THE
SOLAR FLARE
February 2013

The Highway of Demonstration

by Lacey Crabill

Third Place, 2012 American Solar Challenge Race Team

A highway can be viewed as a road for getting from point A to point B, as an avenue for a new adventure, or even the tool that carries millions of people down different paths every day. However, from the vision of a solar car enthusiast, to me a highway is simply the stomping grounds for expression. The Principia Solar Car team thrives on expressing positive qualities which can be found in every individual on this planet. Love, patience, humility, teamwork, ingenuity, and moral courage are all part of the framework which enables people to be successful in every endeavor they choose to pursue. The list of qualities we express as a team is endless as goodness cannot be defined in a literal sense; but at Principia, we have an immediate focus on putting God first: simply putting Principle, Mind, Soul, Spirit, Life, Truth, and Love above all else. So when we start talking solar car, our vision for a successful race down a highway can be seen in an entirely new light.

There are many details in solar car regulations which attempt to quantify the success of a solar car. It is true that to have a functional solar car, it needs to have the physical characteristics of one; batteries and electrical components need to be properly assembled, tires installed, mechanics of the car in proper working order, etc. And certainly solar cars would not hold their title if they didn't have a proper solar array to transfer the energy collected from the sun's rays into the battery pack. But in light of all these details, our team's success in the 2012 American Solar Challenge did not depend on winning a title. The race was an opportunity to work together as a team in order to build something greater than a competitive attitude.

We built our solar car on the firm foundation that to be successful meant glorifying God and knowingly put forth our best effort. Failure cannot exist when one's vision doesn't accept it. On this foundation, we entered the American Solar Challenge with the expectation of success no matter which form that took. Sure, we learned several lessons along the road from New York to Minnesota; lessons that I am certain will only better prepare the current solar car team, both in the building of Ra 8 and in their next solar car race. Without these bumps in the road, our team wouldn't have had the opportunity to challenge the issues at hand and overcome them with our definition of success. So when anyone asks what our final place in the race was, we will happily announce our third place finish with the understanding that we earned more than a title; we experienced the highway of demonstration.

Looking Forward

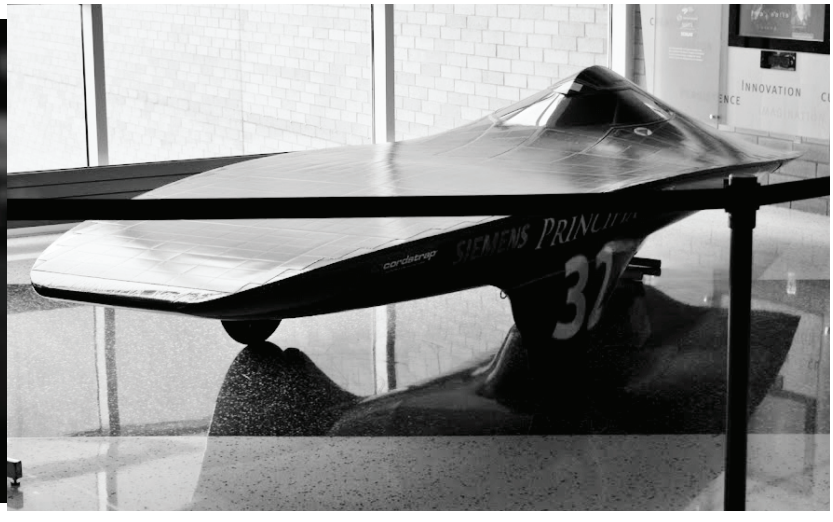
by Kali McKee

Every semester begins with a fresh start: fresh team members, fresh ideas, and fresh energy. This semester, almost all of the active team members are new. With so many new members, it is especially important that the senior members are made available as knowledgeable resources for the new team members. To this end, we have adopted a student leadership model, similar to what the solar car team has done in the past.

Reorganizing the team isn't the only thing that has been keeping us busy for the past few months. This past summer the team participated in the 2012 American Solar Challenge and placed third overall! After the race, the team brought Ra7s back to Principia College to share with Principia Alumni, unpacked from the race, and put everything back in order in preparation for our next big step. As we have known for a while, regulations for all two major races are changing significantly. Both the World Solar Challenge and American Solar Challenge staff envision future races with solar cars that are more similar to the typical car. One of the most significant changes in the regulations is the move from either three or four wheels in the challenge class to only allowing four wheels. That automatically makes Ra7s unable to qualify for the challenge class. The team would like to continue participating in the challenge class, so the team has been in the process of researching and designing our next car, Ra8. The new car will have four wheels and will look quite different than Ra7 and Ra7s. Although nothing is finalized, the team is well on their way to creating the design for Ra8, with the new regulations as our building blocks.

As we look towards the future, there are many possible races. Our current plan is to participate in the 2013 Formula Sun Grand Prix (a track race) which will be hosted in Austin, Texas this June. The team plans on using Ra7s in this race and will use this as an opportunity for the new members to gain race experience. Meanwhile, we are working on designing and building Ra8 which is scheduled to be completed and tested in time for the 2014 American Solar Challenge, usually held in July, and eventually participate in the 2015 World Solar Challenge. We have a long road ahead of us, but there is plenty of time to learn valuable lessons, gain lots of experience, and make amazing memories. The hard work is what makes the Solar Car Team so special.

Ra 7s, 2012 American Solar Challenge



Semester Overview

by Brent Bennett & Cathrine Shepard

Principia Solar Car has started designing Ra8! Fall semester began with welcoming ten new members to the team and introducing them to the solar car shop. The first few weeks were spent cleaning and organizing the shop with help from our student car manager, Pete Telschow. This provided new members with the opportunity to familiarize themselves with the shop and equipment, and an opportunity to bond as a team. Starting with a clean shop allows the design process of Ra8 to be more effective and efficient. Preparations were not limited to shop work, but also involved analyzing new race regulations and splitting into specific groups in order to focus on researching different aspects of the car design. These groups include mechanical, aerodynamics, and electrical, each lead by a senior team member.

Throughout the semester the team attended two outreach events: one in Grafton, Illinois for a fair, and another with one of our top sponsors, Siemens, in St. Louis, Missouri. The term ended with an up close and personal encounter with Ra7s. Team members got a chance to drive the car, familiarize themselves with car safety, and practice strapping the car down in the trailer for travel. As we look towards the future, we're excited about beginning concrete planning and designing of Ra8. Spring semester will be our most intensive design period. We intend to have students stay on campus over spring and summer break and use the time as an opportunity to accomplish significant portions of the building process.

2012 Grafton Art Fair

The History of a Name

by Sean Neel & John Fox

Ra1, Ra7, Ra7s, and now Ra8. What is Ra? Why did we choose this word to represent our car series?

In ancient Egyptian mythology, Ra was a sun god who was considered the creator and controller of the universe. Although the worship of Ra began on a small scale, ultimately it became the state religion and Ra was later renamed Aton. The Pharaoh Amenhotep IV revolutionized Egyptian religion when he declared Aton not only as the true god, but the only god. Egypt's first monotheist, Amenhotep IV was so fanatical that he insisted the word "gods" be removed from monuments. Even given his zeal, though, the sun religion didn't last, and Egypt returned to polytheism after his death. Pharaoh Amenhotep IV was one of the first monotheists and laid the foundation for future monotheistic religions.

The Lord, or God, as found in the Bible has no supernatural or material aspect, but is divine Spirit itself. The Bible describes divine Spirit as "an everlasting light." This description makes sense because God isn't mortal or temporal, but eternal and timeless. Because of our reliance on solar power for our energy, and our reliance on one god, Ra the ancient Egyptian sun god was a fitting choice to name Principia's solar cars.

Ra8 Design:
Through the Eyes of the Electrical Team

by Dennis Adjei-Baah

As the Ra8 design process is underway, the electrical team is looking at a couple of devices that will be used for the newly designed electrical system. Ra8 will be using a few pieces purchased from Tritium, an Australian based company that provides electrical components for electric vehicles. The devices that we will be using in Ra8 are the WaveSculptor 22 (an electric motor controller), a CAN bus LCD Display, EV Driver Controls, a CAN Ethernet Bridge, and a Battery Management System. The overall system will be using CAN technology for its communication. The CAN system is a way for electronic devices to communicate with each other without a main central device delivering messages to other electrical modules. The CAN system can be summarized in this analogy: it's like sending letters to other people without the need for a post office. The letter will be sent to everyone, and everyone will be informed that you are sending a letter. However, only the person that needs that letter will receive and read it.

Each new tritium electronic device is known as a CAN node – it can send and receive CAN messages. A CAN message is of a specific length and structure or frame and is a string of 1s and 0s which are collectively called bits. The frame of a message consists of a set of bits that indicate the start of the message. Another cluster of bits holds message identification information and message priority followed by the actual data. After the data cluster, there is another cluster of bits that represents error checking and error correction. The error checking cluster is present to allow CAN messages to correct themselves if there is an error detected in the message. All CAN devices will be connected to what is called the CAN bus – a communication pathway for all electronics. The ends of the bus are terminated by 120 ohm resistors, which allows for the addition of more CAN devices.

The WaveSculptor 22 is the new motor controller. The WaveSculptor boasts the ability to convert a high voltage DC current into a low voltage three phase AC current to drive motors. The WaveSculptor is also able to perform regenerative braking bi-directionally. This means that we can generate electrical energy from the car when braking in reverse or in forward drive. One advantage of using the WaveSculptor is its weight. The WaveSculptor has a significantly smaller weight than Ra7s' NuGEN motor controller. This allows for flexibility because there are more options on where the controller can be installed inside the car.

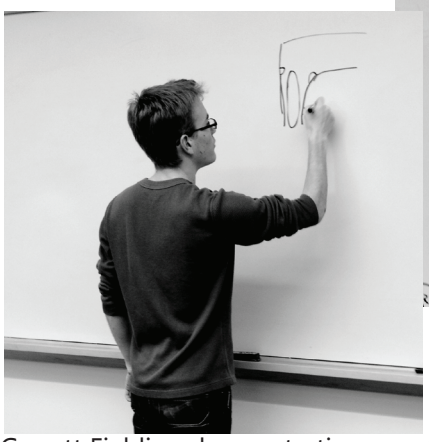
The WaveSculptor will receive commands from the EV Driver Controls which determines how much power needs to go to the electric motor. The Driver Controls also can receive voltage, amp draw, and even motor temperature readings from the WaveSculptor. These readings are packaged into CAN messages and then sent to other nodes, such as the Driver Display, to show up-to-date information about the performance and state of the electric motor.

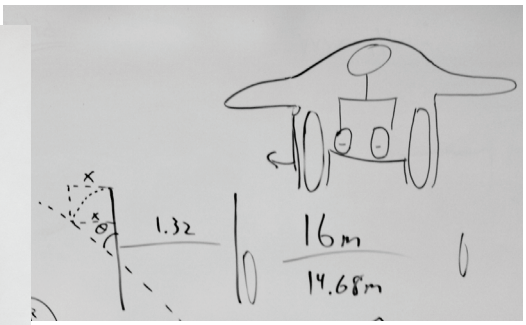
Another device that is going to be used in Ra8 is a new Battery Management System (BMS). The BMS is a system that is used to control and monitor the battery pack of the solar car. The BMS has multiple components called Cell Management Units that are used to manage individual battery modules. The BMS works with the WaveSculptor to regulate how much power is passed to the motor as well as regulating the charging of the batteries when regenerating braking takes place. The electrical team is extremely excited to work with this new equipment. We will be doing some prototype testing of the CAN topology and CAN modules to get a feel for how the whole system works.

Buckle Your Seatbelts:

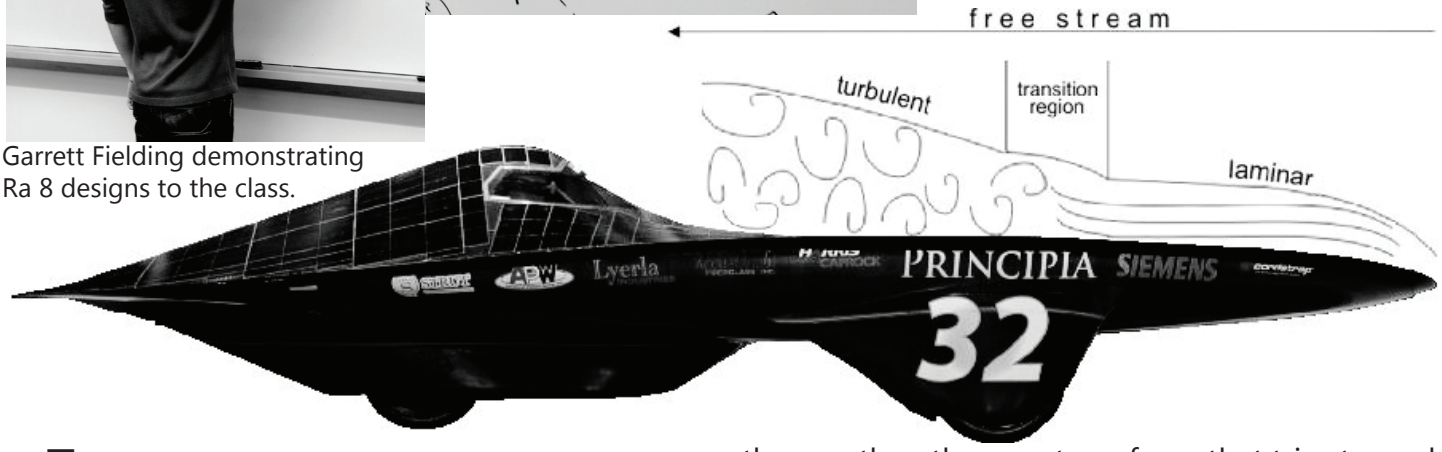
We may experience some turbulence

by Kenneth Stack





Garrett Fielding demonstrating Ra 8 designs to the class.



This past semester our team researched major systems of a solar car in preparation for building Ra8. As body leader, I lead the aerodynamics group as we focus on familiarizing ourselves with new race regulations, basic research, and the design of Ra8 based on the aerodynamics of well-streamlined cars. Throughout the semester, we learned a variety of useful information and have presented our findings to the rest of the team. We discovered that overcoming aerodynamic drag at higher speeds consumes a large amount of the car's energy.

This aerodynamic drag comes from two main sources: skin friction and a pressure difference. Skin friction is a result of air (or any fluid) that "sticks" to the surface or skin of a moving object. This drag increases with rougher surfaces, thicker fluids, more surface area, and higher speeds. The other source of drag that we try to minimize comes from a difference in pressure. There is more pressure on the front of the car from the oncoming air while behind the car there is less pressure. The presence of more pressure on one side of a car than on the other creates a force that tries to push the car backwards. This drag can be minimized depending on the shape of the car. Pressure drag is also affected by fluid density, object size, and speed.

The air flowing directly next to a car is called the boundary layer and is an important part of aerodynamics. In order to minimize friction, one must maximize laminar flow over the surfaces of the car. Eventually the laminar flow will transition into turbulent flow, which creates an increase in drag. We also took a closer look at specific parts of the car body that play a vital role in reducing drag. There is the main section of the upper body which holds the solar cells, the canopy which extends from the main body to cover the driver, the fairings which are built around the wheels, and a protrusion from the underside of the car where the driver sits and rests their legs. The process of understanding aerodynamics plays a significant role in the overall makeup of a car, and will be valuable knowledge when designing our next solar car, Ra8.

3D Printing

by Adam Rolph

When I first heard that there was a 3D printer on campus, my mind raced with ideas about the possibilities of such a device. I've seen that 3D printing is up-and-coming in the consumer market, so I was very interested to work with an industrial sized one and see how it worked. Was I going to be able to replicate Earl Grey tea on demand like Captain Picard of the U.S.S. Enterprise? It certainly felt like it. As it turns out, that's not quite how 3D printers work: at least not yet. What exactly is a 3D printer, how do they function, and why does the Principia Solar car team use one in the construction of the Solar Car?

3D printers are rapid prototyping machines that convert virtual three-dimensional models made on computers with 3D design software into tangible scale ABS plastic versions of those models. They were invented because previous prototyping methods, such as milling with metals, can be very difficult and expensive, especially when creating hollowed shapes. For instance, consider the following 3D printed structure:

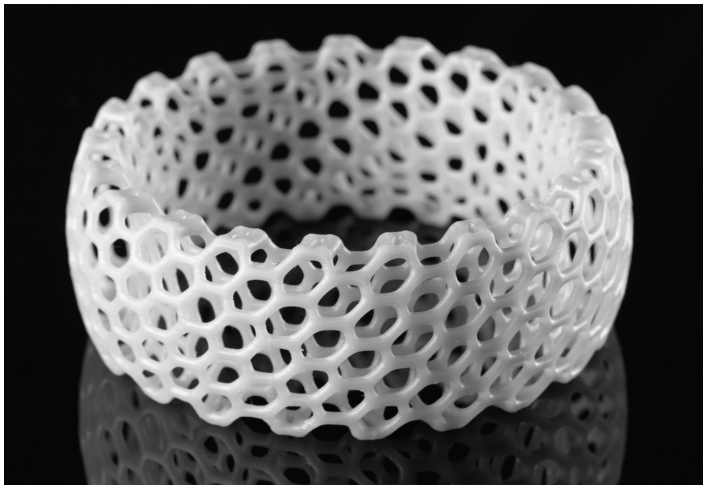


Photo credit: Formlabs and Nervous System Design Studio

Creating this shape using traditional milling methods would be incredibly difficult, if not impossible, since there are a lot of hollow spaces. 3D printers, however, can print out any shape regardless of its design, because of how they operate. 3D printers melt down and layer plastic, line by line, while being directed by an embedded system computer. Thousands of incredibly thin layers are stacked upon one another to create a 3D object. Since each layer is put down one after the other, there is no need to worry about hollow spaces or complex designs.

The next question is where the 3D printed designs come from and how they are used. The Principia Solar Car team uses design software called NX by Siemens. In this program, students can design parts for the solar car down to the last millimeter. With the mouse and keyboard as an interface, vertices can be created, moved, and arranged in such a way that the final result is the desired 3D object represented in virtual space. The computer then converts this design into data the printer can interpret. Button and switch housings, structural components, and even the Formula One steering wheel have all been designed using 3D printing.

So while you may have a good idea of how 3D printing works, you may be wondering what it actually looks like. Does it run out of plastic just like a 2D printer runs out of paper and ink? Is there a robot arm that lays the plastic out? Both answers are yes. The inside of the circle on a 3D printer cartridge is lined with a long string of ABS plastic that is fed into a superheated nozzle during printing. Printing can take 30 hours or longer, depending on the size and density of the object.

But that's not all! The final printed object is actually just a big block of plastic, until it is soaked in a basic chemical bath for 24 hours. This is a necessary step in the process because the printer selectively places ABS plastic where the final object should be and fills any open space with less durable plastic, so that the object remains structurally sound during the printing process. When the object is put in a chemical base, the less resilient plastic fades away and the final object is all that remains. Some of the 3D parts we use directly in the car and others are used for testing before building the actual piece out of other materials.

Siemens Outreach Event

by Matt Herman

This past November, a few members of the team attended an outreach event with Siemens, the largest Europe-based electronics and electrical engineering company, and one of Principia Solar Car's top sponsors. This meeting for the Product Lifecycle Management at the Siemens headquarters in St. Louis, Missouri, was to talk about the future of their software NX, a 3D modeling software. Principia Solar Car has used this software for the vast majority of the design process since 2000. John Broere, Solar Car Advisor, left with the solar car truck early in the morning in order to attend some of the morning meetings. Around 11 am, Solar Car members left campus to drive to Siemens' corporate headquarters in St. Louis, Missouri.

Meeting Steve Shedd, Solar Car Advisor, at the trailer, the four team members unloaded Ra7s and made their way to the entrance of the building. The timing was perfect because employees of the PLM section of Siemens were making their way to and from their lunch breaks. John appeared along with a few employees intrigued to hear about the performance of Ra7s in the most recent race, the 2012 American Solar Challenge. The opportunity was not just a one-way show of the car, but also an exchange of ideas on what some of the Siemens personnel thought of the program and possibilities of the students. It was also an opportunity for Siemens employees to get to know some of the students on the team and learn about their future goals, plans, and aspirations.

The team wrapped up the presentation towards the end of the lunch hour and retired the solar car back into the trailer before heading back to campus. It was a great opportunity to travel to the Siemens corporate headquarters and interact with some of our supporters. We look forward to the continued use of Siemens' NX 3D design software and general resources, especially in the design and creation of Ra8!

Student Bio: Christof Kenworthy

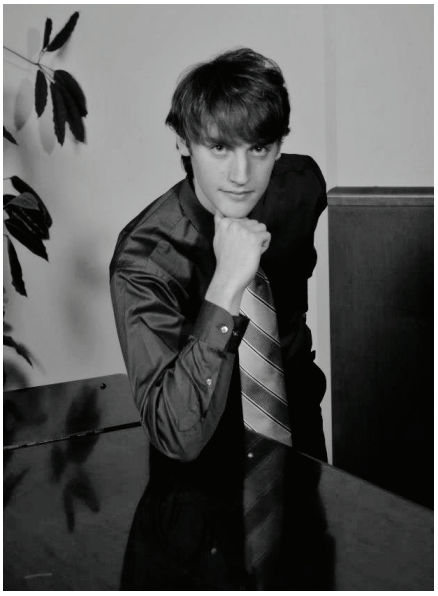
Hello! My name is Christof Kenworthy and I am currently a sophomore at Principia College. My major is computer science, because it is the closest thing to engineering Principia has to offer. Growing up, I played soccer and baseball, and in high school I played football and wrestled. Currently, I am the hooker (center offense) for the Principia Thunder Chickens, Principia College's rugby team. I enjoy the competitiveness of sports, but I also have a sensitive side.

This fall I decided to join Solar Car, and have enjoyed designing Ra8 in accordance with the new regulations. Throughout life, I always liked to figure out how things mechanically fit together such as cars and toys. Until now, the schools I have attended did not have any engineering classes, so I knew I wanted to join the team.

I joined Solar Car for the opportunity to build something and be proud of the contributions I made to the team. Over this past semester I learned a lot, but the neatest facts that have stuck in my mind are that the solar car uses as much power as a hair dryer and some solar cars can drive faster than 80 mph. Little things like that catch my interest and make me want to know how it works. Thank you for your support!

Student Bio: Kyle Meserve

Hey! My name is Kyle Meserve, and I am a sophomore and Biology major at Principia College. Since this was my first semester on the Solar Car Team, I have learned quite a lot about the car that I did not previously know. One of my favorite memories was the opportunity to drive the Solar Car, and experience a taste of what a solar car driver experiences while racing. I concluded that it is an uncomfortable venture that would be extremely stressful, so it's a good thing that I'm too tall to drive it in a race. Or at least, that's what I tell myself as I shed a tear.



Before Principia, I was homeschooled for all twelve years of my education. During that time, I was on a bowling league and I played tennis until my freshman year in high school. I have also played piano since I was six years old, but I stopped taking lessons in high school so I could take guitar lessons instead. This has led to me being mediocre at both piano and guitar, although I have recently started to pick up playing the piano again. At college, I have started playing Ultimate Frisbee and have gotten much better at working as a team than I was directly out of homeschool.

I am excited to see Ra8 slowly take shape over the coming semesters. We have talked a lot about what we are going to be doing as far as design, and construction processes go. I looked into the suspension that the new car may use and I am really looking forward to see the pieces fall into place. My knowledge of cars was almost non-existent before I joined Solar Car, so my experience has increased exponentially during this class.

As a new member of the team, I have learned a lot from the senior members that have been on the team and raced this past summer. Their leadership skills have inspired me, and I will take the skills they expressed and mirror them when I am in their position. Although I will be going on an abroad to Peru this Spring (2013), I will support the team and help as much as I can before I leave!

Student Bio: John Fox

Hello, my name is John Fox. I am a sophomore from Ohio, and studying business at Principia College. I enjoy woodworking, hiking, and biking. My favorite hobby, woodworking, brings me joy and clears the mind because I enjoy working with my hands and making something out of nothing. Because of the enjoyment I get out of working with my hands, I decided to join the solar car team.

I am interested in the mechanical part of the build, but would like to also learn about the electrical part of the car as well. I hope to learn more about the process and expand my technical knowledge. Because of my passion for building and fabrication, I have been thinking about going to a trade school to further my love for the technical field.

Solar Quiz

by Lisa Lewis

Instructions:

Unscramble the solar car related words to uncover the mystery phrase below.

RASY
8 14

RALSO
15 7

HOERACTU
6

NICRIAPIP
9

RRYAA
11

GYOLRFI DGO
3

RCSEERAH
17 4

DO RUO BETS
10

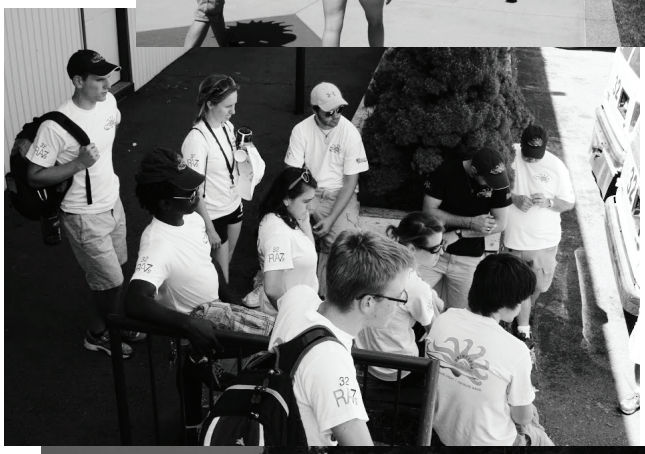
NGDESI
13

WOETARKM
16 12 2

SSEMIEN
1

WNE ERMEMB
5

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 !



Solar Car Team
Principia College
Elsah, IL 62028
www.principia.edu/solar
solar@prin.edu

Solar Car Timeline

Spring Break
March 2013

Summer Break
May 2013

Siemens Outreach Event
June 2013

Formula Sun Grand Prix (Ra 7s)
June 27-29 2013

Go Green Expo (Ra 7s)
October 2013

Upper School Chapel
March 2013

American Solar Challenge (Ra 8)
July 2014

World Solar Challenge (Ra 8)
October 2015

**All uncredited photos are property of Principia Solar Car.

Solar Quiz Key:

Rays
Solar
Outreach
Principia
Array
Glorify God
Research
Do Our Best
Design
Teamwork
Seimens
New Member

Phrase:

Solar Car is awesome!

To receive updates on what we are doing each week, join us at:
http://www.principia.edu/solar

Please address contributions to:

Fundraising Chairman
Principia Solar Car Project
Elsah, IL 62028

Checks payable to: Principia Solar Car Team

All contributions to our 501(c)(3) educational organization are gratefully accepted and are tax deductible. Please include a corporate matching form if your employer has such a program.