**Session 3233**

# Curriculum Integration of Engineering Technology Courses with the Solar Car Project at Middle Tennessee State University

**B. S. Sridhara**
**Middle Tennessee State University (MTSU)**

## Abstract

The US Department of Energy (DOE) organizes a solar car race called Sunrayce, once in every two years. The race is nationally sponsored by corporations such as GM and EDS. It is open for all colleges and universities in North America. As faculty advisor for the solar car team at MTSU, the author submitted a proposal in the Spring of 1996 and we were selected to compete in Sunrayce 97. We were one of the top 30 teams to receive an award of $2,000 from the Sunrayce headquarters. The team consisted of 15 members who designed, fabricated and tested our second solar car, the Solaraider II. In the process, they learned the principles and applications of solar energy, electricity, engineering mechanics, aerodynamcs, machine design, composite fabrication, team work and management, and fund raising. We received help from MTSU and local industries. Our team members worked with the engineers, managers, technicians and machinists at the sponsoring industries and built many parts of the car. We raised approximately $40,000 in cash and gift-in-kind working cooperatively with the Development office at MTSU. the author identified several problems related to the solar car with courses such as Basic CADD, Solid Modeling, Advanced CAD, Statics, Dynamics, Strength of Materials, Senior Problem in Engineering Technology, Energy and Environmental Safety, and Shop Problems. The students received credit in these courses for a term project, paper, final project or special problems, which contributed 25-75% towards the final grade. We worked with the College of Mass Communications at MTSU and produced a video tape on the Solaraider II project which served as a good subject for their Corporate Video Production course. Our solar car project was a success and we participated in Sunrayce 97 in June along with teams from several top-ranking schools in the U.S. and Canada.

## Middle Tennessee State University

Our university is located in Murfreesboro, about 30 miles to the southeast of Nashville. MTSU was founded in 1911 and is the fastest growing university in the state of Tennessee. Currently, the student enrollment is approximately 18,000 and we have 700 full-time faculty members. The university has five colleges; Basic and Applied Sciences, Business, Education, Liberal Arts, and Mass Communication. Engineering Technology and Industrial Studies is one of the 10 Departments under the college of Basic and Applied Sciences. We offer Engineering Technology, Industrial Technology,

Pre-engineering, and Pre-architecture programs. Our Department has an enrollment of 600 students, of which 200 are majors in Computer, Design, Electro-Mechanical, and Manufacturing Engineering Technology concentrations.

## The Solar Car Project

We built our first solar car, the Solaraider and competed in the Sunrayce 95 qualifier in June, 1995. The objectives of Sunrayce are to stimulate interest in technical education and careers among students, and to promote energy efficiency and the use of renewable sources of energy.[1] The race is nationally sponsored by organizations such as DOE, GM and EDS. In the proposal for Sunrayce 97,[2] the author discussed different aspects of the project including Design and Engineering (driver safety, design and analysis, and material selection) in accordance with Sunrayce 97 regulations.[3] Topics such as Organization and Project Planning, Curriculum Integration, Fund Raising and Team Support, Vehicle Testing and Driver Training, and Logistics were also discussed. Proposals submitted by 60 different universities including MIT, Yale, Texas A&M, Stanford, University of Michigan, and University of Waterloo were evaluated and scored by Sunrayce officials. We were selected as one of the top 30 teams to receive an award of $2000.

Our solar car team consisted of fifteen active undergraduate and graduate students. It was divided into subgroups to work in different areas of the project such as fund-raising, publicity, design and analysis, fabrication and testing, and electricity and electronics. As faculty advisor, the author helped the team members at every stage of the project. We met once or twice a week and discussed progress made in each area. We used the electric motor and controller, solar cells, and batteries from our first car. We fabricated the main frame, suspension units, body, canopy and array on campus as well at our sponsors' facilities. We raised approximately $15,000 in cash and built our second solar car, the Solaraider II (FIG. 1). Many other students, the chair of Engineering Technology and Industrial Studies, the Dean of the College of Basic and Applied Sciences, the Public Relations, the Development Office, and the Foundation, at MTSU were involved in the project in different capacities.

## Curriculum Integration

Curriculum integration of our courses with the solar car project is one of the requirements of Sunrayce. This would not only help students get credit for their work on the solar car but also promotes team work. In this project, the students get a unique opportunity to design, fabricate and test a complete system during their stay in school. the author identified several problems related to the car project with our Engineering Technology and Industrial Studies courses. A majority of the team members were the author's advisees and hence they were entrusted with the responsibility of solving particular problems depending on their strengths and aptitude in those subject areas.

**Undergraduate Courses**

Our first solar car body was not aerodynamically sound. One team member designed two different bodies for the Solaraider II using solid modeling techniques. He also designed the main frame made of square, tubular members. This student received credit for his work towards the final project, which contributed 75% to the final grade, in Advanced CAD (ET 433). The wireframe models of the car were sent to EDS for aerodynamic analysis. The results helped our students understand aerodynamic drag, lift and pressure coefficients, and their effect on the car's performance. Driver safety and structural stability are two major aspects of the project.[4,5] Two students performed structural analysis for the Solaraider II[6] considering front, side and rear impact conditions. Another student worked on the analysis of the front suspension axle and control arms.[7] They learned how to use the energy method and apply their knowledge of Statics, Dynamics and Strength of Materials in the analysis. All of them received credit for their work in Senior Problem in Design Engineering Technology (ET 480D).

The main frame (FIG. 2) and the front and rear suspension units were built by 4 team members using square aluminum tubing (grade 6061-T6) at a sponsor's shop. They tested the main frame and other components for impact strength, particularly at the welded joints, and provided suitable reinforcements.

The Solaraider II measures 19'x6'x5' and it was not an easy task to fabricate the shell, array and nose. Our team members decided to slice the computer model of the car body into several parts and obtain a full-size plot of each cross section. They cut plywood templates from these plots, and styrofoam blocks were "hot-wired" to obtain sectional molds. These individual molds were assembled, sanded, and coated with epoxy to obtain a single mold for the car body. Two team members received credit towards their final project in Advanced CAD. Another student received extra credit in Environmental Safety (EST 476B). The molds were taken to one of our sponsors' boat manufacturing facility where all team members worked with the company engineers, managers and technicians, and fabricated fiber glass body parts for the Solaraider II.

One team member designed a steering mechanism for the solar car. The components were machined on CNC machines at a sponsor's shop. He discussed different aspects of design and fabrication with the foreman and the engineer at the company, and learned about material selection, strength-to-weight ratio and stress concentration. This student received credit towards his final project (25% of the final grade) in Solid Modeling (ET 336). He also designed and fabricated an aluminum tubular support for the array. Another team member designed the canopy and the linkage for easy opening and closing using solid modeling techniques. This student received credit for his final project in Advanced CAD. He and other three students built styrofoam and fiber glass molds working closely with one of our sponsors. The Plexiglass canopy was thermally formed at the sponsors shop, and the linkage was fabricated on campus.

One team member machined the front and rear axles using AISI grade 4130 steel. These axles were heat treated at a metallurgical company in Murfreesboro. Our students visited this facility and through their discussion with the metallurgists, learned about surface hardness, toughness and stress relieving. Dynamic performance or braking test is an important part of scrutineering[1,3] in Sunryace. In this test, the solar car should be brought from rest to 30 mph speed, and the brakes should be applied suddenly, and it should be stopped completely in 3 seconds. In Dynamics (ET 384), the author designed problems for tests and the final exam, which involved calculation of variables such as acceleration, deceleration, friction, starting and stopping time and gear ratio for the solar car.

**Graduate Courses**

We have a graduate student in the solar car team. She not only worked on the solar car related projects in 3 graduate courses, but also served as the team leader. In Safety Planning (IS 601), she selected electrical safety of the Solaraider II for her term project which carried 55% of the final grade. In her report, she discussed various safety aspects including the drawbacks of the first car, and made necessary recommendations for the Solaraider II. In Solid Modeling (ET 536), she discussed the existing electrical system of the Solaraider II and recommended specific modifications for improving its performance.[8] This student received credit towards her final project (25% of the final grade) in this course. She calculated the current requirements of the electric motor for various driving conditions, and received credit in Advanced Design Problems (IS 623). In her study, she considered several variables such as the weight of the car, friction coefficient, speed, drive wheel diameter, and motor efficiency. In this course, the term project carried 100% of the final grade.

**Collaboration with Other Departments**

We received a lot of help and advice from the Aerospace Department regarding composite fabrication and the use of aircraft-type fasteners. the author worked with a colleague from the Department of Radio-Television/Photography and arranged a video production describing our solar car project. This provided a very appropriate subject for their course, Corporate Video (RATV 342). Their undergraduate crew consisted of a producer, script writer, photographer, director and an editor. They produced a professional-quality video tape and received credit for the term project which contributed 100% towards the final grade.

**Fund Raising and Public Relations**

Our team members worked with the Development Office and News and Public Affairs at MTSU, and participated in fund raising and public relations activities of the

Solaraider II project. They made presentations and raised funds at the chapter meetings of the Society of Automotive Engineers, the Society of Manufacturing Engineers, and the Rotary club. They visited many of our sponsors such as Astro/Procraft, The Aerostructures Corporation, Southeastern Technology, Midsouth Metallurgical, Plastec, Inc., and Precision Wood. They discussed different aspects of the solar car project with the plant managers, engineers and technicians, and learned about new techniques in production, planning and manufacturing.

## Conclusions

The Solaraider II project at MTSU provided a unique learning experience for our Engineering Technology students. This project not only promoted team work, but also helped the members work with local industries. Curriculum integration is a major part of the solar car project. Our students received credit for their work in Engineering Technology courses such as Computer-Aided Design/Drafting, Shop Problems, Dynamics, Safety Planning, and Senior Problem in Engineering Technology. The learning process has been very practical and meaningful. The solar car team members participated in activities such as fund raising, public relations, meeting with the alumni, and working with MTSU personnel and members of local industry. All of these enhanced their communications skills. The students got an opportunity to learn about the new methods in design and manufacturing. Because of a misunderstanding regarding the scrutineering and qualifier dates, we could not compete in the 1997 race. But we are looking forward to competing in Sunrayce 99.

## Acknowledgment

The author wishes to thank each and every one responsible for the success of the Solaraider II project at Middle Tennessee State University.

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## B. S. SRIDHARA

Dr. B. S. Sridhara is an associate professor in the Engineering Technology and Industrial Studies Department at Middle Tennessee State University. He received B.S.M.E. and M.S.M.E. degrees from Bangalore University and Indian Institute of Science, Bangalore, India. He received his M.S.M.E. and Ph. D. degrees from Stevens Institute of Technology, Hoboken, New Jersey, and Auburn University, Alabama. Dr. Sridhara has written several reviewed articles in the areas of Acoustics, Vibrations and finite element methods. He is a member of ASME and ASEE. He is the faculty advisor for the solar car team at Middle Tennessee State University.


**FIG. 1. Middle Tennessee State University's second solar car, the Solaraider II, and the team**

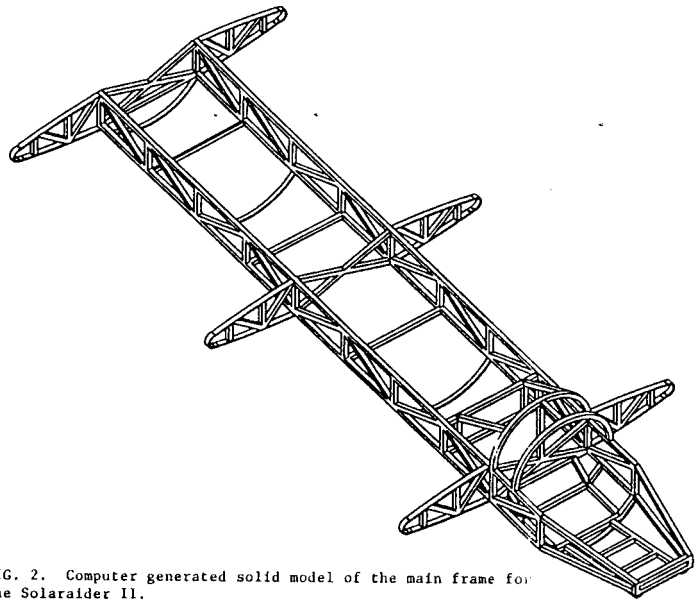

FIG. 2. Computer generated solid model of the main frame for the Solaraider II.

SOLARAIDER II
MIDDLE TENNESSEE STATE UNIVERSITY
SUNRAYCE 97 | ET 433
NAME: BRYAN MEADOWS

**FIG. 2. Computer generated solid model of the main frame for the Solaraider II.**

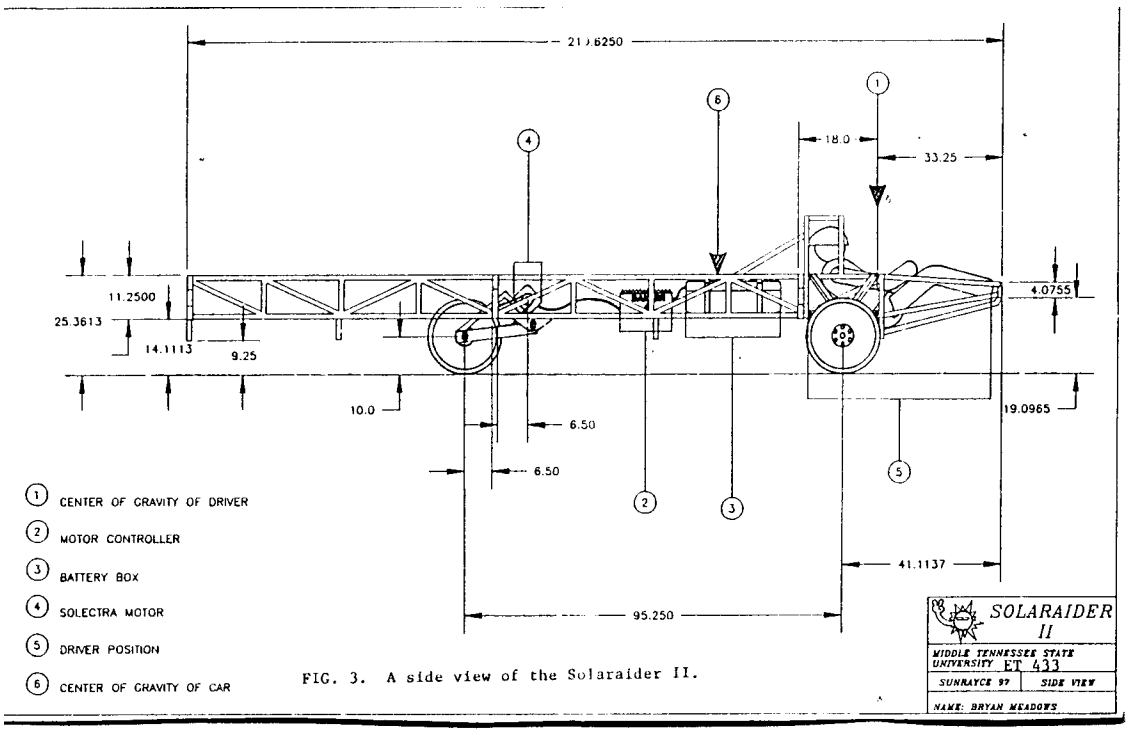


FIG. 3. A side view of the Solaraider II.

**FIG. 2. A side view of the Solaraider II.**