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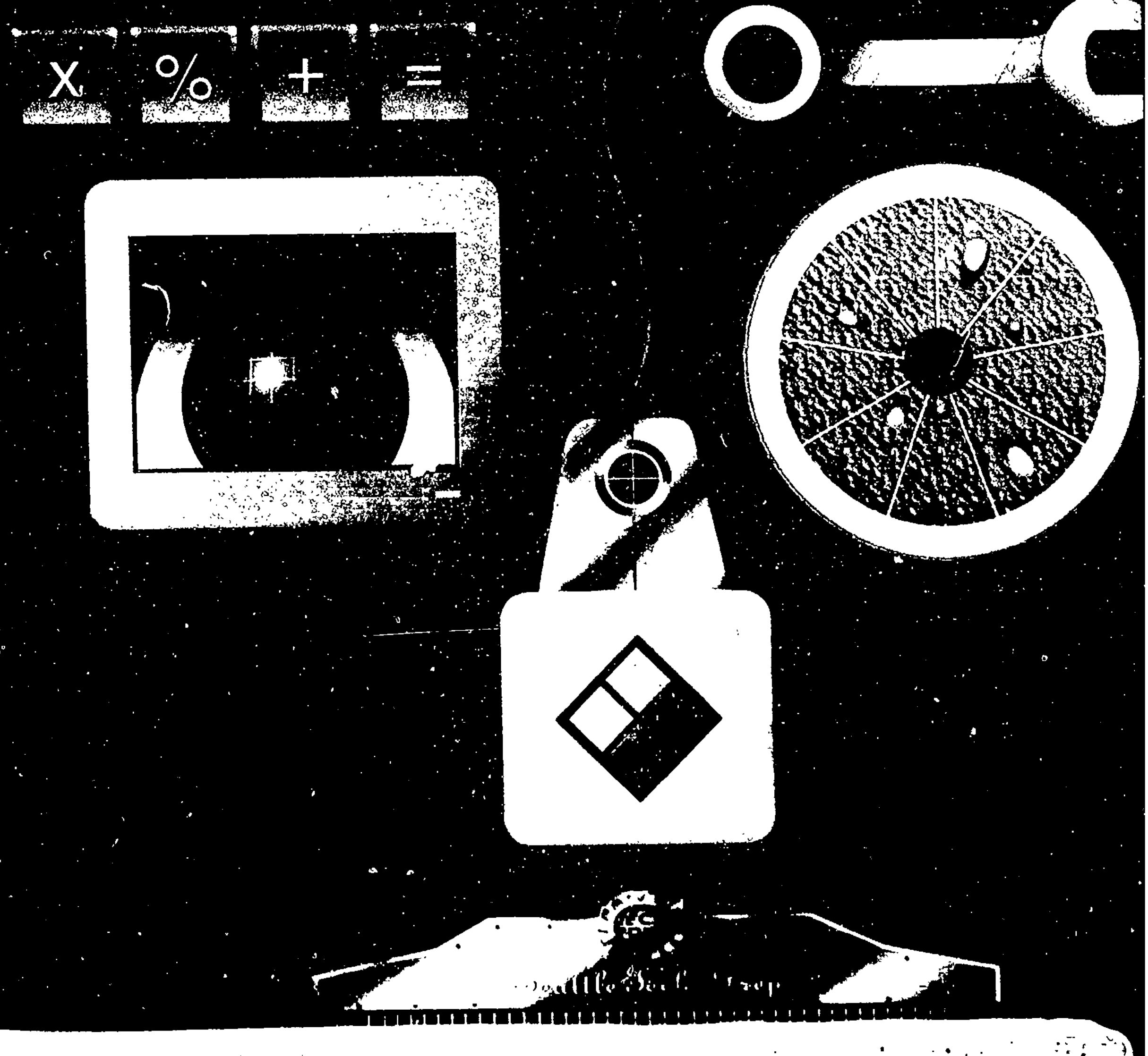
ABSTRACT

This booklet shows how teachers at Ingraham High School and Madison Middle School in Seattle (Washington) challenged their students to tackle demanding technical projects. It also shows how well the students responded to that challenge. The booklet begins with the background of the project, the framework for which would be a university-sponsored statewide competition for remote controlled model solar cars. The two reports that follow are examples of student work and were written by the Ingraham High School Solar Vehicles teams. The first report covers the following: a brief history, fund raising and budgeting, design and engineering, vehicle component development and selection, design and engineering execution techniques, overview of the solar team's duties, vehicle operations procedures, and miscellaneous considerations. The second report describes procedures, evaluation of the hill, rolling friction test, speed test, data analysis, and results. A description of the middle school solar powered boat competition follows. Background information and statistics on Seattle Public Schools conclude the booklet. (YLB)

Solar Car Solar Boat: Model Classroom Projects

Seattle Tech Prep



Solar Car Solar Boat: Model Classroom Projects

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SEATTLE TECH PREP

INTRODUCTION

TECH PREP is an innovation in education that responds to changes in the way people work for a living, the things they need to know to be successful, and the reality that few careers will be immune to change or even obsolescence. Students must be prepared for a work environment in which learning is a lifelong process that demands significant academic, technical, and social skills.

Tech Prep joins Seattle Public School District high schools, the Seattle Community College District and employers in developing an educational program that integrates academic and occupational knowledge in a way designed to prepare students for a meaningful role in society and the workplace. This kind of organizational support is essential, but it falls upon classroom teachers to find a way to help students grasp the opportunity Tech Prep presents and motivate them to remain in school.

This booklet shows how teachers at Ingraham High School and Madison Middle School in Seattle challenged their students to tackle demanding technical projects. The booklet also shows just how well the students responded to that challenge.

Award winner: Ingraham High School's solar car design

Prelude to Tech Prep – Ingraham High School

Solar Car Solar Boat: Model Classroom Projects
Seattle Tech Prep

Rich Thompson has been a teacher at Ingraham High School for 28 years, which is long enough for him to have seen several changes in the way vocational courses were categorized, if not taught. He recalls the fuss over the name change from industrial arts to technology education, the immediate predecessor to the current appellation, technical professional education. So he might be forgiven if he saw Tech Prep as just one more program label. That is not the case.

In a sense, Thompson was a Tech Prep proponent long before the words were coined. Throughout his long career, he has relied upon application-based teaching techniques tied to ambitious projects to motivate students to excel. His students designed and built limited hydroplanes, one of which was driven by a youthful Chip Hanauer, now one of the most successful unlimited drivers. He initiated a marine engine technology program. His automotive students have built hot rods and racing cars that set nine national records on the Bonneville Salt Flats, and won a prestigious national automotive service competition in 1989 through dint of exceptional study and preparation. In reaching these goals, his students have had to master a demanding integrated curriculum without being aware of that fact.

Thompson believes Tech Prep represents the way schooling must go for many students who see little connection between what they are studying in high school and how it relates to their future employment, much less their lives. He has seen the need to move from traditional vocational programs that were rigidly instructional – showing how to tighten bolts, as a simple example, to programs that explain why the bolts need to be tightened and why they are there in the first place.

Rules for Solar Car Competition

1. Cars must be powered only by direct solar radiation to photo voltaic cells.
2. Solar cells are limited to 18 of a specific type.
3. Cells may be encapsulated in any way the team decides.
4. Solar cars must be radio controlled. On board batteries can power the radio receiver on the car, but not the the car itself.
5. Vehicles must have suspensions with at least ½" total compressive wheel travel.
6. Orientation of solar panels may be changed between events. No gears can be taken from or added to the vehicle. All gears must be contained in a transmission that can be changed by remote control or shifted manually by a team member. Gear must be shifted by movement of one lever.
7. Competition will consist of seven events:

   Slalom/Drag Event (timed) – Negotiate 12 cones 10′ apart, 150′ overall.

   Speed Trial (timed) – Between two cones 150′ apart.

   Maze Negotiation (timed) – Reverse direction at each point on course.

   Running Hill Climb (timed) – Two runs over hill obstacle on a 55′ course.

   Static Hill Climb (distance – how high up a 9′ hill the vehicle goes)

   Skid Pad (timed) – One circuit of a 10′ radius skid pad.

   Road Sprint – Qualified cars (those completing all other race day events) race around a course two at a time. Single elimination tournament.

SOLAR CARS – A NEW DIRECTION

Aware that his students needed even stronger academic skills to secure good jobs, Thompson began looking for new projects to challenge them. Western Washington University's successful solar car program provided a tempting model, because it required students to design and build full-scale, state-of-the-art solar cars for international competition.

Thompson thought about starting a similar project at Ingraham, but a budget requirement of more than $250,000 was an insurmountable obstacle. After intensive discussions, Thompson and Dr. Michael Seal, head of the WWU Vehicle Research Lab, found a solution: by literally scaling down the project to the size of common, battery operated remote controlled cars sold in toy and hobby stores, they arrived at a solution that was challenging and affordable.

The framework for the project would be a university sponsored statewide competition for remote controlled model solar cars. To compete, schools had to respond with detailed proposals on a rigid deadline; provide progress reports, again on deadline; design and build vehicles that could pass a strenuous test; and be prepared to face the heat of competition on a set day.

Static test: Nathan Cambell, project model builder and driver, tests performance of vehicle on test stand.

It gave Thompson's Applied Physics and Introduction to Technology classes something to chew on. It also became a catalyst for faculty cooperation. Rich Thompson and his Applied Physics and shop classes provided leadership, Jerry Bisset guided designers in his drafting and computer design classes. Bob Barta's classes helped with manufacturing and metal fabrication. Dr. Tim Phelan taught team members vital math skills.

WINNING TEAM

The team's success is measured in it's unbroken string of victories in the Solar Car Competition: First Place in 1992, 1993, and 1994. Thorough preparation and continuous refinement resulted in a vehicle that surmounted every test.

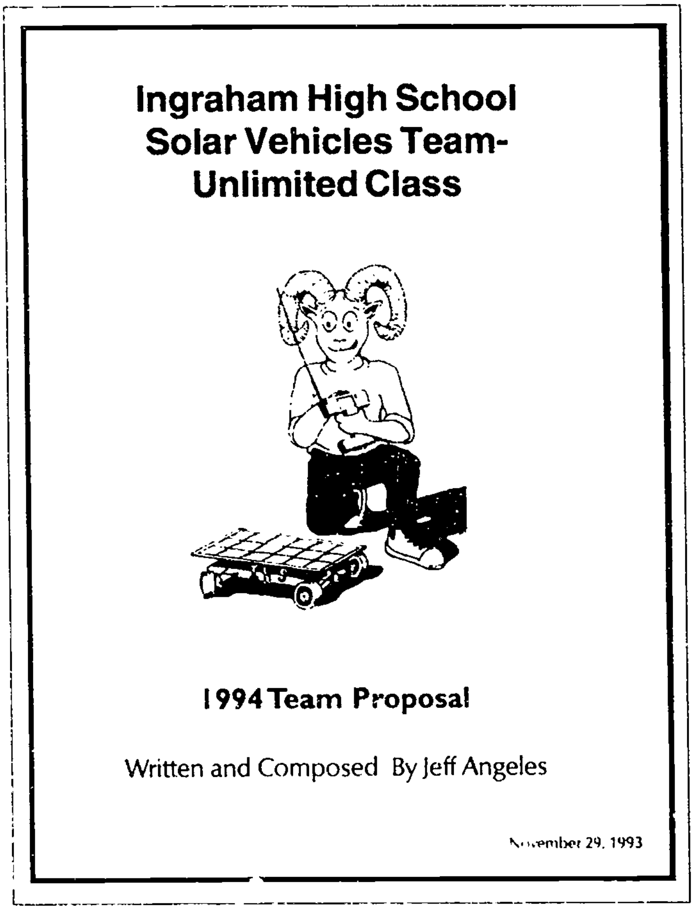
NOTE: The report that follows is presented as an example of student work and was written by Jeff Angeles for the Ingraham High School Solar Vehicles team. It has not been edited for grammar or spelling, although several typographical errors have been corrected.

The 1994 Ingraham Solar Team - Unlimited Class

Once again, Ingraham High School's Solar Vehicle Team is proud to announce its participation in Western Washington University's 1994 Solar Vehicle Competition. We are very anxious to participate again in this event. It is a perfect opportunity for students to experience problem solving and teamwork in the technical world. This project will allow us to improve and expand on what the previous Ingraham Solar Car Teams have achieved.

At Ingraham, we believe that we can succeed. We are eager students. We also have a student who has experience from the 1991-1992 and 1992-93 Solar Car Team. The faculty of Ingraham High School and the community will give us the support we need. Time, money, resources, and team organization are very important. We require these because success depends on all of these parts of the project.

There are new challenges this year. These new challenges include the static hill climb, and the road sprint course, plus creating a shiftable transmission for the car. We can overcome these obstacles with information, solutions, knowledge, resources, and enthusiasm. We use these ingredients to make our finest solar car to overcome these challenges. With our problem solving methods, we can solve these technical problems.



Report cover design

Our project manager is Ingraham senior, Jeffrey Angeles. Jeff is responsible for making sure that the Ingraham Solar Team will work as a unit throughout the entire project. We organize our team in a way that everyone in the 1994 Ingraham Solar Team can make use of their abilities to their fullest. There are twelve specialty positions which will be the keys to our success of this project. General positions include: Project Manager (Jeffrey Angeles), Designer (Roman Yumang, Robert Stoddard, and the CAD class), Fund Raiser (Amanda Waterman and Terri Betts), Project Advisor (Rich Thompson, Jerry

Bisset, Dr. Tim Phelan, and Bob Barta), and Project Consultant (Shawn Franson). Technical positions include, CAM Fabricator (Chris Conrad Thanongsone Daranouvong, and the CAM Class), Composites Manufacturer (Jeff Angeles, Amber Sawicki and Roman Yumang), Component Tester (Robert Stoddard and Jeff Angeles), Electrician (Jeff Miller and Richard Righter), Chassis Fabricator (Ryan Rathe, Roman Yumang, Arthur Rugtvedt, and Chris Conrad), Drivers (Chris Conrad, Brandon Little, and Arthur Rugtvedt),Quality Assurance (Quyen Tuong), and Maintenance/Pit Crew Person (Sean Horn, Arthur Rugtvedt, and Jason Lynch). Other students in classes of technical education are responsible for data collection and interpretation tasks on the Solar Team.

Communications are an important factor for our success. For that reason, our team members attend mandatory Monday meetings. The purpose is to discuss what we need to deal with for the week. Then, we hold Friday meetings to gather all of the information we have and use it to make improvements on the solar car. Success would not be possible if we are unable to express and share our ideas for the project.

1993 Trophy winners: Ingraham team members Jeff Angeles, Robert Stoddard, Nathan Cambell, Arthur Rugtvedt, Sean Horn and (seated) teacher Rich Thompson show first place trophies.

A BRIEF HISTORY

Throughout the past two years, Ingraham has excelled in the State Solar Vehicle Design Competitions. Many may think it is due to our access to advanced technology. We do not believe that. We believe in using advanced technologies to its fullest. Our secret of success is creating a team that is capable of working together. An example of that is we are open to new ideas. We listen to all of our members on what works well and what can be improved. Another one is continuous tests and data analysis. That means we go out of our way to find better materials and processes, plus we test them to see how much better they are. A standard we impose is the 20:1 Rule. That means if the part can withstand twenty test cycles, it is good for one race. As a result, we produce a quality solar car that can excel. Overall, if we work together, we can be ahead of the competition.

FUND RAISING AND BUDGETING

Ingraham Juniors, Amanda Watermann and Terri Betts, are responsible for raising money to pay for Ingraham's solar vehicle expenses. Solar Team Members agree to donate a reasonable amount of cash for transportation and miscellaneous costs. Team members may volunteer for local fund raisers such as car washes, candy sales, etc. Major funds come from these businesses: Washington Natural Gas, NW. Chrysler/Plymouth, Nelson Chevrolet, Phil Smart Mercedes-Benz, Lake City Elks, Schucks Auto Works of North Aurora, and Case Construction Company Incorporated. We get additional funds from the Seattle Schools Technical Education Department (Central Office), and parents of the Solar Team members.

Successful fund raising methods will be necessary for us because we will need money to cover the costs of parts, materials, equipment, and other related costs. As with most projects, we cannot start a project without knowing what materials we need and the money to purchase it.

DESIGN AND ENGINEERING

Before we start building our new solar car, we hold weekly meetings and run tests with our last years solar car. We run and time all six courses. That way we can make changes, alter, optimize, make compromises, and improve on its design. Roman Yumang, Robert Stoddard, and the CAD class uses our ideas to create working drawings on exactly how we should build our car. This year, the CAD process will be more efficient due to the eight new PCs with AutoCad For Windows. Then, the CAM fabricators and the students of our Principles of Technology class use the plans to fabricate and obtain the components for the solar car. As a result, our solar car can overcome the established obstacles this year.

VEHICLE COMPONENT DEVELOPMENT AND SELECTION

After the designs are completed, the CAM fabricators, chassis fabricators, and composites fabricators use the working drawings to create the parts. Each part is fabricated under strict tolerance levels. Ingraham Seniors, Jeff Angeles and Robert Stoddard are in charge of component testing. They are responsible for manufacturing many parts of the solar vehicle and continuously running tests on the vehicle. Their jobs will insure that the vehicle will excel in reliability, craftsmanship, and performance. When they test the vehicle, they test every aspect to build the finest solar vehicle possible. All the tests will take place in the P.T. Lab. We examine each part of the vehicle to the finest detail possible to insure that the vehicle will operate. Mobility, speed, rolling friction, weight, and other related tests are to make sure the vehicle will perform at its peak ability. If the vehicle does not pass or perform to its peak in any aspect, changes will be made and will go through more tests. This is necessary because, if we do not finish, we cannot win.

Ingraham's Design And Engineering Execution Techniques

There will be aspects we need to examine to construct our vehicle without any unnecessary limitations or defects. The sun and our eighteen solar cell limit makes us aware of our limited energy source. The courses tells us how we need to build a solar vehicle that can run the established courses. Money, parts, skill, and time will also put limits on how well we can build our solar vehicle.

To build a solar vehicle that will operate correctly without spending excessive funds on it, the component testers test the components and connections. One of our tools is our solar panel dynamometer. Our solar panel dynamometer is a measuring device that uses a variable resistor. We use this as a load while we check for voltage, amperage, and then calculate wattage.

While the panel is under load, we can check for defects such as substandard parts, and poor connections with a voltmeter. We also check for cumulative voltage from the negative terminal to the positive terminal. As a result, we can find out if each solar cell and its connections are good.

We check for connections and control losses by attaching the cell dyno in place of the motor and inspecting for voltage losses with the system under load.

We also use a dyno for motor testing and selection procedures. This tool tests voltage, amperes, and revolutions (RPMs). The output drives a generator while using a variable output load. The torque reaction of the generator feeds into a triple-beam scale. We use the length of the lever arm on the generator with this formula to calculate horsepower. The formula is:

$$\frac{\text{Torque X Revolutions (RPM)}}{5252} = \text{Horsepower}$$

The calculated results will tell us how much mechanical force there is. This device is an excellent tool for measurements in electromechanical efficiency. Our tests for the chassis consists of two items. One is the test tracks where we operate the vehicle. The other is an auxiliary power source that will supply power to the vehicle. Our main vehicle test location is our hill. We constructed the hill by using the published specifications. The car will go over the hill while the auxiliary power source supplies power. The amount of power used will tell us how we should alter the design. When we alter the design, we alter certain parts for maximum performance. Parts we alter are tires, gears, better electronic components, different speeds, etc.

AN OVERVIEW OF THE SOLAR TEAM'S DUTIES

This section is read by all of the team members and the individuals who want to join the Solar Team. The objective is to give the team an understanding of how we do our job.

Educational elements:
Leadership
Fund raising
Research
Scientific principals
Data gathering and evaluating
The scientific method
Brain storming
Prototype development
Development of testing methods and devices
Testing
Building
Operating, improving and maintaining a complex electromechanical system
Teamwork
Group participation
Problem solving
Time lines
Goal setting
Real-life engineering project
Presentation of research orally and written
Building a technical vocabulary
Sketching
CAD drawing
Running and participating in meetings
Social interaction while focusing on a project
Publicity
Materials and process exploration
Electricity and electronics exploration

Some areas to focus attention on:
Driver operate skill development
Run on batteries using a crushable dummy cardboard panel. Real panels are expensive and fragile — accidents happen.

Tradeoffs to consider:
Durability
Weight
Cost
Serviceability
Simplicity
Manufacturing ability

Frictional analysis:
Coast down test—a stop watch and adjustable slant board are used.
The lower the angle the car will roll on.
The less friction in the drive train.
Unhook the motor pinion from the ring gear to get usable data.
Bearing quality and lubricant selection.
Have a standard soar cell to do comparative measurement against.

Test and match cells:
All cells are not equal.
A panel is no stronger than the weakest cell.
Indoor cell testing is possible using a halogen light source.
Temperature of cell defects cell output.
Use 3 10 ohm 10 watt resisting in parallel.
Load test the completed panel then check IR drops across each soldered cell connection.
We have had the best luck sweat soldering the cells in the tabbing tape after only tinning the tabbing tape.
We use Radio Shack -013# silver solder and rosin flux applied separately to cell with a toothpick.

Gear ratios:
Compromise for acceleration.
Try to match sun, cell, output, and motor gear ratio.

Other Considerations:
Panel tilting top will pick up around 15 percent power depending on time of day and latitude.

Heat lowers cell output. A cold winter day is as good as a hot summer day if the air is clear and clean.

Radio controlled glitching is a major problem if motor doesn't have proper capacitors properly installed. It also helps to physically separate radio from motor and servos.

A speed control upgrade to Novek 610 HRV for approx $100 is a good investment.

Gears come in 64 and 48 pitch. The 64 uses slightly less power to operate, but is less durable.

Most teams plan too long and test too little. The scientific method requires trial and error. A little science with data collection and analysis will over-power supposition most times.

Vehicle Operations Procedures

While we construct our vehicle, we will choose drivers to operate it. They need to operate the vehicle safely while running the best times possible in every course. It is also important for us to always keep records of the vehicle's performance. Maintenance is under the supervision of Jason Lynch and Sean Horn. They will make sure that the vehicle will always run at its best. We assign other members of the Solar Team to record data for tests and practice lap times. Jason, Sean, and other members of the Solar Team will also make necessary repairs, if needed. Chris Conrad, Brandon Little and Arthur Rugtredt are the drivers who will operate the vehicle. Their R.C. Car experience will insure that our vehicle will finish without any damage. Although we believe vehicle operations are not the most important part of this project, we strongly believe in good maintenance and driving procedures. If we do our best, we have a chance to win the solar vehicles race.

Miscellaneous Considerations

Although the objective of this competition is to make the best solar car possible, we take every consideration into account. Team morale is one of our main considerations. Our team meetings help us build our team morale. That way, every member can share their ideas on what works and what needs improvement. At the end of the competition, we commend each member for their efforts in making this project successful. We award our team members who have gone above and beyond the call of duty. Transportation is another consideration. When we go to the WTEA conference and the final race, we provide our own transportation. This is done by letting one or two people who have access to a van carpool everybody else. These considerations do not seem important to us but we believe this is necessary because these make us more of a team.

Working the numbers: team member Amber Sawicki checks data.

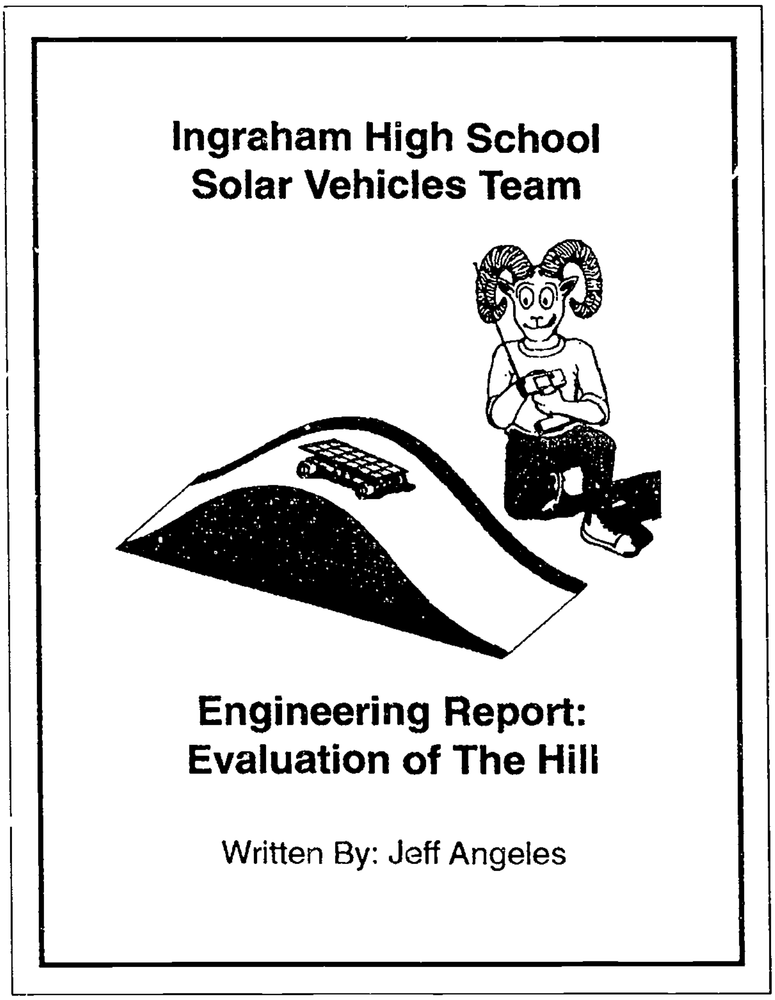
NOTE: The report that follows is presented as an example of student work and was written by Jeff Angeles for the Ingraham High School Solar Vehicles team. It has not been edited for grammar or spelling, although several typographical errors have been corrected.

INTRODUCTION

There will be variables we need to consider during the construction of our vehicle so it can overcome these obstacles with the highest performance. The course tells us how to build a solar vehicle that can run these courses. One of our main concerns is making a car that can successfully conquer the hill. Some conditions we are not able to control are: the sun, final hill course dimensions and final hill construction. A few aspects we can change are gear rations, car mass and construction, and tire dimension and composition.

PROCEDURES

We are using last year's car as a prototype for our final car. The results we achieved are being used to make a vehicle that can surpass last year's car while overcoming all obstacles. Intensive testing will show us how well the car will perform under the courses we put it through. Collected data are recorded onto graphs, tables and worksheets. They help us understand what needs to be done for the vehicle. They are also used for future references for our next vehicle.


Ingraham High School
Solar Vehicles Team

Engineering Report:
Evaluation of The Hill

Written By: Jeff Angeles

Report cover design

THE HILL

As mentioned before, the hill is one of our main concerns because its design proves to be rather difficult to overcome. When we put the design of the hill on graph paper, it was shown that it has a slope value near 1. A 1 slope value is equivalent to a 100% grade of 45°. Hills in the streets do not have grade values anywhere near 1005. A 23% grade is extreme for regular cars. These tests are one of our main tools to overcome the hill. The other tools are constant data analysis, weight reductions, experimentations of gear ratios, proper motor selection and proper tire composition.

ROLLING FRICTION TEST

This test is run because we need to find out how much force is needed to climb the hill. We also examine how fast the vehicle will go in certain sections of the hill. Tests are performed on each station to see which part of the hill will be the most difficult to overcome.

Our first test setup consists of a prototype solar car, which is tied to a string and a spring scale. It is then dragged along each station of the hill. Each station is measured out 7 1/2 inches across from the bottom of the hill. The actual road length on the hill varies from 7 – 9 inches per station. Results of the drag test are recorded and graphed. Figure 1 shows the results we obtained in the force test from the specified car. The results on the graph showed that it needed less than two newtons of force to operate the car on the top and bottom of the hill. It also showed that it took much more force in order to move through the middle of the hill.

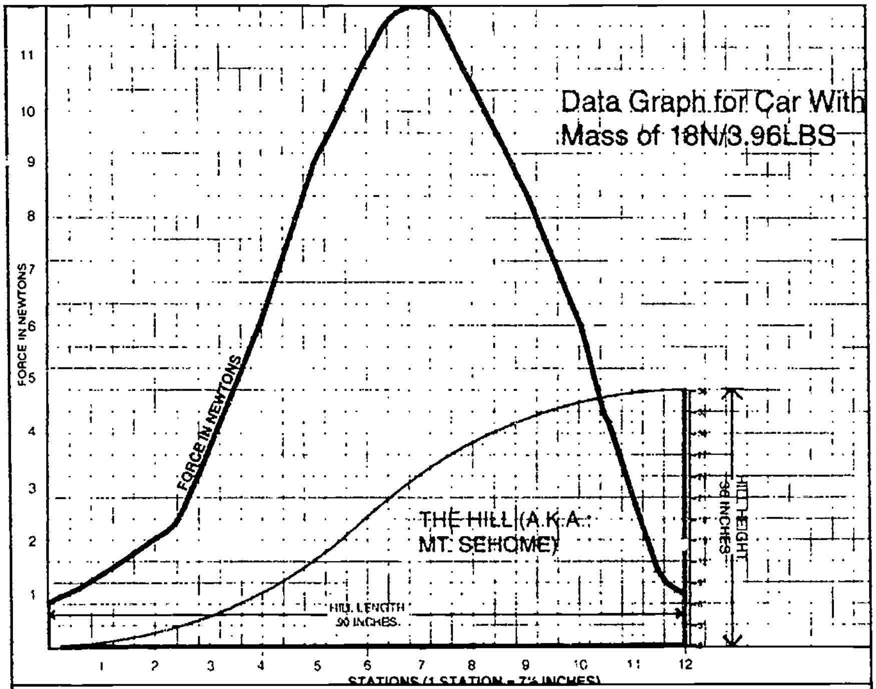


Figure 1 – Force Data Graph on the Hill

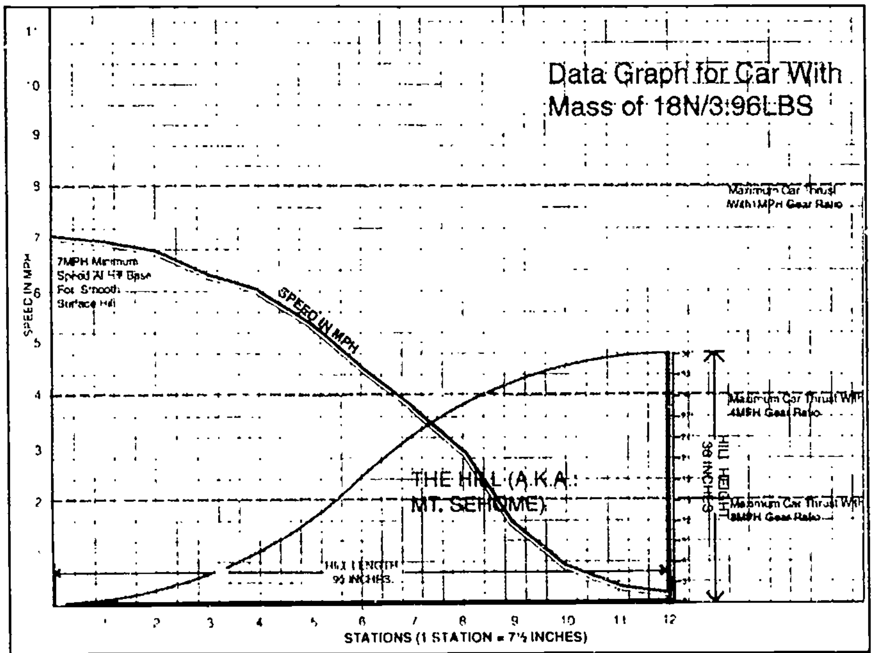


Figure 2 – Speed Data Graph on the Hill

SPEED TEST

Our second test setup consists of one person operating the vehicle, while the other person times the vehicle's run on each station. Each reading is recorded as inches per second. Before the data is graphed, it is converted to miles per hour. Figure 2 shows that the car accelerated around 6 – 7 miles per hour at the bottom of the hill. It also shows that it went less than 1 mile per hour when it is near the top of the hill. Our purpose of the graph is to show how much speed we need. Also, it guides us on what changes we need to make on our vehicle in order to optimize the vehicle's performance.

DATA ANALYSIS

Before we make any final changes, several things are done. We examine our results and graphs and compare them with last year's results. This will tell us what we need to do to improve our car as much as possible. This is possible by use of our graphs, worksheets, and data. Any necessary changes are made if the car underperforms

The Hill: Ingraham's solar care passes its most demanding test, cresting the student-built hill obstacle.

in any aspect. This is done to make sure our car can overcome any obstacle while staying competitive in the race.

RESULTS

We believe that these tests and evaluations will benefit us in the long run. Our efforts will give us the advantage in the actual race. This project will give students a taste of what the technical workplace would be like. Most of all, solar team members are able to experience actual engineering and scientific techniques of problem solving, which is not done much in many science classes.

Solar Car Solar Boat: Model Classroom Projects
Seattle Tech Prep

Middle School Solar Powered Boat Builders

Technology courses taught in middle school give students a glimpse of the ground Tech Prep courses cover in high school. Richard Earle and William W. Freeborn, metal and wood shop teachers at Madison Middle School, first participated in Western Washington University's statewide, middle school solar boat competition in 1992. They believed the project would be both enjoyable and challenging for their students.

Western Washington University selected model boats for the competition because they were easier for middle school students to construct and test than model cars. The boats would be powered by a limited number of solar cells and steered by a battery powered remote control. All original design and construction was to be done by students. The boats were not kits. Components such as motors, solar cells and remote control devices could be purchased, but students had to design and fabricate the hull, solar panels and required connectors.

The Boat: David Rigert holds the Madison Middle School boat that placed first for its performance, design and craftsmanship in a statewide, student-built solar boat competition.

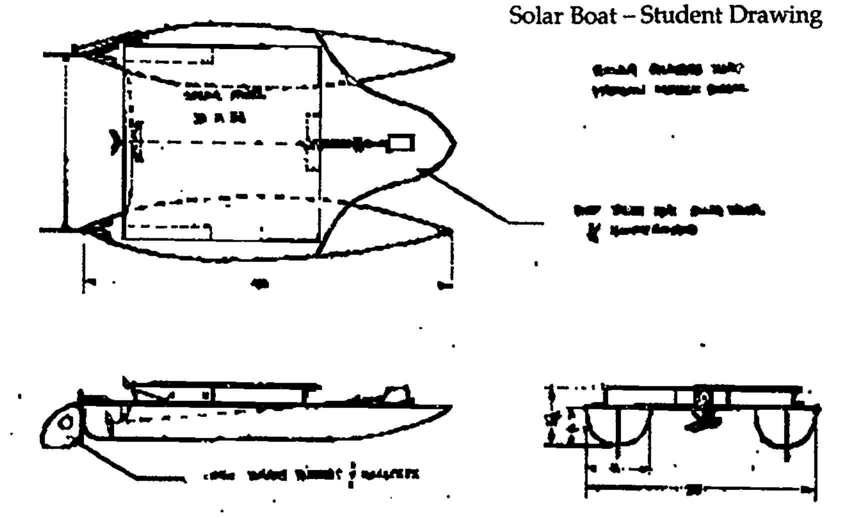
Students attended a seminar on solar power sponsored by Western where they learned the basics of solar power and solar cell soldering. Back in the classroom they realized that to win a boat race using solar power, they would need a hull design that moves through the water efficiently and could support the weight of the necessary control and propulsion equipment.

The students evaluated a variety of hull configurations including racing shells and aircraft floats before deciding that kayak hulls best suited their purpose. They also settled on a twin hulled design for stability, to be approximately 48 inches long by 24 inches wide.

The team decided to shape the hulls from low density styrofoam, a material well suited to the skill levels of middle school students. From the outset, Teachers suggested that students use reliable components, many purchased from hobby shops, to assure maximum performance.

The team continually sought systems and materials that were stronger and lighter, and refined the design accordingly. The team changed materials used in the superstructure from honeycomb panel to balsa wood and later to a carbon graphite material used to make arrow shafts. Students learned that changes in material should be supported with such impirical evidence as reduced weight, greater strength, or imperviousness to water.

Rudder design provides a good example of this effort. Students were able to reduce weight and maintain efficiency by switching from brass, weighing 127 grams, to plastic, weighing 48 grams, to plywood, weighing only 6 grams. By simply experimenting with different materials, the team produced a six-pound second generation boat, compared to their 13-pound first generation boat. Further weight reduction is anticipated.



Solar Boat – Student Drawing

Madison Middle School Solar Boat Specifications

Hull: Catamaran design, styrofoam hulls. To give the styrofoam a smooth surface, students apply several primer coats of latex house paint, which won't melt the styrofoam, as a filler. The hulls are joined by honeycombed panels, with holes drilled for lightness, that also support the solar panels, radio gear, motor and drive shaft.

Power train: Students constructed the motor mount from aluminum sheet and an automotive hose clamp. The drive shaft was made from 1/8" welding rod to transfer power from the motor to a 2" bronze propeller, using a standard brass "prop dog" and universal joint as connectors. Students fabricated brass brackets to align and support the drive shaft.

Steerage: The first boat was steered by brass rudders attached to each hull with a removable hinge pin. Brackets for the rudders were also brass and were bolted to the honeycomb platform. The team used a Futaba 2-channel radio unit with servos to control both the rudders and shutoff.

Power source: Thirty solar cells four inches square, soldered in parallel/series circuits with a switch to control which circuit is used. Later boats employed the maximum 33 cells permitted in the competition.

The mostly eighth grade team members spend many hours testing boats in the shop before they are placed in the water. They wear out dozens of batteries making sure propulsion and remote control systems perform consistently and reliably. The students see how important the hours of research and development are in the making of a competitive product. Some class time and a great deal of after-school time is spent perfecting these superbly-crafted boats.

This dedicated effort has paid off in performance: Madison Middle School boats placed first second and third in the first two competitions, and placed first in the 1993 and 1994 races.

Background Information – Statistics

A medium sized urban school district, Seattle Public Schools serves 44,000 students in 97 elementary schools, middle schools, high schools and alternative schools. The Seattle Community College District enrolls 22,015 students total at three campuses, three training centers and a vocational center. The city of Seattle had a 1990 census population of 516,259.

Seattle Public Schools Statistics (1992-93)

NUMBER OF SCHOOLS	
Elementary Schools (K-5)	61
Middle Schools	10
High Schools	10
Alternative Schools	16
Total (1992-93)	97
ENROLLMENT	
Elementary (K-5)	22,470
Middle (6-8)	9,483
High (9-12)	12,123
Total (1992-93)	44,076
ETHNIC BREAKDOWN	
African American	10,159
American Indians	1,398
Asian	10,641
Caucasian	18,726
Chicano/Latino	3,152
BILINGUAL STUDENTS	
Total for 1992-93	8,638
Percentage of Enrollment	20.7%
Total Languages Spoken	77

SPECIAL EDUCATION STUDENTS	
Total Students	3,322
Percentage of Enrollment	7.9%
FULL-TIME STAFF	
Teachers	2,388
Administrators	236
Support Staff	2,525
TEACHER/STUDENT RATIO	
Elementary (K-5)	1:28
Middle (6-8)	1:29.5
High (9-12)	1:30
DROPOUT RATE	
Elementary (K-5)	5.4%
Middle (6-8)	7.3%
High (9-12)	15.6%
GRADUATION RATE	
Total Graduates	1,982
Percentage of Seniors Graduating	79.3%
1993-94 BUDGET	
Total (millions):	**$296.2**

Seattle High Schools and Enrollment

Ballard	1,275	Sealth	901
Cleveland	734	West Seattle	897
Franklin	1,464	American Indian Heritage (Alternative)	110
Garfield	1,484	Marshall (Alternative)	421
Nathan Hale	1, 131	Middle College (Alternative)	175
Ingraham	1,043	Nova (Alternative)	127
Rainier Beach	860	Sharples (Alternative)	201
Roosevelt	1,480	Summit (Alternative)	622

Seattle Community College District (1992-93)

	Central Seattle Community College	North Seattle Community College	South Seattle Community College	Seattle Vocational Institute
FTE students:	4,833	3,875	3,419	227
Total students:	7,838	7,257	6,426	494
Full-time faculty:	137	104	76	9
Part-time faculty:	306	203	214	14
	Includes: Wood Construction, Maritime Training Center		Includes: Duwamish Branch Training Center	

Seattle Community College District 1992-93 Operating Budget: $77,376,089

The Seattle Public Schools
815 Fourth Avenue North
Seattle, WA 98109-9985

SUPERINTENDENT
William M. Kendrick

The Seattle Community College District
1500 Harvard
Seattle, WA 98122

CHANCELLOR
Dr. Charles A. Kane

Seattle Schools

The Seattle School District provides Equal Educational Opportunity without regard to race, creed, color, national origin, sex, disability or sexual orientation. The District complies with all applicable State and Federal laws and regulations to include but not limited to Title IX, Title VI of the Civil Rights Act, Section 504 of the Rehabilitation Act, RCW 49.60 "The Law Against Discrimination," and RCW 28A.640 "Sex Equality," and covers, but not limited to, all District programs, courses, activities (including) extra-curricular activities, services, access to facilities, etc. The Seattle School District is an Equal Employment Opportunity, Affirmative Action employer. The District employs individuals without regard to race, creed, color, national origin, age, sex, marital status, disability or sexual orientation. The District complies with all applicable State and Federal laws, including, but not limited to Title VI, Title VII, Title IX of the Civil Rights Act (ADA), RCW 49.60, Law Against Discrimination, Section 504 of the Rehabilitation Act, and RCW 28A.640, "Sex Equality." The Title IX Officer and 504 Coordinator with the overall responsibility for monitoring, auditing, and ensuring compliance with this policy is John Yasutake, Manager, Affirmative Action Office, 815 Fourth Ave N., Seattle WA 98109, Telephone (206) 298-7175. Individuals who believe they have been discriminated against in any of the District's employment or educational activities can file an internal discrimination complaint with the District's Affirmative Action Office. If you need TDD assistance, call 298-7805.