates the public about renewable energy resources.

The Midnight Sun is a student initiative dedicated to producing a competitive solar race car to challenge other universities in North American races. The current team is planning to compete in Sunrayce 1997 and in the Canadian Solar Discovery. Since it is the fourth solar car project at Waterloo, there is a solid foundation upon which to build a successful vehicle. The current team strongly believes that through commitment, experience, and ambition the Midnight Sun IV will be a strong contender in the races to come.

Due to the large amount of community and media exposure that the project receives, your sponsorship will provide a unique marketing opportunity to gain public exposure for your company. It will also associate your company with high technology, environmental awareness, and education. Moreover, the students involved will be provided with an opportunity to apply their engineering skills and creativity to a very unique project as well as learn valuable leadership skills.

We hope that you will take this opportunity to join our dynamic team.

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## The Challenge

Midnight Sun is the largest student project in the history of the University of Waterloo. Over the past eight years the university has entered a solar car into the Sunrayce competition. Midnight Sun IV is a culmination of the lessons learned from the previous three teams which will result in an experienced approach to solar car design. It is difficult to convey the commitment necessary to drive a project of this size, both in terms of student time and also in terms of financial commitment from the community. The project offers many diverse challenges to the student team; all aspects of the project are student-driven and managed. The venture to design, build, and race a solar car is eagerly accepted by a handful of students who discover the project rapidly becomes the primary focus of their academic careers. The project is largely funded by corporate sponsors, and to a lesser degree, by government agencies and university alumni. It is the commitment of corporate sponsors that makes the Midnight Sun endeavour possible.

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## The Car

To create a successful solar race car, many design factors must be optimized and balanced. Solar cars incorporate superb aerodynamic, electrical, and mechanical efficiencies through the innovative use of leading-edge technologies. The solar vehicle, like a typical race car, seats one person. It weighs about half that of the average automobile and has three wheels, although some are designed with four. The car is equipped with a 'solar array' which consists of photovoltaic cells designed to absorb solar energy. This energy is then converted into electrical energy which is stored in rechargeable batteries. The car is driven by an electrical motor which draws the energy from the batteries. Its top speed varies from car to car, but is usually in excess of 100 km/h.

The Midnight Sun solar car is designed and built from scratch by the student team. The vehicle systems include the frame, motor, batteries, suspension, electrics (including lights, horn, etc.), array, cockpit, array, aerobody, ... the list goes on. Each of these systems can be sourced and bought off-the-shelf, partially designed with some off-the-shelf parts, or fully designed by the students. Machining of the components can be done in-house by the students, or contracted out to professionals. These choices are made by the management team based on the resources available. The Midnight Sun IV is budgeted to cost \$266 000.

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# The Races

The Midnight Sun project team hopes to attend both feature solar races in North America.

## Sunrayce 1997

Sunrayce is a ten day race across the midwestern United States in June 1997. The first Sunrayce was held in 1990, when General Motors decided to sponsor a race for American universities. The race was named after Sunraycer, General Motors' winning entry from the first World Solar Challenge. Consecutive races occurred in 1993 and 1995 and were organized by National Renewable Energy Laboratories (NREL). The race is heavily promoted and the race route winds its way through major city centers, covering approximately 2000 km. City streets and rest stops are packed with spectators who often take the opportunity to question team members and inspect the cars.

The winning team is the one which completes the course with the lowest cumulative elapsed time, including race time, and penalties. This requires not only a fast and efficient car, but also a sound strategy. The end of the course maps through the foothills of the Rockies; this is very demanding in terms of energy consumption, and makes for an exciting finish!

Sunrayce 97 promises a new level of challenge and competition as the number and quality of entries increases and prior experience helps to eliminate many of the typical first-race oversights. The students' innovative solutions to these challenges have sparked interest and motivation that in turn benefit the entire vehicle research industry.

This race is the focal point for the Midnight Sun team. The car is designed and built to meet specifications for this race and Sunrayce is the climax of the solar car project.

## Canadian Solar Discovery Challenge (CSDC) (1996 & 1997)

The Canadian Solar Discovery Challenge is being planned as a four day tour in May from London, Ontario to Montreal, Quebec. The solar cars will stop at Waterloo, Toronto, Kingston, and Ottawa. The tour is being organized by the Solar Energy Society of Canada, Inc. Canadian universities are organizing and participating in this event; currently six teams, University of Waterloo included, are expected to take part. This event is intended to showcase the solar cars and allow teams to train for Sunrayce 1997. The public will have ample opportunity to view the solar cars and to question students.

This event will be the largest exhibition of solar cars ever to be seen in Canada. As the first event to take the cars onto Canadian highways, organizers are predicting high

levels of exposure for the participating teams.

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## The Public

An important aspect of the Midnight Sun project is to educate the public. Team members travel to numerous events to display previous Midnight Sun solar cars and to promote solar energy. Midnight Sun has appeared in several different venues including: the Toronto Autoshow, the Toronto Molson Indy, Niagara Envirofest, and various University of Waterloo events. Team members have appeared on television and radio broadcasts and have performed lectures at public schools. The Midnight Sun car and team members are also extremely popular in the Kitchener-Waterloo parades, including the highly publicized Oktoberfest parade. They have three goals at these events: speaking to the public to generate interest in renewable energy in general, and solar cars specifically; to display the car and sponsor board in promotion of our sponsors; and, when possible, to attract new sponsors.

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## Midnight Sun IV Mission Statement

- To strive to create a solar race car that reflects the team desire for excellence and success by building on the experience gained by previous Midnight Sun projects.
- To foster an environment that rests on a solid engineering foundation, encouraging both creativity and innovation.
- To increase public awareness of global environmental concerns and to spread the team's enthusiasm for ecological preservation.

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## The Team

The Midnight Sun team is comprised of over 100 students who commit varying levels of time and energy to the project during the life span of the vehicle. The core team is comprised of less than ten members who, by the completion of the project, will have committed thousands of hours to management, marketing, design, construction, and communications issues, on top of their normal course load.

The Midnight Sun project draws together students from many different faculties. This cross section of the university population brings fresh concepts and solutions together and promotes dialogue which benefits both the project and the students. Learning to

communicate and integrate diverse tasks to achieve a common goal is an enriching experience when compared to the single-discipline projects of a typical university curriculum.

The Midnight Sun team is unique because of UW's predominantly co-op oriented student population. Students in a co-operative education program have the advantage of considerable experience in real work environments. This immensely valuable practical experience and knowledge results in a better design, a better team, and an overall better product. Experience gained on the Midnight Sun project complements experience gained on-the-job and in the classroom.

## Previous Midnight Sun Awards

### Sunrayce 1990

- Daily leg placement award
- Sportsmanship award

### Sunrayce 1993

- Sportsmanship award

### Canadian Solar Challenge 1995

- Second place overall
- Delaware track solar car speed record

### Sunrayce 1995

- Technical innovation award - battery pack

Midnight Sun has a history of successful vehicle designs. Midnight Sun I was praised by officials of Sunrayce 1990 for having an exceptional design. At Sunrayce 1995, Midnight Sun III was one of three teams out of 46 to pass both dynamic and static testing in the first round. It finished second among Canadian teams, third among unseeded teams, and is the highest standing for Waterloo in the history of Sunrayce.

## Team Objectives

The Midnight Sun IV team has the following objectives:

- to provide an enriching educational experience for university students from diverse disciplines
- to provide students with practical experience in large scale projects, while working in teams and industry leaders in the community
- to promote energy efficiency and the use of renewable sources of energy
- to promote our sponsors as organizations who actively support education, the environment, and engineering

Large amounts of drive and determination are necessary to make this project a success. Students at the University of Waterloo are already hard at work planning and working towards the success of Midnight Sun IV.

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## Why Sponsor?

Interest in solar car racing is growing at a phenomenal rate in North America. High technology applications interest everyone from the child who loves the futuristic appeal of the Epcot Centre and the Star Trek Enterprise, to the senior citizen who shakes his head at 'what will they think of next'. The public is becoming increasingly aware of environmental concerns and renewable resources are at the head of the list.

Benefits of sponsoring the Midnight Sun IV project are two-fold. The diverse viewing audience of the extensive media coverage surrounding CSDC and Sunrayce 97 provides a unique marketing opportunity for your company. As well, your company will contribute to your community's growth in four important ways. The Midnight Sun project will:

- stimulate the local economy
- further the development of alternative fuel technologies
- contribute to community education and awareness about environmental issues
- encourage talented young students to expand their horizons

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## The Marketing Opportunity

Media exposure of the past three Sunrayces was extensive. It included complete local coverage as well as national newspaper coverage, trade journals, and national television programs. The race is extensively promoted, both by the race organizers and through a dedicated Midnight Sun marketing campaign. In addition, the University Information and Public Affairs Department will be promoting the race and sponsors through various university publications and events.

During the race, sponsors' names or logos are visible on the car, support vehicles, sponsor board, and on team shirts which are available to the public. Media stops are scheduled throughout the race to encourage comprehensive coverage of the event and of the teams participating. Our sponsors are promoted through visual media and also by team members during interviews.

This year the SESCOI proposes to hold the first solar car event on Canadian roads. Previously limited to a track event, this new exposure promises heightened interest for solar racing in Canada. Extensive media coverage is expected, as the organizers are planning comprehensive promotion. This includes media announcements,

promotional paraphernalia, and a series of Canadian Solar Discovery Exhibits in London, Toronto, Kingston, Ottawa, and Montr(al).

The Midnight Sun project has been featured in segments on CBC, CKCO, CNN, and the Discovery Channel. Due to the high public appeal of the solar car, the Midnight Sun team and vehicle has attended several local and national events including:

- Sunrayce 1990, 1993, 1995
- Canadian Solar Challenge 1993, 1995
- Toronto International Auto Show 1992, 1993, 1994, 1995, 1996
- Toronto Molson Indy 1993, 1994, 1995
- Kitchener-Waterloo Oktoberfest Parade 1994, 1995
- Kitchener-Waterloo Santa Claus Parade 1995
- Kitchener-Waterloo Canada Day Parade 1993, 1994
- Kitchener-Waterloo Auto Show 1993, 1994
- University of Waterloo Science & Technology Fair 1995
- Ontario Science Centre Display 1990-1992
- Niagara Environmental Festival 1995
- University campus and alumni events

At shows and displays, the sponsor board is always on display with the solar car, ensuring that sponsors are promoted. The Midnight Sun is already scheduled to appear in several upcoming 1996 events including the Molson Indy, the Canadian Solar Discovery Challenge, and the University of Waterloo Science & Technology Fair.

Due to the national media exposure, diverse viewing audience, and the University of Waterloo's strong academic reputation, we are confident that sponsoring corporations will receive tremendous exposure through the team and the event. Accordingly, corporations receive much more than the fulfillment of a social contribution. Involvement in upcoming races may be leveraged as a cost effective marketing tool to showcase your company.

## An Environmental Awareness

Environmental pollution and squandering of environmental resources have surfaced only recently as global concerns. As more information is collected and published concerning topics such as global warming and depletion of fossil fuels, we look with increasing concern to the future and hope that such damage can be avoided. Your sponsorship is an investment in our global future, and the future of generations to come. Solar racing represents an attractive image in tune with today's energy-minded philosophy.

## An Educational Commitment

Your sponsorship will provide several rare opportunities to students. Engineering students will have a chance to apply and advance their practical knowledge working on a complex and competitive project. Business students learn to interact with industry, approaching companies for consultation, services and funding. It allows students to



employ a cross-disciplinary approach to problem solving and learn to communicate with others outside their normal realm of learning. Several senior students are provided with the opportunity to manage a large-scale project and to learn to deal with complex management issues. The skills learned by students on the solar car project are applicable to many areas; thus sponsoring this project represents a contribution to increasing the quality of education available to the designers and leaders of tomorrow.

## A Tax Deductible Contribution

The solar car team is a recognized non-profit organization, thus all corporate sponsorship is fully tax deductible. The University of Waterloo has also recently established the University of Waterloo Foundation. By making a personal donation to the Midnight Sun Solar Race Car Project through the UW Foundation, you are eligible to claim donations of up to 100 percent off your net.

We are willing to co-ordinate with your public relations department to explore further avenues of exposure which fit your company's current and future goals.



## Sponsorship Packages

There are many highly visible areas within the project that we can use to promote your company. Corporate sponsorship is available at several different levels. All in-kind donations will be adjusted to a cash value.

Friends of the Midnight Sun - \$500 and over

- Corporate name displayed on trailer along with "Midnight Sun IV" and "Sunrayce 97" signage

Base Package: Supplier/Supporter \$1 000 and over

- Corporate name displayed on trailer along with "Midnight Sun IV" and "Sunrayce 97" signage
- Promotion at events - name on sponsor board
- Photograph of vehicle

Bronze Package: \$5 000 and over (includes Base Package)

- Corporate name displayed on solar car - small lettering

Silver Package: \$10 000 and over (includes Base Package)

- Corporate logo displayed on car
- Promoted as sponsor at selected media interviews

Gold Package: \$25 000 and over (includes Base Package)

- Corporate logo displayed on solar car - large format
- Exclusive sponsorship privileges within field - promoted as major sponsor at selected media interviews
- Use of Midnight Sun IV for corporate publicity and advertising purposes
- Name on support vehicle

Platinum Package: \$60 000 and over (includes Base Package)

- Corporate name or logo displayed on solar car - exclusive advertising real estate
- Corporate name or logo displayed on associated material for the life span of the vehicle
- Exclusive sponsorship privileges within field - promoted as title sponsor at all media interviews
- Use of Midnight Sun IV vehicle for extended corporate display and advertising purposes
- Name on support vehicle

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## Midnight Sun Budget

### Mechanical

Space Frame \$ 7500  
Suspension/Brakes/Steering \$ 5000  
Wheels/Tires \$ 5000  
Hardware \$ 2000

### Aerobody

CFD Analysis Software \$ 15000  
Research \$ 10000  
Mold Construction \$ 90000  
Aerobody Construction \$ 25000

### Electrical

Batteries \$ 3000  
Motor/Controller \$ 20000  
MPPTs \$ 6000  
DC/DC Converters \$ 1000

Miscellaneous \$ 4000

## Array

Solar Cells \$ 25000

Solar Cell Lay-up \$ 10000

Composite Array Support Construction \$ 25000

## Administration

Logistics \$ 20000

Operations \$ 5000

Public Relations \$ 10000

Race Support \$ 20000

TOTAL \$ 266000

The project is not funded by the university; instead students are required to find funding through donations both on and off, campus. This cost does not include donated labour.



## Project Needs

### Administrative

Photocopy Contract

Courier Service

Office Supplies

T-shirt Sponsor

Promotion Aids

Business Cards

Display Case

### Race

Food Sponsor

Hotel Sponsor

Car Rental

Generator

### Electrical

Solar Cells  
DC/DC Converters  
Battery Charger  
Rate of Charge Limiter  
Multimeters  
Batteries  
State of Charge System  
Voltmeters  
Soldering Supplies  
Soldering Iron  
Instrumentation  
Motor Controller  
Peak Power Point Trackers  
Discrete Components  
Oscilloscope  
DC Brushless Motor  
Sensors  
Fans, Blowers  
Breadboards  
Wire, Solder, Cables  
Fluke scope meter

## Mechanical

Bearings, Housings  
Hardware  
Rod Ends  
Brake Shoes  
Brake Lines  
Wheels, Rims, Hubs  
Tires  
Hydraulic Cylinders & Fittings  
Chain Drive System  
Tools  
Aluminum  
Suspension Components  
Aluminum  
Castings Manufacture  
Plating Supplier

## Computer

Workstation  
Network cards

## Aerobody

Pre-preg Composite Sheet  
Canopy Material  
Composite Skin Material  
Fiberglass Mold Manufacture  
Foam Materials  
Bondo/Body Filler  
Reflective Coating  
CNC Mill (Very Large)  
Painting

## Miscellaneous

Communications Equipment  
Cellular Phones & Air Time  
Paints, Bonding, Cleaners  
Uniform Sponsor  
Fuel Card



## Conclusion

The Midnight Sun project is quickly becoming one of the most recognized projects at University of Waterloo. The team is dedicated to producing a competitive solar race car to challenge other universities in Sunrayce 1997. The current team strongly believes that through commitment, experience, and ambition, this tradition will be one of utmost success and international recognition.

Becoming a sponsor promises a good return on investment, an excellent opportunity for corporate relations and community involvement, and the personal satisfaction of becoming part of the Midnight Sun team. The success of this team is dependent on your corporate support.

Thank you for taking the time to consider our sponsorship proposal. We hope that we have been able to convey our immense enthusiasm and dedication in Midnight Sun IV, and have engaged your interest in our project and solar car racing.

Team members are always available to answer any questions your marketing and/or public relations department may have. For more information, please contact the Midnight Sun office.

Please take this opportunity to become involved.

If you are interested in making a donation, please make cheques payable to "Midnight Sun" and mail to:

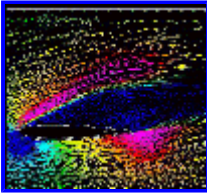
Midnight Sun  
Department of Systems Design Engineering  
University of Waterloo  
200 University Ave. W.  
Waterloo, Ont.  
N2L 3G1

An income tax receipt will follow after the cheque has been deposited.

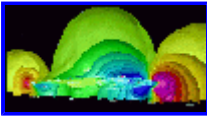
For further information on the Midnight Sun IV Project, or if you wish to give a "gift in kind" please contact (519) 888-4567 ext 2978

## Assorted Pictures

Building the Midnight Sun IV involves a tremendous amount of design and construction. The following is a collection of interesting photos and graphics that show a bit of what we're doing on that front.



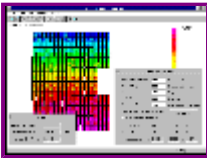
[CFD case \(~300K\)](#) - TASCFlow for CAD by ASC is our main aerodynamic modelling tool. Besides being highly functional, it also offers some spectacular graphic representation of fluids. Here is one of the airfoils researched by the team.



[CFD case \(~80K\)](#) - Also generated by TFC is this graphical pressure distribution over a test car body.



[FE case \(~50K\)](#) - I-DEAS solid modelling is being used for the frame design. Here is what it looks like when we're working on it.



[Custom software \(~160K\)](#) - To understand solar array performance, the team wrote some comprehensive modelling software. Here is a screen snapshot of array output.



The Official newsletter of:

# MIDNIGHT SUN

Midnight Sun V  
Issue 7  
April-May 1999

## With a Little Help From Our Friends...

### What's New...

#### Technical Focus: Solar Cell Encapsulation

#### Logos, Unveiling, it is almost time to rayce!

#### Australia - here we come!

#### [Online Newsletter Archive](#)

The Solar Car Team is happy to welcome several new sponsors. Even with the Sunrayce 99 qualifier less than 3 weeks away the team still has needs to be met. Several local businesses, as well as university organizations have come through for us in terms of material, services, and financial support.

*Jim Wilson, The Minister of Energy, Science, and Technology* visited the Solar Car team and was very impressed not only with the environmental aspects of the car, but with the support that industry has placed in the team. The Minister pledged \$5,000 towards the team's \$100,000 fundraising goal needed to participate in the World Solar Challenge in October.

*The Math Endowment Fund, or MEF*, has become a Bronze level sponsor with an additional \$3,000 to the \$2,300 it has already given the project. This money will most likely be allocated to funding for *The World Solar Challenge* that takes place this October in Australia.

#### *The Canopy Story*

Four regional companies came together to facilitate the construction of the Canopy for Midnight Sun V. The Canopy is the dome like structure made of a type of plastic called Lexan®. This area is the "cockpit" where the driver is seated. Midnight Sun would like to thank each of these companies for helping the team.

*Millard Precision Machine & Tool Ltd.*, a local business that specializes in custom tooling and machining, was kind enough to lend its services. *Millard*, a Bronze level sponsor, is responsible for machining the Plug for us. The Plug is used to produce the Canopy mold for the car. They have also machined several parts of the mechanical system.

The Plug was then taken to *Kitchener-Waterloo Fiberglass*, who then took things one step further. They used the Plug to make a mold for the Canopy that will be used on the solar car.

*Modern Pattern Ltd.* in Etobicoke donated both their precious time and material in making the vacuum box for the Canopy. This box is necessary for the vacuum forming as it maintains the vacuum seal on the part.

*Plastic Development Industries* of Etobicoke, or *PDI*, was kind enough to donate their precious time and expertise as well. Using the mold and our



material, *PDI* manufactured the actual Canopy.

### ***More Aerobody Support***

#### **Midnight Sun Office**

(519) 888-4567 x2978

FAX: (519) 746-4791

[mail@midnightsun.uwaterloo.ca](mailto:mail@midnightsun.uwaterloo.ca)

<http://midsun.uwaterloo.ca>

Another new local sponsor, *Colours Collision Centre*, located in Kitchener, is currently in the process of painting the Midnight Sun V aerobody. The owner, Dave Nagle, specializes in high quality restorations of cars of the caliber of Jaguars, Mercedes, Porsches, and BMWs. This will be his first solar car! The car will be white, like Midnight Sun IV, but Dave has added a special flare of his own - check it out at the unveiling!

## Telemetry, Cockpit & Dash-board Microcontroller

The Telemetry microcontroller and the Cockpit and Dashboard (C & D) microcontroller are now almost complete. These two systems are very important during the race as they control the electrical systems and relay important information about the vehicle's performance to the support vehicles.

The Telemetry microcontroller monitors the car's 'vital signs', such as the amount of energy currently stored in the batteries, energy consumption and speed, and relays that information to computers in the support vehicles where strategic decisions will be made. The C & D microcontroller relays information to the driver on a dashboard display similar to a conventional vehicle. It provides a speed read-out along with other vital signs, controls acceleration and braking and other required items, like turn signals.

Two sponsors helped in the manufacture of the printed circuit board. A new sponsor, Multi-Circuits of Mississauga produced the films needed to create the circuit boards. Advanced Circuit Technology of Kitchener then used these films to print the circuit boards. Advanced Circuit Technology is a returning sponsor. The boards have been populated with components and are currently being tested.

Multi-Circuits is a Canadian company, founded in November 1986, that manufactures single and double sided printed circuit boards. Multi-Circuits provide Quick Turnaround Prototype circuit boards as well as Just In Time production boards. The company occupies a 10 000 sq. ft. building with a fully equipped shop and office and can provide design and engineering for printed circuit boards.

We would like to welcome Multi-Circuits to the project. Many thanks to both Multi-Circuits and Advanced Circuit Technology for their assistance with the microcontrollers.

## Australia - here we come !

As has already been announced, Midnight Sun is competing in the World Solar Challenge '99, which will be held this October. The decision is a big one, as it will cost the team an additional \$100 000 to participate. Our major expenses will be transportation to and from the race, which is held in Australia. The cost of shipping the car one way is approximately \$7500 and airfare will cost roughly \$2500 per person. Once in Australia, our other major expenses will be the rental cars needed to serve as support and towing vehicles, food, and living expenses for

three weeks. Another important cost will be spare parts for the event of a breakdown.

If any of our current sponsors can help us, either with money, materials or resources to help us get to Australia, the help will be greatly appreciated. The entry fee of \$5,000 to compete in the World Solar Challenge is due by the end of this month. Every donation counts and will help us compete in this world famous, international race. We look forward to showing the rest of the world what the University of Waterloo, the Midnight Sun, and our sponsors can

# Technical Focus: Solar Cell Encapsulation

To protect solar cells from moisture, dust, and roadway stone damage, the solar array needs to be encapsulated. There are several commonly used methods.

Midnight Sun IV used a method that involved two donated Dow Corning Products: 2-Part Silicone 184 and One-Part Silicone Conformal Coating (1-2577). The 2-Part was used to hold large modules of bare Siemens solar cells down to the car. The One-Part was then poured over the top to act as the encapsulant.

This time, *Canrom Photovoltaics Inc.* has provided Midnight Sun V with a special Solar rate to cut, tab and EVA (Ethylene Vinyl Acetate) laminate our cells. A clear thin sheet Dupont film called Tefzel® was bonded to a thin layer of EVA placed over the tabbed solar cells. Another layer of EVA was then placed under the cells along with another Dupont film called Tedlar®. EVA is similar to sheet hot-glue. When exposed to heat it melts and bonds to the solar cells and the plastic films. A special heat-vacuum laminator is used to slowly melt the EVA and then pull trapped air from the laminate materials. This method gives a smooth finish to the array and provides excellent waterproofing. A smooth finish to the array is important to help minimize aerodynamic drag, a key factor in building a fast solar car.

## Logo Time!

It is time for us to start collecting logos from all our sponsors. Twin City Graphics in Kitchener is printing them for us again this year. Twin City Graphics has been a long time sponsor of our project as they have been printing the Midnight Sun logos since Midnight Sun III. Our contact is Deborah Sachs and she has a few formatting requests:

- Please send files in the following formats: EPS, PS or Corel Draw via email to [mail@midsun.uwaterloo.ca](mailto:mail@midsun.uwaterloo.ca)
- Please convert all text to curves

Logos can also be submitted on floppy disk directly to Twin City Graphics. Please note, however, that they cannot receive Corel Draw Files.

Please send logos to the following address:

Twin City Graphics Inc.  
Deborah Sachs  
Re: Midnight Sun  
350 Shirley Ave, Unit 7  
Kitchener, Ont.  
N2B 2E1

She can be reached from 8 - 4pm EST at (519) 743

Please let either of us know if you have any problems or questions!

As a note of interest: Twin City Graphics is appearing in TruckFest at Bingemans in Kitchener on the 5th and 6th of June. They will be displaying the Midnight Sun IV aero-body for which they created the logos. Please come by and have a look!

# A Gala Event

With Sunrayce '99 fast approaching and construction on the car set to wrap up soon, the time has come for us to show off what we have worked so hard on for the last two years - Midnight Sun V. The official unveiling is scheduled for Friday, June 4th. The event will be held to give our sponsors and the media a first hand look at the car before it competes in the race.

A reception will be held at the university at noon and will be followed by speeches by some of the people involved in the project and then the official unveiling of the car.

An invitation is extended to all of our sponsors and to the media. We ask those who are able to attend to fill out the card below and mail it back to us. Alternatively, send a reply to our e-mail address, ['mail@midsun.uwaterloo.ca'](mailto:mail@midsun.uwaterloo.ca) to let us know that you will be there. Don't miss out on this exciting and important event!

Midnight Sun Unveiling Reply Form for \_\_\_\_\_ from \_\_\_\_\_.  
Name: \_\_\_\_\_; Company: \_\_\_\_\_

- Yes, I will be attending the Unveiling of the Midnight Sun Solar Car at noon on June 4.  
I will be bringing \_\_\_\_\_ people with me.
- No, I will not be attending the Unveiling.

# Midnight Sun V Sponsor Team

The Midnight Sun Solar Race Car project could not be successful without the help of dedicated groups and companies. We think that your company should be on this prestigious list, please contact us at the address or phone number on the cover. Thank you sponsors!

[Click here for a complete list of Sponsors.](#)

We thank you for your interest in the Midnight Sun Solar Race Car Team. Please direct question or comments to:  
[mail@midsun.uwaterloo.ca](mailto:mail@midsun.uwaterloo.ca)

# Online Newsletter Archive

[April-May 1999](#)  
[January-February 1999](#)  
[November-December 1999](#)  
[September-October 1999](#)



**MIDNIGHT SUN  
SOLAR RACE TEAM**

Midnight Sun V  
Issue 7  
April-May 1999

## What's New...

### Apology

After publishing and distributing the last newsletter, we were alerted to a serious error in one of the articles. The error is corrected in this newsletter.

### Minister of Energy Visits Midnight Sun

On February 4, Minister of Energy, Science and Technology, Jim Wilson, visited the University of Waterloo and the Midnight Sun project.

### A New Addition

The Midnight Sun team welcomes two German exchange students to the team.

[Online Newsletter Archive](#)

The Official newsletter of:

# MIDNIGHT SUN



Husky representative David Messenger presents Midnight Sun with \$30,000

## Husky Contributes \$30,000

Husky Injection Molding Systems Ltd. of Bolton, Ontario, has continued its support of the Midnight Sun with a donation of \$30,000 - the second of two installments of that amount. Husky has again taken the lead as a **Platinum** Sponsor. David Messenger and Taia Husky, came to the University of Waterloo in early November for a check presentation. CTV/CKCO News was on hand to film the presentation, which was aired on the local news. Midnight Sun would like to thank Husky for its generous support of the project.

Husky is a global supplier of injection molding systems to the plastics industry, generating over \$1 billion for the fiscal year ended July 31, 1998. Husky designs and manufactures injection molding machines, PET preform molds, hot runners and robots. They have customers in over 70 countries from 33 service and sales offices in 25 countries. Their campuses are located in Bolton, Ontario; Dudelange, Luxembourg; and Miami, Florida.

A big thank-you goes out to Husky for its ongoing support!☀

## Midnight Sun Office

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<http://midsun.uwaterloo.ca>

## Solar Cells at CANROM

Midnight Sun has sent its solar cells to CANROM Photovol-taics Inc. for encapsulation using Tefzel donated by DuPont Canada. More on Tefzel inside time...

## Correction...

Dear Reader,

After publishing and distributing the November - December 1998 newsletter, the Midnight Sun Team was alerted to a serious error in the lead article.

In that publication, the caption underneath the cheque presentation photograph on the first page incorrectly read: "RIM representative Kent Nickerson presents Midnight Sun with a \$5,000 donation". This caption should have been: "Husky representative David Messenger presents Midnight Sun with \$30,000."

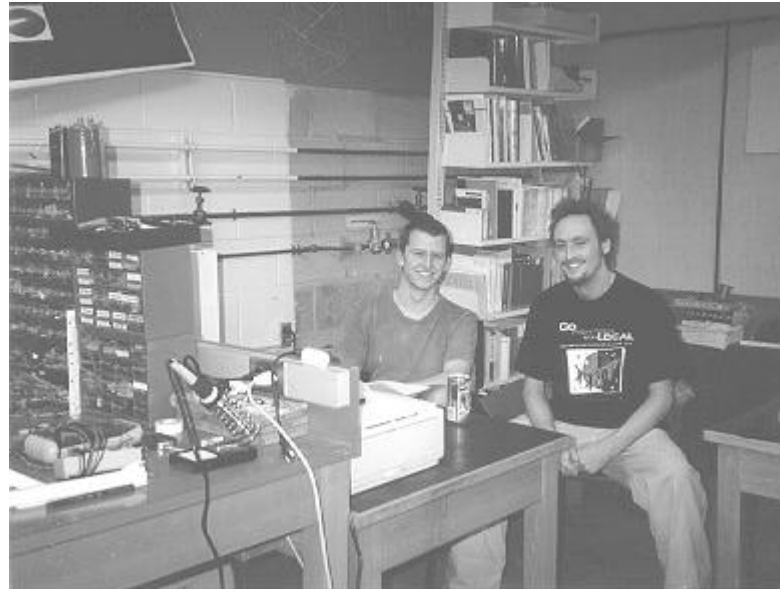
For this regrettable error, the Midnight Sun Team, and I personally, would like to apologize to Husky Injection Molding, Research in Motion, Mr. Messenger, and Mr. Nickerson.

In order to rectify the situation, the lead article, the accompanying picture, and the correct caption have been reprinted. In the future, every effort will be made to avoid another similar occurrence.

Sincerely,

Lukasz Pawlowski

Business Manager



**Our two German exchange students, Thomas Megerle (left) and Rafael Kumschier.**

## A Few New Additions

The Midnight Sun team happily welcomes the second wave of German exchange students to the project. The University of Waterloo and Fh-Karlsruhe have a direct exchange program that allows students who are in a related field to come to Waterloo and spend a work term on the project.

Rafael Kumschier will be working as a part of the strategy team. His project more specifically, will be to work on the weather station that will enable the team to prepare for any adverse weather during races. Rafael will receive an undergraduate degree upon the completion of this term, and then plans to pursue his International Masters upon his return to Germany.

Thomas Megerle, the second of the two visiting students, is helping the mechanical team develop the motor controller. This component is used to regulate torque and engine speed. Thomas plans to find a job involving satellites upon completion of this term.

We are ecstatic to have some more hands (and brains) on the project, and we hope Rafael and Thomas will have a great time in Canada, and especially on the project. ✨

## DuPont Canada Donates Tefzel

A special thanks to DuPont Canada for the donation of the high performance Tefzel to the project. Tefzel will be used to electrically

insulate and protect the Midnight Sun Solar array from the elements. The polymer is a sheet of plastic film that melts and bonds to the solar cells when exposed to heat. The process by which the polymer is applied is called encapsulation. The solar cells that we will be using are manufactured by ASA-Americas. The design for the array calls for the cells to be cut in half and then assembled into modules of approximately 6 half-cells. These modules will then be laid on the solar car aerobody. This will occur at the end of February – more details will follow in our next newsletter. Stay tuned! ✨

## Minister of Energy Visits

On February 4, the Honorable Jim Wilson, Minister of Energy, Science and Technology came to visit Midnight Sun. The Team presented to the Minister the Midnight Sun IV car and took the opportunity to discuss issues such as the pursuit of solar energy and clean renewable resources.

During a brief presentation to the Minister, Team Manager, Ruth Allen, and Business Manager, Lukasz Pawlowski, recounted some of the achievements of the Midnight Sun project including the finish of Midnight Sun IV in Sunrayce 97 as the Top Canadian Solar Car. In an informal question and answer session that followed, the Minister spoke with team members about improvements to the car that will be made for Sunrayce 99 and the teams plans for World Solar Challenge.

After all the talk was done, the Minister was impressed with the support that industry has placed in the Midnight Sun Team and pledged to donate \$5,000 to the team to help the team towards its \$100,000 fundraising goal needed to attend World Solar Challenge in October. ✨



was designed and developed. The group asked many questions concerning the sleek unconventional car. It seemed the lack of steering wheel and the car's unique shape intrigued the children. The flaring of the Cub's imaginations soon worked its way into reality as the children were encouraged to sketch their vision of a solar car.

The team amazed the Cub's parents by holding the children's attention for an hour and a half. But it wouldn't have appeared a challenge to any on-looker, at one point the children's voices were ringing happily through the hall: singing along with the Sunrayce video to the tune of "I to be Wild". ✨

## Construction Continue





**Steve Burany, Baloo, (back row center) watches as his Cubs design solar cars.**



**Midnight Sun team members hard at work on the aerol mold**

## Midnight Sun Presents

The Boy Scouts 17<sup>th</sup> Waterloo Cub Pack discovered that their Cub leader, Steve Burany, had more to offer than just his good company. Steve - Cub name Baloo - a long-time member of the University's Solar Car project, thought his young Cubs would enjoy learning a little about what can evolve from hardwork and dedication.

Midnight Sun team members Lukasz Pawlowski, Sri Artham, and Connie Kwan presented 15 Cubs and their parents with an educational overview of how Midnight Sun V

## Midnight Sun V Sponsor Team

The Midnight Sun Solar Race Car project could not be successful without the help of dedicated groups and companies. think that your company should be on this prestigious list, please contact us at the address or phone number on the cov  
Thank you sponsors!

[Click here for a complete list of Sponsors.](#)

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We thank you for your interest in the Midnight Sun Solar Race Car Team. Please direct question or comments to:  
[mail@midsun.uwaterloo.ca](mailto:mail@midsun.uwaterloo.ca)

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## Online Newsletter Archive

[April-May 1999](#)

January-February 1999

[November-December 1999](#)

[September-October 1999](#)





The Official newsletter of:

# MIDNIGHT SUN

Midnight Sun V  
Issue 5  
Nov-Dec 1998

## What's New...

### Website Gets Facelift

With a new wish list and a lot of new information the Midnight Sun Website is striving to keep everyone up to date.

### Construction of the Aerobody Moulds

CNC machining of the aerobody moulds has been completed by Reko and the moulds are back in Waterloo waiting to be finished.

### Media Campaign

Midnight Sun has successfully begun a media campaign aimed at raising the profile of the project, its goals, and its supporters.

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Husky representative David Messenger presents Midnight Sun with \$30,000

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A big thank-you goes out to Husky for its ongoing support!

### World Solar Challenge

It's official. Midnight Sun will try to compete in World Solar Challenge. The race across Australia in October 1999. The major stumbling block: \$100,000 extra is needed for Midnight Sun to attend. More inside.



# Midnight Sun Trying for World Solar Challenge

It is official. The Midnight Sun Solar Race Car Team at the University of Waterloo will try to attend World Solar Challenge (WSC) to be held in October 1999 in Australia. This event is the single most prominent solar car competition in the world. Entrants in the past have included universities, companies, and individuals.

Stretching 3010 km between Darwin in Australia's north to Adelaide in the South - the 1999 event is set to build on the significant success of the previous four races. The inaugural 1987 event attracted 23 entries and saw the GM Sunraycer set an average speed of 67 km/h. By 1996, the Honda Dream team had increased that average to 89.76 km/h. The race, held every three years since 1987, passes through several distinct climates. Tropical Darwin, outback desert, and Mediterranean Adelaide provide challenging race conditions unlike anywhere else in the world.

The race differs substantially from the Sunraycer series of competitions. Whereas Sunraycer is a staged race, in WSC the goal is to cover the maximum distance possible during the racing time, from 8 am to 5 pm each day. At the end of the race time, teams setup camp along the Stuart Highway where they finished that day's run. At 8 am the next morning the teams begin where they left off the previous day. The first team to the finish line wins.

For more information, visit the WSC website: <http://www.wsc.org.au/sections/car/index.html>



Midnight Sun hopes to be one of the teams to compete and test its against the daunting challenge of the Australian continent in October 1999. Things are looking up for the team as they have almost raised the amount needed to compete in Sunraycer '99. However, getting to WSC is a significant financial commitment. The cost of competing - registration, travel to and from Australia, shipping of the car and equipment, etc. - is expected to cost in the vicinity of \$100,000.

## 3M Presentation Draws Over 200 Students

On Monday, November 23, representatives of 3M Canada came to the university to give a presentation about their company. The talk, which focused on the history of the company, current product lines, and visions for the future, was presented before a standing room only audience in the Davis Centre at the University of Waterloo.

The seminar, which was made possible with the help and cooperation of the Midnight Sun Business Group, helps to raise awareness of 3M as both an employer of Waterloo students and as a major influence in many facets of today's world. The hour-long presentation was followed by a



Standing room only as 3M talks about innovation.

reception in the Davis Centre Fishbowl where students had the opportunity to meet 3M's representatives and members of the Midnight Sun team.

## Aerobody Moulds Return

Reko International Group has finished CNC machining the aerobody moulds that will be used to create the outer shell of Midnight Sun V. The moulds arrived at Engineering 3 in late November after being hollowed out using one of the largest CNC machines in Canada at Reko's facilities in Windsor, Ontario. The Institute for Marine Dynamic (IMD) facilitated the machining by lending Midnight Sun the drill head used in the CNC process. Apache Specialized shipped the moulds to and from Reko's facilities at not charge. Many thanks go out to Reko, IMD, and Apache Specialized for their contributions towards the completion of this essential task.

The next step in the aerobody construction is for the moulds to be sanded and all cracks filled. These steps will be performed at the University of Waterloo by team members. This work is to be completed by the end of January in anticipation for the creation of the completed aerobody by the end of March.



Midnight Sun IV on the set of CKCO-TV Midday News

## Newsletter Available On-Line

The Midnight Sun newsletter is now available on the World Wide Web. It can be accessed from the Midnight Sun

## Web Page Facelift a Refreshing Change

On October 25, the Midnight Sun Web Site took on a new look. The website sports the new Midnight Sun V logo and more information than ever. Now accessible from the website are links to information about Sunrayce 99, Midnight Sun history, information for sponsors, a list of our current sponsors, the most recent newsletter, and the Midnight Sun Wish List.

The goal of this site is to keep the Internet community abreast of the activities and needs of the project, and to publicize all the organizations and individuals that help toward our goals. New features to look for in the coming months are: an automated sponsor list featuring the possibility of a link to each sponsor's website and each sponsor's logo, a list of Adopt-A-Cell participants, an automated signup to receive electronic notification of our newsletter, an order form for Adopt-A-Cells and T-shirts and much more information about all aspects of Midnight Sun.

The site is available at <http://midsun.uwaterloo.ca>

## Midnight Sun in the Media

Midnight Sun was featured on the CKCO-TV noon newscast Tuesday, November 24. Ruth Allen, Team Manager, and Lukasz Pawlowski, Business Manager, were interviewed. The Midnight Sun IV car was shown in the studio. All aspects of the project were discussed, including student participation, sponsorship and the race itself. The station has also agreed to provide daily results and highlights during the race in June on the 6 o'clock newscast.

This interview was the latest in a series of articles and TV spots aimed at promoting the project, its goals, and its supporters to the business community and the public in general. Other publicities have included articles in the newspapers such as the Record, Waterloo Chronicle, UGazette, Imprint, and Iron Warrior, and several check presentations that have been aired by CKCO TV. Midnight Sun would like to thank all these organizations for their support and the opportunity to tell the public about the

website, at <http://midsun.uwaterloo.ca>. The on-line newsletter will be published in the same format as the current printed version. Both versions will be published at approximately the same time, every one or two months.

It is hoped that publishing on-line will allow us to save on paper, printing and distribution costs associated with the newsletter. Those recipients who wish to receive the newsletter electronically can contact us at [mail@midsun.uwaterloo.ca](mailto:mail@midsun.uwaterloo.ca) to let us know of your choice.

project.  
If you know of other media sources that might be interested in stories about Midnight Sun, please let us know by sending an e-mail or by giving us a call.

## Solar Cell Testing Done at NSTF ORTECH

Midnight Sun would like to thank National Solar Test Facility (NSTF), ORTECH Corp., for the use of their testing facility. Based on testing done at this laboratory, we were able to decide the type of solar cells that will be used on Midnight Sun V. NSTF provided the use of their testing facility free of charge; renting the facility would have cost approximately \$4,000. However, only a \$200 fee was incurred to cover the cost of materials.

Sunrayce provides a choice between two different types of cells to be used in the race. The decision was to be made between Siemens and ASE cells. Under normal circumstances, it was that both cells produced the same amount of power. The decision between which cells to use was made based on the performance of the cells when broken - something that could happen during Sunrayce. Which ones did we choose? That will have to wait. We will release a technical specification of Midnight Sun V.

## Midnight Sun V Sponsor Team

The Midnight Sun Solar Race Car project could not be successful without the help of dedicated groups and companies. If you think that your company should be on this prestigious list, please contact us at the address or phone number on the cover. Thank you sponsors!

[Click here for a complete list of Sponsors.](#)

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We thank you for your interest in the Midnight Sun Solar Race Car Team. Please direct questions or comments to: [mail@midsun.uwaterloo.ca](mailto:mail@midsun.uwaterloo.ca)

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The Official newsletter of:

# MIDNIGHT SUN

Midnight Sun V  
Issue 4  
Sept-Oct 1998  
**What's  
New...**

## Meet the Midnight Sun V Project Core Group

Some information about our core group... find out who we are and what we do when we're not working on Midnight Sun

## Construction of the Aerobody Moulds

Epoxying foam for aerobody mould construction has been completed. They will be CNC machined by Reko this month.

## 3M Canada Makes a Donation

Many thanks to 3M Canada for their donation of epoxy to aid us in the construction of the aerobody moulds

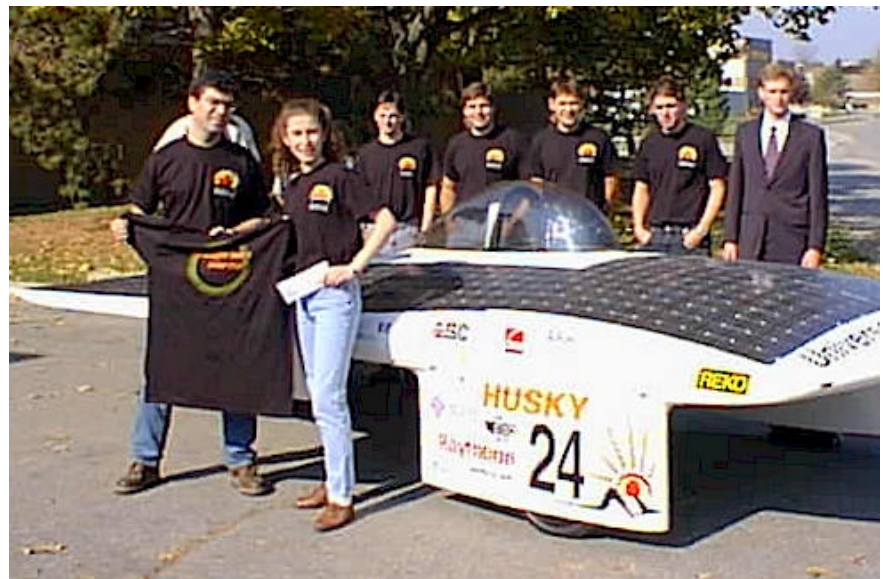
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RIM representative Kent Nickerson presents Midnight Sun with a \$5000 do

## RIM Becomes a Bronze Sponsor

Research In Motion Ltd. (RIM) has become a **Bronze** sponsor of the Midnight Sun solar car team. RIM visited the university on Friday October 16 to present a cheque for five thousand dollars. Following the presentation of Midnight Sun IV was given for CKCO TV who filmed the presentation on the 6 pm news that night. The money was used to purchase batteries for the car. We are delighted that RIM has graciously donated their money to help Midnight Sun continue its history of success.

Founded in 1984, RIM has emerged as a leader in today's rapidly evolving communications industry. RIM is based right here in Waterloo and its headquarters is located at 295 Phillip Street, Waterloo, Ontario, Canada N2L 3W8. Its manufacturing site is located nearby in Kitchener.

RIM has a history developing new technologies that are on the cutting edge and keeps in close contact with network operators, suppliers and its customers in order to create new innovative technologies. RIM specializes in designing, manufacturing, and marketing wireless electronic access technology. Such technologies include two-way pagers, wireless computer car adapters, security connectivity tools and embedded wireless radios. These devices cater to both to-business and consumer applications. The goal of RIM's technologies is to provide mobility with the ability to stay in touch with people and information. RIM

technologies allow wireless coverage in previously unreachable places.

Thank you RIM for your generous donation!

## Meet the Midnight Sun V Core Group

### **Ruth Allen**

Ruth is the Midnight Sun V Team Manager. She is currently in 2B Chemical Engineering. Her career goals after graduation possibly include developing batteries or fuel cells, with the specific goal of lessening human impact on the environment. While growing up, Ruth was involved in classical ballet and trained for four years in the professional program of Les Grands Ballets Canadiens and still dances recreationally.

### **Steve Burany**

Steve is the Mechanical and Solar Array Manager for Midnight Sun V. He is a graduate of Mechanical Engineering in 1998 and has been involved in Midnight Sun since Midnight Sun II. He was heavily involved with Midnight Sun IV and participated in Sunrayce '97, maintaining the car's mechanical systems. For the current project, he is overseeing the manufacturing of the car's component parts. In his free time, Steve enjoys gliding in the summer and skiing in the winter as well as hiking and camping. Steve has also become involved with a local Scouting group.

### **Michael Deutsch**

Michael is a Co-Aerobody Manager for Midnight Sun V. He first joined the Midnight Sun project to work on

### **David Keil**

David is a Co-Manager of Primary Electrical Systems for Midnight Sun V. He is a student in Chemical Engineering and is currently in his 3B term. His long term career objectives include a career in medicine, possibly as an orthopaedic surgeon. His interests include music, photography, electronics and a variety of sports. David is also interested in Automobile suspension design and automobile repair.

### **Winston Mok**

Winston is the Strategy Team Manager for Midnight Sun V. He is currently enrolled in 2A Computer Engineering. In his spare time, Winston enjoys developing personal projects, working, URA position and break dancing.

### **Lukasz Pawlowski**

Lukasz is the Business Manager for Midnight Sun V and is in 2B Systems Design Engineering. Since joining the team, he has been working on the business aspects of the project. He has held co-op positions in research and development of helicopter simulations for training, automotive manufacturing process improvement, and pharmaceutical drug development



Midnight Sun III, in first year. He is a graduate of Mechanical Engineering in 1998 and is currently working on a Masters degree, doing research in plasma arc welding. Michael's interests include rock climbing, skiing and playing guitar.

### **Simon Foo**

Simon is the Secondary Electrical Systems Manager for Midnight Sun V. He joined the project in his 1B term and later designed and built the body microcontroller for Midnight Sun IV. He has built the C&D microcontroller for Midnight Sun V and is currently managing all other electronics projects. Simon's interests include listening to classical music and playing the violin and cooking.

and design. He is currently interested in becoming knowledgeable in software-hardware interaction.

### **Chris Sheppard**

Chris is currently a Co-Aerobody Design Manager and IS Manager for Midnight Sun V. Chris also worked on Midnight Sun IV, aiding in the construction of the Aerobody. He is a 1998 graduate of Mechanical Engineering, specializing in fluid and thermal dynamics. Chris enjoys computer programming as a hobby, plays squash and is an avid biker.

### **Derek Wright**

Derek is a Co-Manager of Primary Electrical Systems for Midnight Sun V. He is a third year Electrical Engineering student. Among Derek's interests are engineering, electronics, computers and sailing.

## 3M Canada Donates Epoxy

The Midnight Sun solar car team has received epoxy donated by 3M Canada. With their generous donation, 3M Canada has become a sponsor of the Midnight Sun solar car. The epoxy has proven to be very useful in the construction of the solar car moulds over the past few weeks.

3M Canada was founded in 1951 and was one of 3M's first international subsidiaries. 3M Canada's head office is in London, Ontario. 3M has plants in Brockville, Havelock, Perth and Toronto, Ontario and a plant in Morden, Manitoba. Between them, these plants employ 1950 Canadians. 3M Canada serves many markets such as Construction, Electronics, Telecommunications, and Transportation.

3M Canada makes abrasives, adhesives, fluorochemicals, pressure-sensitive tapes, cleaning materials, colored roofing granules, decorative striping,

microscopic glass bubbles, protective coatings and even health care products. Last year (1997) 3M Canada had a sales figure of \$787.8 million (Cdn. \$), a 2.9% growth from 1996. The 3M worldwide net income was \$2.1 billion (U.S. \$)

3M Canada boasts a global reputation for quality, competitive prices, reliable delivery, and customer satisfaction. The main focus of 3M Canada is innovation. Research and development is key in manufacturing unique products. Here are some of the popular products produced by 3M: Scotch brand tape, Scotch brand magnetic audio tape, Thinsulate brand thermal insulation, and Post-it brand Notes to name a few.

## Ford/CAA Autoskills Competition

In June 13, 1998, the Ford/CAA National Student Auto Skills Competition was held at the Ontario Science Center in Toronto. The competition was aimed at grade 12 automotive students from across the country. Midnight Sun was there to display the car alongside the competition. This opportunity allowed us to promote the project and the University of Waterloo to high school students and to the automotive community.

In recognition of our contribution, Ford and CAA presented us with a Certificate of Support, which is currently on display in the Midnight Sun office.

## Construction of the Aerobody Moulds

The construction of the moulds for the aerobody has been completed. Construction on the tables to hold the high density polyurethane foam began in late August and assembling of the foam blocks began around September 25. With the hard work of many dedicated students, under the leadership of Mike Deutsch and Steve Burany, construction was completed on October 4.

At this point, it was found that the tables that were constructed were not rigid enough to support the foam blocks, which weigh approximately 2 tonnes each. Supports had to be designed and built to stiffen the tables and prevent them from deflecting. The moulds will be left for two weeks for the epoxy adhesive to cure before being shipped to Reko International Group, in Windsor, where they will be CNC machined to produce the moulds from which the aerobody will be formed.

Construction was greatly facilitated by the donation by 3M of epoxy and the loan of an air gun to apply the epoxy. We would also like to thank the Civil Engineering Department for providing space for us to construct the moulds in the Concrete Lab and McDonald Steel for donating the time and materials to construct the support tables.