3-D WORLD

News For The CADKEY/DataCAD User

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Rochester Institute of Technology's solar-powered SPIRIT on the road.

Solar Racing: A Student Saga!

by Geoffrey Hitchings and Lynn Bishop III

Editor's Note: This article is an abridgement of a paper documenting the SPIRIT project at Rochester Institute of Technology.

Faint hums and whines are all that you hear as a small teardrop-shaped vehicle passes you on the highway. This oddly shaped car never has to stop for gas, and it produces no harmful emissions. Is this a dream? No, it is SPIRIT, the solar-powered car designed and built by students at Rochester Institute of Technology (RIT).

In December 1988, General Motors, the U.S. Department of Energy, and the Society of Automotive Engineers announced that they would sponsor a race for solar-powered vehicles. They requested proposals from all interested colleges and universities. The first GM SUNRAYCE USA in 1990 was a road race from Orlando, Florida, to Warren, Michigan for vehicles powered only by the sun. The race took place during a period of eleven days, July 9-19, 1990, and covered almost 1,700 miles, passing through seven states.

The student chapter of the Society of Automotive Engineers at Rochester Institute of Technology in Rochester, New York, submitted a proposal for participation, and it was one of the 32 schools chosen from the 64 proposals. This was the beginning of our SPIRIT team. SPIRIT is an acronym for Solar-Powered Innovation at Rochester Institute of Technology. It takes most major car manufacturers almost five years to design and build a new car. We had just under a year and a half to design

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Cadkey, Inc. Repositions Itself in the Marketplace!

Cadkey Celebrates its 10th Anniversary

Ten years ago, in October 1981, Peter Smith and Livingston Davies founded Micro Control Systems, now known around the world as Cadkey, Inc., to manufacture and market the Three-Dimensional Space Tablet™ that they had invented and patented. In 1988, Micro Control Systems changed its name to Cadkey, Inc.

Peter and Livingston used the garage and cellar of Peter's home in Manchester, Connecticut to create their Space Tablets, the Space Graphics™, and the Advanced Space Graphics™ software that made the tablets work. Paulette Smith, Peter's wife, collaborated by letting these

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two inventors take over her kitchen. They assembled the components and heat-sensitive glue into Space Tablets on the kitchen table and baked them, one at a time, in the oven of her kitchen stove to set the glue. The Three-Dimensional Space Tablet allowed users to enter true, x,y,z-coordinate graphical data into Apple and IBM-compatible personal computers. The first applications for the Three-Dimensional Space Tablet were in medicine and in reverse engineering. One of the original Space Tablets now has a home in the Computer Museum in Boston, Massachusetts.

Micro Control Systems' Space Tablet evolved into the Perceptor™, a more robust and more accurate successor to the Space Tablet. The Perceptor's applications were essentially the same as the Space Tablet: medicine and reverse engineering. In January 1985, Micro Control Systems introduced CADKEY® into the marketplace, the first, truly three-dimensional, PC-based, CAD software product for mechanical design and engineering. CADKEY became the only PC-based CAD software to earn the distinction of being **PC Magazine**'s **EDITOR'S CHOICE** three times: 1986, 1988, 1990.

Cadkey, Inc. now offers a broad range of software products dedicated to the needs of M/E/C, A/E/C, and manufacturing professionals.

Cadkey Has New Logo

A company's logo establishes an identity, an awareness, in the mind of the general public. We are proud to make public our new corporate logo. It appears on the back page of this issue of **3-D WORLD**.

If you look closely, you see that the logo is an open three-dimensional object. The stripes along the logo's spine recall Cadkey's previous striped logo, and with it, our history of innovation in true, three-dimensional, PC-based and workstation-based CAD. However, the openness of the design represents the innovation that has historically been characteristic of Cadkey's products in the M/E/C and A/E/C markets. That same openness is leading Cadkey into new directions in the markets that we serve.

The logo's design elements create the interesting effect that a viewer's eyes can perceive the logo from different perspectives, changing the appearance of the design. This feature projects the image that new products which Cadkey currently has in development will foster change in the engineering and manufacturing markets.

Cadkey Has New Location: N41°52'45", W72°44'15"

Effective August 19, 1991, Cadkey, Inc. has established a new position for itself in the world. Our world coordinates: North of the Equator 41 degrees, 52 minutes, 45 seconds, and West of the Prime Meridian 72 degrees, 44 minutes, and 15 seconds, correspond to Windsor, Connecticut. Our new address is:

Cadkey, Inc.
4 Griffin Road North
Windsor, CT 06095

Telephone: (203) 298-8888
Fax: (203) 298-6401
International
Fax: (203) 298-6402

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A Student Saga!

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and build a car from scratch that required totally new and untested technology.

We first set about organizing our team of 25 engineering students at RIT. A project of this kind had rarely been done on a college level. In fact, we didn't even really know what we were getting into! All of us were volunteers. This project was strictly extra-curricular, with no class credit given.

We divided the team into five groups: Mechanical, Electrical, Shell Design, Strategies and Tactics, and Logistics. Each group worked on its own part of the project. The group leaders kept everyone working in the same direction. The use of CADKEY(R) in the design process was one of the unifying elements. With the tight time schedule, designs had to be produced efficiently the first time. There was not time for complete redesigns. The systems to be used in the car had to be thoroughly researched, and all design criteria and constraints had to be established immediately.

The Goal

The goal of this project was to design a car that would be as aerodynamically, mechanically, and electrically efficient as possible, and that would extract the maximum amount of power from a limited array of solar collectors. To be competitive, we had to be able to reach speeds between 60 and 65 miles per hour. Weight was a major concern; the car had to be very light. We calculated that every extra pound would cost five minutes at the end of the race. We also had to meet other design criteria that would make the care safe and relatively practical. To meet all of these requirements, we had to be able to optimize every aspect of the design. We used computers in every part of our project. The requirement that no part would go to be machined without an approved part file on CADKEY, assured that every one of our designers worked with the same standards and basic drawings. Our drive-train designer was working to the same frame as our seat designer. This quality-control measure kept our diverse group together, at least in theory.

The Shell

The shell group started immediately to gather possible aerodynamic configurations for the SPIRIT. The "tear drop" profile proved to be the most aerodynamically efficient while providing stability and maximum area available for exposure to the sun. The shell designers designed the shell, 6 meters long by 2 meters wide and 1.6 meters high, in 3-D, using CADKEY. They decided to incorporate technology from the experimental light-aircraft industry. Since the shell only had to support its own weight and the solar cells, they calculated that a polystyrene/sprucewood composite structure covered with a dacron skin would be much lighter than the more expensive graphite/kevlar composites, while providing adequate rigidity. The shell consisted of many oblique planes and required unique construction techniques. Design by hand would have taken us well beyond the actual date of the race itself. The shell designers used 3-D cubic parametric spline curves to detail the entire shell. Areas and centroids were computed using CADKEY SOLIDS to calculate solar exposure of the cells, and to

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A Student Saga!

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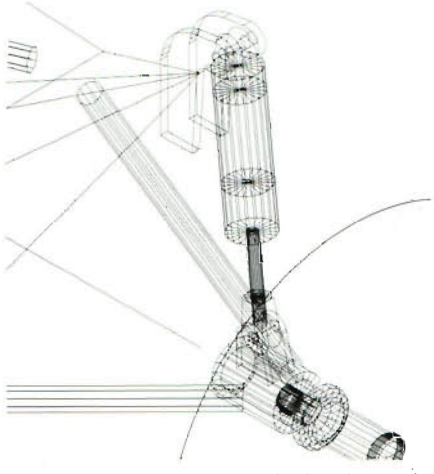
aid in aerodynamic predictions. Structural cross-sections were plotted at full scale and transferred directly to the polystyrene and dacron patterns. Using silicon monocrystalline solar cells rated at 12% efficiency, the total peak power output was 900 watts. This is less than the power output by an ordinary hair dryer. The finished shell was completed without significant problems, and weighed only 54 lbs., including the solar cells and connections. The shell's weight made it one of the lightest shells in the competition.

The Drivetrain System

The drivetrain designers used CADKEY's 3-D capabilities to design the drivetrain system. Using a 2-horsepower, DC, brushless electric motor donated by General Electric, they decided that the SPIRIT needed a transmission, coupled to a 6.2:1 reduction unit, to keep the motor operating within its range of peak efficiency. At the same time, the transmission would allow the motor to propel the car to a speed of 65 mph with adequate start-up torque. The drivetrain designers designed the transmission unit on CADKEY, using the jackshafts and gearsets from a 6-speed, low-displacement motorcycle transmission. They drew the transmission's components on CADKEY and modified the pitch lines to increase gear efficiency. They also designed a new transmission case on CADKEY, and they integrated the gear components into the case. They had Swain Technologies of Scottsville, New York, apply a coating of low-friction plasma to the components to improve gear efficiency even more. The magnesium transmission weighed 12 lbs. They integrated this transmission with the motor to produce a compact propulsion system that gave the SPIRIT a top speed of 69 mph.

Wheels and Brakes

Other members of the SPIRIT team designed the wheels, brakes and hubs using CADKEY, too. The wheel assembly had to be light, strong and unquestionably reliable. Traveling more than 1,600 miles on secondary roads, flat tires were to be expected. We had to be able to change a tire in a very short time with minimal trouble. We designed a wheel with an outer hub that locked into an inner spindle. The entire wheel could be removed without disturbing the disc brakes or the drive system. SPIRIT used 20-inch slick tires on aluminum rims built specifically for the participants in this event by the Goodyear Tire and Rubber Company. The rims were spoked directly to our custom-built hubs. We covered the spokes with plastic fairings to reduce aerodynamic drag. During the race, we had only one flat tire. The wheel design allowed our well-trained team to change the tire in less than one minute, i.e., from stopping the car to starting again. The braking system composed of lightweight, aluminum hydraulic calipers floated on the strut housing. Disc blanks, 6.5-inches in diameter, were drilled to reduce rotating inertia, and mounted on the inner spindle.



Detail of left rear axle, shock-absorber and frame assembly.

Suspension and Steering

Other team members designed the suspension and steering systems in complete detail on CADKEY. These systems were vital to the performance and efficiency of the vehicle. We sought minimum rolling resistance since rolling resistance decreases the overall energy potential of the car. We were also concerned about good handling characteristics because they affect driver safety and response. Good handling characteristics would also help to protect SPIRIT's delicate electrical components and solar cells. We determined that a MacPherson strut suspension would best accommodate all the design criteria. The struts consisted of a machined magnesium housing with a one-half-inch tool steel actuator rod. We mounted modified, aluminum shock absorbers, inboard, at the front, to reduce unsprung weight, and to increase damper-motion ratios. Members of the team analyzed very closely the three-dimensional geometries produced by the complex non-coplanar inclinations of the suspension system. We did this to assure minimum rolling resistance through various changes in attitude by the vehicle, and to provide good handling characteristics and stability. We analyzed spring frequencies and dampening coefficients to isolate the vehicle from undesirable vehicle responses. Using CADKEY greatly simplified the integration of the rack-and-pinion steering system. By rotating components around the non-coplanar axis of the suspension, we could see precisely what effect each steering movement and each suspension movement would have on the contact patch of the tire.

The Frame

After we confirmed the SPIRIT's major subsystems, the team designed the frame to

provide structural mounting points for those systems. Laying out the frame also required consideration of the driver and the placement of other components. We decided to use an aluminum-tube space frame because of its light weight and rigidity. We transferred the frame design from CADKEY into a stress-analysis program to determine where adjustments needed to be made in the design before making final decisions. The frame's design required minor adjustments. We then made working drawings of the individual tubes; double checked them, and produced hardcopy plots for our machinists. All of the tubes were machined, fitted and welded. The finished frame, with mounts, weighed 28 lbs.

Computers in the Car

We not only used computers to design the SPIRIT; we designed them into the car, too. We designed an on-board computer system, using Intel's 80C186™ microprocessor, to control all of the car's systems, as well as to monitor the vehicle's sensors. The computer provided us with cruise control and other features that made driving the car easier. A digital dashboard gives the driver all the information needed about the car's performance. An infrared system relays all the information from the SPIRIT to the telemetry computer in a chase vehicle several times per minute. This information helps in updating simulation and strategy programs. It also provides a means to monitor important data, such as, voltages, temperatures, and battery power. Battery storage, for example, consisted of 100 silver-zinc batteries, rated at 3 kilowatt hours.

Assembly of the SPIRIT

Having all the designs standardized on CADKEY made the task of assembling the car much easier than it would have been otherwise. It also saved valuable time. We imported the designs from different groups into master files. The designers of individual systems in the car matched the different parts very accurately. To optimize assembly, we held to very tight tolerances in the integration of the car's systems. We made final design changes, and slowly the car began to resemble what everyone had anticipated for a year. For a prototype vehicle, the SPIRIT went together amazingly well.

We learned first-hand one of the major advantages of CAD: the ease with which a design can be changed. After our frame had returned from the welder, we found a very unpleasant surprise. A fixture error resulted in the two front suspension nodes being 1.5 inches lower than they were supposed to be. This would have been a major setback if it had been necessary to modify by

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CADKEY SOLIDS' New Graphical Interface Makes Use Easy!

CADKEY SOLIDS™ now integrates with CADKEY® Version 4 through an easy-to-use graphical interface. CADKEY Version 4 users have access to CADKEY SOLIDS now right from the CADKEY main menu's new option 9: ADVANCED. You never have to leave CADKEY to work in CADKEY SOLIDS.

Selecting option 9, ADVANCED, either with the F9 function key or with the cursor, displays a menu of all of the advanced-function software that you have installed in your CADKEY system. Select SOLIDS from the menu, and you enter CADKEY SOLIDS.

In order to use CADKEY SOLIDS, you create a part file of wireframe geometry in CADKEY, and output it as a CADL™ (CADKEY Advanced Design Language) file. After you have selected CADKEY SOLIDS from CADKEY's new advanced-functions menu, CADKEY SOLIDS displays its main menu and invites you proceed. FRAMES presents you with options to define the type of operation that CADKEY SOLIDS is going to perform on the wireframe model that you have created, e.g, rendered output, perspective, Boolean operations, etc. PROCESS allows you to run CADKEY SOLIDS while you are still in CADKEY. In UNIX-based systems, you can process the model in background mode while you work in CADKEY in foreground mode. RESULTS displays your model after CADKEY SOLIDS has completed the work that you defined for it to do. CONFIG gives you access to all of the global settings defined for CADKEY SOLIDS so that you can change them quickly, if you want to do so. FILES sets up your file names and lets CADKEY SOLIDS remember them for you.

The only thing that you cannot do in CADKEY SOLIDS is to modify the original wireframe model that you are using as input and output that modified model to a CADL file. The reason for this is that modifying the geometry of the original wireframe model is a job that you normally do in CADKEY. CADKEY SOLIDS is running on top of CADKEY; so you have never left CADKEY. You can switch back and forth between CADKEY SOLIDS and CADKEY, at will, to make any needed modifications.

Dialog Boxes and Pop-up Window Options

When you select one of the functions from CADKEY SOLIDS' main menu, a dialog box appears in the upper half of the monitor's screen. Each parameter in the dialog box is preceded by a blue button. You must use the cursor to select a parameter that you want to define, by selecting the parameter's button. When you select it, the dialog box highlights the selected button in red. The dialog box also displays a pop-up window containing the options available to define the parameter that you have selected. After you have selected the option that you want in the pop-up window, you can change your mind by selecting CANCEL button with the cursor, or you can select the DONE button with the cursor, and move on to the next item that you want to define.

All of the dialog boxes and pop-up windows in CADKEY SOLIDS' functions work in the same fashion. They integrate the defining of frames, color palettes, boolean operations, and mass properties in a consistent, easy-to-use, visual format.

For example, the dialog box for the FRAMES function has two sections. On the left side are the control functions that allow you to create new frames, and to move around among the frames that you have already created. On the right side are the parameters that you have defined for the current frame of the file in which you are working. You can define up to 20 frames, one after another. This feature is similar to having 20 exposures on a roll of photographic film in a camera. The FRAMES dialog box is the only dialog box that has two sections.

User-Friendly Integration of Functions

CADKEY SOLIDS' new user interface brings together all of the functions that CADKEY SOLIDS has always performed, but in a more uniform and consistent way. No longer do you have run half a dozen different programs to get the results of CADKEY SOLIDS. From within CADKEY, you can set up the types of rendering that you want CADKEY SOLIDS to produce; you can define where the light source is located, what material composition each object has, what the color palette is, and what CADKEY SOLIDS' global settings are. After your model has been processed, you have full access to all of its output files, without leaving CADKEY SOLIDS. You can display all of the graphical and numerical results of CADKEY SOLIDS with just a menu pick.

COMING IN THE NEXT ISSUE OF 3-D WORLD

Look for an article about Cadkey's **Cutting Edge**™ in the November/December issue of **3-D WORLD**!

What Are The Boundary Element Method and CADKEY ANALYSIS?

Editor's Note: The article **What A Month!** that appeared in the July/August issue of **3-D World** generated a substantial number of questions about Cadkey Inc.'s new product-in-development, CADKEY ANALYSIS™, and about the Boundary Element Method on which it is based. The following article is not in any way a formal introduction of CADKEY ANALYSIS. This article merely presents the technology involved in CADKEY ANALYSIS that makes this product-in-development different from existing analysis products based on the Finite Element Method. CADKEY ANALYSIS is scheduled to ship as a product by the end of 1991.

CADKEY ANALYSIS™ represents a significant technological advance in the performance of engineering analysis on products during the design phases of their development, especially in the areas of heat-transfer, stress/strain and thermoelasticity. Its technological significance resides in its implementation of the Boundary Element Method of analysis to do its work.

In the late 1980's and early 1990's, engineering management has been urging staff members to use Finite Element Methods of analysis (FEM/FEA) to reduce the cost and time of product development. However, those involved in the design process have found the complexity of finite element tools to be cumbersome and demanding. Thus, they still rely on physical-prototype testing as the most common method of verifying a design. They make use of FEM tools for the design of extremely critical parts.

The Boundary Element Method (BEM) appears to live up to the needs of designers in ways that engineering managers had hoped when they urged the introduction of numerical methods into design. BEM and FEM are both based on the same governing partial differential equations (PDE) which describe engineering variables, such as temperature, flux, displacements, stress, etc. due to imposed boundary conditions.

How Do the Methods Differ?

FEM/FEA

FEM/FEA requires two steps. The first step creates a so-called finite element mesh (or model) from the boundary description of the object to be analyzed, i.e., mesh generation or preprocessing. The second step performs the analysis itself.

For three-dimensional analysis, the mesh generation divides the interior volume of the object being analyzed into discrete units by creating brick-like building blocks (elements)

that fill the volume of the object. In two-dimensional analysis, FEM divides the interior area of the object into discrete units by creating a grid of polygons (elements). An assembly of these elements is also called a mesh. This 3-D or 2-D mesh must completely fill the volume or the area of the object without excessive distortion of the elements. This task can require a substantial amount of time. If the geometry is complex, it can sometimes take days or even weeks to develop an acceptable mesh.

Furthermore, any change in the design of the object requires that the mesh be generated all over again, starting from the beginning. Due to the iterative nature of the design process, this makes FEM impractical for use as a design tool. Thus, the designer must either consult with analysis groups, or overdesign the part. This frequently results in serious delays not only in the individual project, but also in overall product development of which the project is a part.

BEM

BEM allows you to input merely the edge description of a three-dimensional object (wire-frame model), and to identify boundary conditions, such as temperature and heat flux, or loads and displacements. For two-dimensional analysis, all you have to do is identify a perimeter or set of perimeters, and corresponding boundary conditions. Consequently, BEM requires only a 2-D mesh to perform 3-D analysis, and a 1-D mesh to perform 2-D analysis. This dramatic reduction in dimensionality means that the Boundary Element Method avoids the Finite Element Method's difficulties of creating a three-dimensional mesh.

After the object's surface or perimeter has been coated with polygons or line segments, you indicate the location within the boundary where, for example, a specific heat flux, temperature, load, or displacement needs to be known.

A change in the design does not require that BEM start from the beginning to regenerate the mesh in the object being analyzed. Only the surface or perimeter mesh at the location where the change occurred needs to be regenerated. This simplifies and speeds up the preprocessing phase of the analysis. Moreover, since meshing is not a problem in BEM, a change in the design does not result in any real delay either in the individual project or in the overall product development of which it is a part.

Accuracy

The Boundary Element Method is significantly more accurate in its calculations than Finite Element Methods, especially at locations of large solution gradients (i.e, stress concentrations). The maximum values for problems involving linear heat transfer/stress lie on the surface of the object.

BEM uses singular Green's functions to perform its calculations, whereas FEM uses algebraic polynomials. Algebraic polynomials cannot accurately approximate large solution gradients.

BEM also provides accurate solutions to heat transfer/stress problems within the interior of the object being analyzed. The solutions to interior problems at particular locations provided by FEM are generally less accurate due to finite difference approximations.

BEM represents a significant advance in technology due to its simplicity, computational efficiency, and ability to handle a wide range of analysis types. BEM can solve more than 90% of all the problems currently analyzed, and nearly 100% of the typical problems involved in preliminary design for quick verification.

To be sure, BEM will not completely replace FEM/FEA, which is still useful in handling many nonlinear problems, especially those with complex internal configurations.

CADKEY ANALYSIS

CADKEY ANALYSIS fits directly into CADKEY Version 4, with access to all of CADKEY's capabilities. CADKEY ANALYSIS allows you to rotate the object to view it from any side, and to compute the temperature or stress at any point inside the object. The initial modules of CADKEY ANALYSIS are aimed at serving those design engineers who have seldom used computer-based analytical techniques due to the enormous complexities involved in using them.

In its initial phase, CADKEY ANALYSIS offers steady-state and thermoelastic types of analysis. Other types of analysis will be offered later.

CADKEY ANALYSIS does not make anyone not trained in heat transfer or in structural stress an expert in these matters. However, because it allows users to work on real-world problems with relative ease, students and engineers can gain insights into these types of problems that would be difficult to achieve merely from course work.

'91-'92 Courses in BEM

Worcester Polytechnic Institute is offering a graduate-level course, **Advanced Boundary Element Method**, using a pre-release version of CADKEY ANALYSIS™, in the Fall 1991 semester, Sept. 6-Dec. 12. Anil Gupta is the instructor. WPI will also offer a second graduate course, **Introduction to Boundary Element Method**, during the Spring 1992 semester, Jan. 15-May 5. The instructor will be Joseph Rencis. For additional information contact the Mechanical Engineering Department, Worcester Polytechnic Institute, Worcester, MA, (508) 831-5236.

Clarification of Cadkey, Inc.'s Government Sales

The July/August issue of **3-D WORLD** included an article, **CADKEY Products Now Available to U.S. Government Customers on GSA Schedule**, on page 8. The article indicated that the contact people for government customers are Larry Boardman and Karen Miller. After that issue was printed, Scott Wilkman, Cadkey's Director of Sales, reassigned some responsibilities within the Sales Department.

Larry Boardman is now the Regional Manager for the South Central States, and Karen Miller is Maintenance Sales Manager.

Effective July 1, 1991, Scott Wilkman assumed direct responsibility for government-related sales under Cadkey's GSA schedule (Contract Number: GS00K91AGS5124). Sales under the GSA contract are limited to direct sales by Cadkey, Inc. only at the present time.

Government customers seeking to procure CADKEY or DataCAD products through the GSA schedule must contact the regional manager or the inside sales representative for their area at Cadkey, Inc., 4 Griffin Road North, Windsor, CT 06095. Tel.: (203) 298-8888. Fax: (203) 298-6401.

THIRD-PARTY NEWS

Complicated Roofs Don't Bother Roof Builder 2

People Software of Pollock Pines, California, has released Roof Builder 2™, a DCAL macro that enables DataCAD users to create and to edit complicated three-dimensional roof surfaces quickly and easily.

Roof Builder 2 uses your existing 2-D roof plan to define its boundaries. Each roof surface may contain a maximum of 36 points. After you have established the height of the beginning plate, Roof Builder 2 calculates and draws a roof slab

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THIRD-PARTY NEWS

Macola, Inc. Releases CADKEY Version of RAMP Design Series

Macola, Incorporated of Marion, Ohio, has released a CADKEY™-specific version of its RAMP™ Design Series. RAMP (RApid Modeling Platform) is a front-end, three-dimensional, PC-based design system that integrates with CADKEY through CADL™ (CADKEY Advanced Design Language). RAMP's CADKEY-specific version allows CADKEY users to design equipment, systems, and complete plants for moving liquids and gases (including air) by entering parameters through a keyboard and mouse. Among its modules, RAMP features an Equipment Builder for custom-designed parts and assemblies, Piping Design, and HVAC (Heating, Ventilation, and Air Conditioning) Design. RAMP produces 2-D and 3-D models as CADL files in CADKEY. RAMP's CADKEY Version offers a user interface that features a menu bar and pop-down windows. Users can access functions through the arrow keys, a mouse, or a two-character command.

Originally designed in 1986, for mini-computer-based CAD systems and workstations, Macola has ported RAMP to 80286, 80386, and 80486 personal computers. RAMP incorporates a completely relational database which allows a user to move from one application to another, while working on the very same model. On the screen, RAMP's 3-D model has a wire-frame appearance, but the database understands the model as an object. RAMP provides full interference checking with a user-defined clearance between the systems being designed.

"RAMP represents some of the most advanced technology for PC-based computer-aided design software," commented Macola's CADD Product Manager, John Antjas, "and we are very pleased that we can now provide these capabilities to CADKEY users." Jeff Hall, CADKEY's Strategic Partners Manager added, "RAMP is a valuable addition to CADKEY's line of front-end products. Specifically, its total plant-design capabilities, as well as its drawing, model and bill of material generation will be of great benefit to our users."

Building a part with RAMP requires only that the designer specify the size parameters for components. RAMP builds the part automatically, creating not only the geometry of each component, but also incorporating connectivity information into each component so that the component fits automatically into its proper place in the part.

Another powerful feature of RAMP is the software's ability to use a three-dimensional center line to portray the path of a piping or HVAC assembly. Macola calls this feature the *Magic Arrow*. "The *Magic Arrow* is used to route center lines," John said. "The *Magic Arrow* allows you literally to sketch accurately in 3-D using a mouse. This is a benefit because it is easier for people to think in terms of references and what they see on the screen, versus trying to figure out the actual distance. For example, a user can route a center line simply by telling the *Magic Arrow* to go in a certain direction until it gets three feet higher than the top of this tank. The time savings and accuracy that this feature provides are impressive." This center line serves as the basis for RAMP's automatic placement of parts in a piping or HVAC assembly.

RAMP also has the ability to generate section drawings by using up to six simultaneous slice planes. This feature permits extraction of any section or view from a design. RAMP automatically generates 2-D drawings, with hidden lines fully removed, of the section or view, without any limit on the number of drawings that you can produce. "RAMP's power lies in the fact that it can produce as many drawings as needed to depict the design, four to ten times faster than previous methods. Each drawing can be a combination of systems, and RAMP automatically produces the bill of materials for each drawing," John added.

RAMP's Mass Drawing Processor and Mass Bill of Material Processor automatically generate output in CADKEY and DIF formats. The DIF output option permits the transfer of the information into spreadsheet programs. "For example, if you need to produce estimates before completing the drawings, all you need to do is tell the system which bills of material it should create, RAMP's BOM Processor does the work for you," John said. "Or, if you need to produce an isometric view of a steam system, RAMP's Drawing Processor automatically generates it."

For additional information about the CADKEY Version of RAMP, contact Macola, Incorporated, 333 East Center Street, P.O. Box 485, Marion, OH 43301-0485. Telephone: (614) 382-5999. Fax: (614) 382-0239.

Roof Builder 2

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according to the slope, thickness and overhang settings that you have already defined.

For additional information about Roof Builder 2, contact People Software, 2746 Barrett Pass Road, Pollock Pines, CA 95726. Tel.: (916) 644-8841. Fax: (916) 626-6926. A 5.25-inch demo disk is available, free of charge, upon request. To request it, call (800) 647-DEMO.

CADKEY Users' Groups

CADKEY users frequently request information about where and when a local Users' Group meets. Here is a listing of CADKEY Users' Groups for your convenience. Some users' groups have formal names; others do not. Members frequently host meetings at different locations. The address listed with the contact person's name is not necessarily the meeting place. If your CADKEY Users' Group is not included in this listing, please let us know.

State	Location/Contact	Meetings/ Serving
Ala.	**CIMPRO**, Div. of I.C.T., Inc. 206 South 8th Street Opelika, AL 36801 Jeffrey Simon (205) 749-9705	Montgomery, AL; Atlanta, GA; Knoxville, TN.
Ariz.	**Arizona CADKEY Users' Group** Acoustic Imaging 10027 South 51st St. Phoenix, AZ 85044 Dwayne Quatier (602) 496-6681	
Calif.	**CAD MICRO SYSTEMS** 5120 W. Goldleaf Circle Suite 100 Los Angeles, CA 90056 Ed Johnson (213) 291-2000	Quarterly. Los Angeles, San Bernardino, Orange, & Ventura Counties.
	CADKEY SOFTWARE USERS' GROUP (Meeting at various locations.) 14621 Titus Street Van Nuys, CA 91402 Bob Messamer (818) 994-8881	Monthly. San Fernando Valley area.
	ELECTRO OPTICAL INDUSTRIES, INC. 859 Ward Drive Santa Barbara, CA Ernie Liu (805) 964-6701, x133 T.J. Twombley (805) 238-1121	Quarterly. San Luis Obispo, St. Barbara & Ventura Counties.
	POELMAN'S DESIGN SERVICE 901 Campisi Way Suite 360 Campbell, CA 95008 Mike Poelman (408) 377-3585	Quarterly. Northern California and Sacramento.
Calif.	**SOUTHERN CALIFORNIA CAD ENGINEERING** 7673 Winnetka Av. Canoga Park, CA Roberto Guerra Susy Baudry (818) 700-0398	Monthly. Los Angeles, San Bernardino, San Fernando, Orange, Ventura Counties.
	3-D CADWARE 45690 Murfield Drive Temecula, CA 92390 Jim Neeley (714) 676-3223	Quarterly. San Diego, Riverside, Orange Counties.
Colo.	**CADKEY Users' Group** CADKEY-Colorado 4582 Ulster St. Pkwy. Denver, CO Sue Evans (303) 770-2024	Monthly. Greater Denver area.
	U. OF COLORADO AT DENVER 1200 Larimer Street Denver, CO 80204 Andreas Vlahinos (303) 556-2370	Quarterly. Denver, Boulder areas.
Conn.	**CENTRAL CONN. STATE UNIVERSITY** 1615 Stanley Street New Britain, CT 06050 Paul Resatarits (203) 827-7370	Call for schedule. Greater Hartford.
	Hartford CADKEY Users' Group 94 Riggs Avenue W. Hartford, CT 06017 Peter Szkoda (203) 521-5325	Bi-monthly Greater Hartford.
Fla.	**METRA ELECTRONICS** 460 Walker Street Holly Hill, FL 32017 Brian Gross (904) 257-1186	Monthly. Orlando, Daytona, Titan, N. Jacksonville.
Ga.	**Georgia CADKEY User's Group** CAD/CAM, INC. 6733D Jones Mill Court Norcross, GA 30092 Jeff Opel (404) 449-5186	Central Georgia
Ill.	**PFB CONCEPTS** 2525 E. Oakton Drive Arlington Heights, IL Paul Bergetz (312) 640-1853	Quarterly. N. Illinois, Wisconsin.
Mass. **N.H.** **Maine**	**New England CADKEY Users' Group** (Meets at various locations during year.) Dana Seero Jay Jacobs (617) 631-9662 (800) 640-4546	Bimonthly. Northeastern New England
Md.	**DATA ENGINEERING** 6259 Plaited Reed Columbia, MD 21944 Robb Karl (301) 730-1318	Quarterly. Columbia, Baltimore, Wash., DC.
Mich.	**CAD CAM, Inc.** 11887 Belden Court Livonia, MI 48150 Lynn Bryant (313) 425-8494	Bi-monthly Southeast Michigan.
	SOFTWARE FIRM 736 East Cork Street Kalamazoo, MI 49001 Frank Lucatelli (616) 381-4527	Southwest Michigan.
Minn.	**Minnesota CADKEY Users' Group** Anoka-Ramsey Community College 11200 Mississippi Blvd. Coon Rapids, MN Tom Loftus (612) 427-2600 Don Emerson (612) 462-7900 Tom Holman (612) 724-6678	Monthly. Upper Mid-West.

State	Location/Contact	Meetings/ Serving
N.Y. N.J.	**American Training Center, Inc.** 118-21 Queens Blvd. Forest Hills, NY Arkady Kleyner (718)544-8100 (800) 273-ACTI (N.Y. only)	Monthly New York and New Jersey.
N.Y.	**CADIMENSIONS, INC.** 5858 East Molloy Road Syracuse, NY Pete DiLaura (315)454-5543	Call for meeting schedule. Central New York.
	Central New York CADKEY Users' Group 148 Castleman Road Vestal, NY Doug Miller (607)721-4422	Bi-annual. Central New York: Binghamton, Troy, Syracuse.
	COLLEGE OF STATEN ISLAND Sunnyside Campus 715 Ocean Terrace Staten Island, NY Changmin Kim (718)390-7733	Staten Island and surrounding areas.
	ROCHESTER INST. OF TECHNOLOGY 1 Lomb Memorial Drive Rochester, NY. 14623 Robert Hefner (716)475-2205	Buffalo & Rochester.
Ohio	**PROGRESSIVE COMPUTING** 6964 Spinach Drive Mentor, OH 44060 Mark Orzen (216)255-0460	Bi-monthly All of Ohio; Pittsburgh; Detroit.
Ore.	**CTR BUSINESS SYSTEMS** 6420 SW Macadam Av. Portland, OR Anne McKasson (503)293-8627	Monthly. Portland, Vancouver areas.
Pa. N.J. Del.	**MICRO CONTROL** 390 Middletown Blvd. The Lofts, Suite 204 Langhorn, PA 19047 Barry Bennett (215)752-5510	Monthly. Pennsylvania, New Jersey, Delaware.
Texas	**DFW CADKEY** Users' Group P.O. Box 153882 Irving, TX 75015 John Henderson (214)438-7691, x242	Bi-monthly Greater Dallas and Fort Worth
	MLC CAD SYSTEMS 5316 Highway 290 W. Suite 420 Austin, TX 78735 Michael Leesley (512)892-6311	Austin, Houston, Dallas.
	VECTOR CAD 5787 South Hampton Suite 330 Dallas, TX 75232 Steve Roberts (214)337-8997	Monthly. Dallas/Fort Worth metroplex.
Utah	**MOUNTAIN WEST COMPUTER SYSTEMS** 754 South 400 East Suite 200 Orem, UT 84058 Paul Findley (801)226-1342	Semi-annual. Greater Salt Lake City area.
Wash.	**Northwest CADKEY Users' Group** Sundstrand 15001 NE 36th Street Redmond, WA 98073 Joe Brouwer (206)842-4314	Monthly. Greater Seattle area.
Wis.	**CAD PROfessionals** 120 Bishops Way Suite 136 Brookfield, WI 53005 Dave Roberts (414)782-9199	Quarterly. Wisconsin cities.
Wis.	**WAUSAU METALS CORPORATION** 1415 West Street P.O. Box 1746 Wausau, WI 54401 Joe Ramuta (715)845-2161	Monthly. Wausau, Stevens Point, Merril.

CANADA

Prov.	Location/Contact	Meetings/ Serving
New Brunswick	**MANUFACTURING TECHNOLOGY CENTRE** U. of New Brunswick P.O. Box 4400 Fredericton, N.B. Canada Evelyn Richards (506)453-3533	Quarterly. Fredericton, Moncton, Saint John, Bathurst, N.B.; Halifax, N.S.; Charlottetown, P.E.I.; St. John's, NFLD.
Newfoundland	**CADKEY Users' Group of Eastern Newfoundland** Memorial University S.J. Carew Building Prince Philip Parkway Saint John's, Newfoundland,Canada Dr. T.R. Chari (709)737-8901	Quarterly. Eastern Newfoundland.

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Note from the Editor

3-D WORLD Reader-Response Card

You will find a reader-response card enclosed in the envelope with your copy of **3-D WORLD**. If you enjoy reading **3-D WORLD** and want to continue to receive it, please fill out the response card, and mail it back to Cadkey, Inc. Your written response is essential if you want to continue to receive **3-D WORLD**.

What to do if there is no response card in the envelope

If, by chance, you do not find a reader response card in the **3-D WORLD** envelope, or if you have unintentionally thrown it away, you may write directly to me, Frank Simpson, expressing your desire to continue to receive **3-D WORLD**. If you would like some other people in your organization to receive **3-D WORLD** in addition to yourself, please write to me, and include their names and addresses in your letter.

Writing is essential in this case

In any case, your written expression of interest in receiving **3-D WORLD** is essential. Please do not telephone. That will not do any good. Written communication from you is the only way to continue to receive **3-D WORLD**.

CANADA (continued)

Prov.	Location/Contact	Meetings/ Serving
Ontario	**CADWIRE** 950 Denison Street Unit #116 Markham, Ontario Canada Charly Kovacshazy (416)475-6545	Toronto area.
Québec	**Centre de Recherche Industrielle de Québec** 8475 Rue Christophe Colomb Montréal, Québec Canada Manon Dubé (514)465-0974	Every 6 weeks. Greater Montréal area.

AUSTRALIA

State	Location/Contact	Meetings/ Serving
Victoria	**CADKEY Users' Group of Australia** meeting at the Royal Melbourne Institute of Technology Victoria University of Technology Faculty of Art Dept. of Design GPO Box 2476V Melbourne, Victoria Australia Des G. Harris Tel.: (03) 660-2559 FAX: (03) 663-2764	Call for schedule. Greater Melbourne area (Continued on

NEW ZEALAND

Prov.	Location/Contact	Meetings/ Serving
North Island	**Interlock Hardware Developments, Ltd.** P.O. Box 100-407 North Shore Mail Centre Auckland, New Zealand Brett May Tel.: (64) 9-444-4407 FAX: (64) 9-444-0087	Call for schedule. Auckland, Wellington, Christchurch.

ZIMBABWE

Prov.	Location/Contact	Meetings/ Serving
Mashanaland	**SYSTRON (Pvt.) Ltd.** P.O. Box 3458 Manhattan Court 61 Second Street Harare, Zimbabwe Andrew Wynne 739881	Quarterly. Mashanaland.

If your CADKEY Users' Group is not included in this list, please inform Danielle Cote at CADKEY so that we may publicize your meeting schedule. Telephone (203) 647-0220, ext. 7150.

If you would like to start a new CADKEY Users' Group in your area, please call Danielle Cote. A FREE CADKEY Users' Group Start-Up Kit is available to help you.

Changes in DataCAD Users' Groups

State	Location/Contact	Meetings/ Serving
Conn.	**Connecticut DataCAD Users** Ian Scott TRA Design Group 85 Willow Street New Haven, CT 06501 (203)562-2181 or Ralph Linn DeCarlo & Doll, Inc. 1100 Sherman Avenue Hamden, CT 06514 (203)288-4067	
N.Y.	**Upstate New York DataCAD Users** Tom Cisek, R.A. 999 Design Group 25 McCleary Avenue Amsterdam, NY 12010 (518)758-9046 or Vito Mazzariello 999 Design Group 2 Skyview Lane Valatie, NY 12184 (518)758-9046	Upper New York state.
Wyo.	**Wyoming DataCAD Users' Group** Tom Judson Archaeopteryx P.O. Box 701 Riverton WY 82501 (307)856-9719 Fax: (307)856-5927	Monthly All of Wyoming.

Two New Publications Available

CADKEY, INC. has two new publications available free of charge — or almost free of charge — to our users. You pay the postage. The ***CADKEY 4 Hardware Update*** (Part Number 50131) lists new supported plotters and tablets, and gives you a little more detail on plotter clip limits. The ***CADKEY 4 386 Configuration Errata*** (Part Number 50132) describes how the Phar Lap™ compiler uses memory, and it tells you how to use the command-line switches inside the compiler.

End users can obtain a copy of one or both of these documents by writing to CADKEY Customer Service, Attention: Free Documents, 4 Griffin Road North, Windsor, CT 06095. Please enclose a self-addressed 8.5-inch by 11-inch envelope. Postage to be affixed for one document is $.75. Postage for both documents is $1.21.

Checking things out...

Colleague Pays Highest Compliment to 3-D WORLD

Michelle Elcheikh Ali, a member of CADKEY INC.'s Information Systems Group, read the story, **DataCAD User Delivers 50-Story Skyscraper On Time!**, in the July/August issue of **3-D WORLD**. On the weekend of July 6-7, Michelle and her husband, Aziz, went to Montréal, Québec, Canada, to visit relatives. They made a point of going to see the Marathon-IBM Tower at 1250 Boulevard René-Lévesque while they were in the city.

"We went to see it up close, and then we went to Mount Royal to see it from the summit," Michelle said. "What a tremendous building!"

A Student Saga!

(Continued from page 5)

hand all the parts that we had designed. What could have taken weeks took only a couple of days with CADKEY. We adjusted all of the affected parts, generated new prints, and got back underway.

Last Determined Efforts

All 25 of us continued to work on the project through the winter, putting in more than 40 hours a week, while carrying a full load of classes. We spent school breaks, even Christmas vacation, working on the car. As classes ended for the summer of 1990, we only had one month left to get the car ready, with three months of work left to do. All of us gave up everything to get the SPIRIT done. We slept an average of two to four hours a night, often in the Engineering Building. When the day to leave for Florida arrived, by some miracle we were essentially ready. Two years of hard work culminated in a 435 lb. vehicle dependent only on the sun.

SUNRAYCE U.S.A. 1990

The **SUNRAYCE** proceeded from Epcot Center in Orlando, Florida, to General Motors' plant in Warren, Michigan in 8-hour timed stages. Each stage covered between 150 to 200 miles. Every day there was a two-hour charging period in the morning and in the evening. The crowds that came to see the race were amazing. Thousands of people came to see the cars, lining the route, and packing the overpasses.

On July 6, 1990, all 32 entries went through a technical inspection and parade lap at Daytona Speedway, Daytona, Florida. Our SPIRIT received the fourth place award for engineering design and safety. SUNRAYCE U.S.A. 1990 started from Orlando, Florida, on July 9. The SPIRIT was in 17th position. We made good progress, passing several other teams, until a mechanical failure in the drivetrain (a sheared woodruff key in the initial reduction unit) forced us to stop. While we were replacing the woodruff key, the electric power lines overhead exploded, sending a shower of sparks down onto us and onto the car. This added to the drama of the scene as people watched

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Training Schedule at Cadkey, Inc.

We have Training dates scheduled through August, 1991. Please call Customer Service to register: (203) 647-0220, ext. 8030.

Course	Sept.	Oct.
Introduction to CADKEY	16-18	14-16
Introduction to DataCAD	23-25	21-23
Advanced Geometric Modeling	19-20	17-18
CADKEY SOLIDS		3-4

CADKEY/DataCAD Training In U.S. & Canada

Many authorized CADKEY and DataCAD Training Centers have scheduled courses in addition to the training available at CADKEY's world headquarters here in Manchester, CT. The following is a list of who is doing what, where, and when:

State	CTC	Location/Contact	Course	Dates
Ark.	Arkansas State University	State University, AR Charles Coleman office: (501) 972-2088 office: (501) 633-6554	*Intro. to CADKEY*	Call for schedule.
	Crowley's Ridge Vo-Tech School	I-40 and Crowley's Ridge Rd. Forrest City, AR Charles Coleman school: (501) 633-5411 office: (501) 633-6554	*Intro. to CADKEY*	Sept. 7 & 14 Sept. 21 & 28
Calif.	CAD MicroSystems	5120 W. Goldleaf Cir. Suite 100 Los Angeles, CA Monica Hunter (213) 291-2000	*Intro. to CADKEY*	Call for schedule.
	Consulting Services International	14621 Titus St. Van Nuys, CA Bob Messamer (818) 994-8881	*Intro. to CADKEY* *Advanced CADKEY*	3rd full week of each month. Scheduled on request.
	Desktop Productions	18200 Yorba Linda Bd. Yorba Linda, CA Carol Buehrens (714) 579-3066	*DataCAD for the Architect* (Mon./Wed., Tues./Thur., & Wed./Fri.) *DC Modeler* *Advanced DataCAD & Velocity DataCAD Keybd Macros*	Sept. 10-19 Sept. 23-Oct. 2 Oct. 9-18 Oct. 21-30 Sept. 13 Oct. 1, 31 Scheduled on request. Sept. 20, Oct.15
	Golden West College	15744 Golden West St. Huntington Beach, CA Jack North (714) 895-8209	*Intro. to CADKEY*	Nov. 1-3
	Nikken Design Systems	2116 Arlington Av. #209 Los Angeles, CA Roy Yoshino (213) 734-9433	*Intro. to DataCAD* *Advanced DataCAD* *DC Modeler*	Scheduled on request.

CADKEY/DataCAD Training in U.S. & Canada (continued)

State	CTC	Location/Contact	Course	Dates
	Poelman's Design Service	901 Campisi Way, #360 Campbell, CA Mike Poelman (408)377-3585	*Advanced CADKEY* *CADKEY SOLIDS*	Oct. 28-30 Sept. 23-25
	Ukiah High School	1000 Low Gap Rd. Ukiah, CA Jim Howlett (707)463-5253, x284	*Intro. to CADKEY*	1st weekend of every month.
Colo.	University of Colorado at Denver	1200 Larimer St. Denver, CO Andreas Vlahinos (303)556-2370	*Intro. to CADKEY* *Advanced CADKEY* *CADKEY SOLIDS*	Call for schedule. *CADKEY SURFACES* *CADKEY and FEA*
Conn.	DATAMAT Programming Systems	9 Mott Avenue Norwalk, CT Matt Reuben (203)855-8102	*Intro. to CADKEY*	Sept. 9-13 CT Oct. 28-Nov. 1
	University of Hartford	S.I. Ward Coll. of Tech. 200 Bloomfield Av. W. Hartford, CT Don De Bonee (203)243-4763	*Intro. to CADKEY*	Sept. 5 to Dec. 12, 8:30-9:45 a.m.
Fla.	Gateway Computer Learning Center	10901B Roosevelt Blvd. St. Petersburg, FL Terri Long (813)576-0549	*Advanced CADKEY* *CADKEY SOLIDS*	Scheduled on request.
	Indian River Community College	3209 Virginia Av. Fort Pierce, FL Bill Sigurdson Dean Zirwas (407)468-4700, x4269	*Intro. to CADKEY*	Oct. 24-Dec. 9 5:30-10:30 p.m. Individualized audit courses available.
Idaho	Ricks College	Revburg, ID Melvin F. Eckman (208)356-1874	*Intro. to CADKEY* *Advanced CADKEY* *Intro. to DataCAD* *Advanced DataCAD*	Call for schedule. Call for schedule.
Ill.	PFB Concepts a.k.a. CADPRO Chicago	2525 E. Oakton Av. Arlington Heights, IL Bob Konczal (708)640-1853	*Intro. to CADKEY* *Advanced CADKEY* *CADKEY SOLIDS* *CADKEY Light*	Sept. 4-6 Sept. 18-20 Sept. 26-27 Sept. 13
Ind.	Tekni	4011 South Wayne Av. Fort Wayne, IN Dennis Jeffrey (219)744-3575	*Intro. to DataCAD* *DCAL* *Intro. to CADKEY* *CADL*	Scheduled on request. On-site courses available.

A Student Saga!

(Continued from page15)

from the sidelines. Nevertheless, we got back on the road within an hour. We finished the first day in 20th place.

We determined that the drivetrain problem was related to motor start-up. During our test of the SPIRIT, we had climbed inclines with no difficulty, but we had started on level ground. Starting out on an incline was a different situation. The motor bounced between poles until it reached approximately 200 rpm. This transmitted shock loads to the entire drive system that caused the woodruff key to shear. That night we decided that we needed a centrifugal clutch to engage the motor at a higher rpm, eliminating the shocks that had caused the key to shear. We bought a clutch at a local *go-kart* track and proceeded with the design change. We had brought a PC along with us to use with our telemetry system during the race. We had also brought the SPIRIT's part files and CADKEY. We loaded the drivetrain files into CADKEY; modified the parts, and printed out drawings. We faxed our new drawings back to our machine shop at RIT. Our colleagues in Rochester machined the parts that night, and sent them by overnight express to our hotel. The next day, we installed the new parts and the new clutch. The drivetrain did not give us any more trouble.

In spite of rain and cloudy weather, SPIRIT moved up steadily in the rankings. On July 19, we arrived in Warren, Michigan. We finished the race in a very respectable 12th place among 32 teams.

Rework at RIT

After we returned to Rochester, we immediately began to redesign and improve our car. Graduating members of the team passed all of the CADKEY files to the new members. These new designers made many significant improvements, including a new drivetrain and a new shell. We reduced the car's overall weight from 435 lbs. to less than 400 lbs.

American Tour de Sol 1991

We entered our new SPIRIT in a five-day race, May 20-24, from Albany,

New York through Hartford, Connecticut, to Plymouth, Massachusetts, called the **American Tour de Sol**. The Tour de Sol included 26 entries, in three classes of cars: (1) Electric Commuter-class cars: battery-powered cars designed to travel up to 50 miles in continuous operation; (2) Tour de Sol class cars: solar-powered cars designed to travel up to 50 miles in continuous operation, and (3) Cross-continental class cars: solar-powered cars designed to travel at least 200 miles in continuous operation. The batteries of the electric commuter cars get recharged by connecting them overnight to electric power. The batteries of the solar-powered cars get recharged exclusively from the sun.

This race was not as eventful as the SUNRAYCE, but in solar racing this is a good sign. We had five days of perfect sun. The reliability designed into the new SPIRIT was evident. Our car performed superbly over some very steep hills (the Berkshire Mountains) that stopped our competitors in their tracks. We finished the Tour de Sol in first place for the Cross-Continental Class vehicles.

On to Another Adventure

Now that we have two races under the sun, we have decided to build an entirely new car, from the ground up, to compete in the **World Solar Challenge** in Australia in 1993. We shall use all of the ideas that have proven themselves, and we shall include state-of-the-art technologies still in development. Computers are going to become even more essential as tools. We have acquired an additional 386 computer and a 486, plus updated CADKEY software.

Editor's Note #1: Geoffrey Hitchings and Lynn Bishop III are fourth-year Mechanical Engineering students at Rochester Institute of Technology.

Editor's Note #2: Anyone interested in helping to sponsor the SPIRIT Team in the **1993 World Solar Challenge** in Australia, can contact Dr. Robert J. Hefner, Mechanical Engineering Department, College of Engineering, Rochester Institute of Technology, One Lomb Memorial Drive, P.O. Box 9887, Rochester, NY 14623-0887. Telephone: (716) 475-2205.

CADKEY/DataCAD Training in U.S. & Canada (continued)

State	CTC	Location/Contact	Course	Dates
Iowa	Iowa Lakes Community College	300 South 18th St. Estherville, IA Roger Patocka (712)362-2604	*Intro. to CADKEY*	Special schedules by request.
Mass.	Springfield Technical Community College	Engin. Transfer Dept. 1 Armory Square Springfield, MA Bill White (413)781-7822	*Intro. to CADKEY* *Advanced CADKEY* *CADL*	Jan 16-18, 1992 Jan. 13-14 Jan. 15-16
Md.	Anne Arundel Community College	101 College Parkway Arnold, MD Sina Sepehri (301)541-2435	*Intro. to CADKEY*	Oct. 18-19 Oct. 25-26
Mich.	Future Solutions	5900 N. Lilley Rd. #101 Canton, MI Paul Zwarka (313)981-7455 FAX: (313)981-7473	*Intro. to CADKEY* *Adv. Geo. Modeling*	Sept. 10-12 Oct. 29-31 Nov. 25-27 Sept. 23-24 Oct. 21-22
Minn.	Albert Lea Technical College	2200 Tech Dr. Albert Lea, MN Larry Gilderhus (507)373-0656	*Intro. to CADKEY* *Advanced CADKEY*	Scheduled on request.
	Anoka Ramsey Community College	11200 Mississippi Blvd. Coon Rapids, MN Tom Loftus (612)427-2600 (Customized classes at CTC or on site scheduled on request.)	*Intro. to CADKEY* Intermed. CADKEY & *DRAFT-PAK* *Adv. Geo. Modeling*	Sept. 9-11 Call for schedule. Call for schedule.
	Moorhead State University	Industrial Studies Dept. Moorhead, MN Wade Swenson (218)236-2466	*Intro. to CADKEY* On-site courses on request.	Oct. 5, 12, 19 Nov. 18-20
	Northwest Metro Technical College	3300 Century Av. North White Bear Lake, MN Jeff Jahnke (612)770-2351, x323	*Professional CADKEY* *Advanced CADKEY*	Call for schedule.
	St. Paul Technical Institute	235 Marshall Ave. St. Paul, MN Michael Haffner (612)221-1307	*Intro. to CADKEY*	Call for schedule.
Miss.	Mississippi Delta Community College	Highway 3, Box 668 Moorhead, MS Tony Honeycutt (601)246-5631, ext.103	*Intro. to CADKEY*	Oct. 28-30
Mont.	Montana School of Min. Sci. & Technology	West Park St. Butte, MT Dick Johnson (406)496-4452	*Intro. to CADKEY* *Advanced CADKEY*	Call for schedule. Scheduled on request.
N.C.	Entré Computer Center	110 Charlotte Plaza Charlotte, NC John Murphy (704)332-1557	*DataCAD I* *DataCAD II* *DC Modeler*	Scheduled on request.

CADKEY/DataCAD Training in U.S. & Canada (continued)

State	CTC	Location	Course	Dates
N.H.	Portsmouth Senior High School	Alumni Drive Portsmouth, NH Kenneth Webber (603)436-7100	*Intro. to CADKEY*	Call for schedule.
N.J.	Advanced Micro Systems	511 River Drive Elmwood Park, NJ Pat Neary (201)703-0404 Fax: (201)703-0546	*Intro. to DataCAD*	Sept. 11-13
	Collingswood High School	Collings Avenue Collingswood, NJ Gary Krause (609)962-5701	*Intro. to CADKEY*	Sept. 9-Oct. 21 (Mon. 7-11 p.m.)
	Glassboro State College	Dept. of Technology Glassboro, NJ Michael Guerard (609)863-6203 (work) (609)468-3087 (home)	*Using CADKEY to Solve Special Problems*	Call for schedule.
N.Y.	American Training Center, Inc.	118-21 Queens Blvd. Forest Hills, NY Arkady Kleyner (718)544-8100 (800)273-ATCI (N.Y. only)	*Intro. to CADKEY*	Sept. 3-5 Oct. 1-3 Nov. 4-6 Dec. 2-4
			Advanced CADKEY	Sept. 6-7 Oct. 4-5 Nov. 7-8 Dec. 5-6
			Intro. to DataCAD	Sept. 11-13 Oct. 7-9 Nov. 11-13 Dec. 9-11
			Advanced DataCAD	Sept. 16-17 Oct. 10-11 Nov. 14-15 Dec. 12-13
	Central Technical Vocational Center	258 East Adams St. Syracuse, NY Dick Harroun (315)435-4150	Intro. to CADKEY Intermed. CADKEY	Sept. 9-Oct. 16 (M,W 3:30-6:30) Sept. 10-Oct. 17 (T,Th 3:30-6:30)
	Rochester Institute of Technology	1 Lomb Memorial Dr. Rochester, NY Dr. Robert Hefner (716)475-2205	*Intro. to CADKEY* *Advanced CADKEY*	Call for schedule.

Look for an article about **RoboHoop** in the November/ December issue of **3-D WORLD**!

CAD/CAM/CAE User Satisfaction Survey Applauds CADKEY(R)

In early 1991, ***Nikkei Mechanical***, a Japanese magazine for professionals in Mechanical Engineering, surveyed 500 of its readers who use any of the CAD/CAM/CAE products advertised in the magazine's November and December 1990 issues. ***Nikkei Mechanical***'s readers rated 60 CAD, CAM, and CAE software products in the four categories listed below. 42.8% of those surveyed responded. CADKEY(R) ranked first in this **CAD/CAM/CAE User Satisfaction Survey**. The magazine provided a 16-page report of its findings to its advertisers.

Category	Average score for products in the survey	CADKEY's score in the survey
Ease of use	0.71	2.57
Functionality	0.65	1.29
Ease of Customizing	0.28	0.86
Technical Support	0.18	0.43
Cumulative Total	1.81	5.14

3-D WORLD regrets that authorization to identify the other products included in ***Nikkei Mechanical***'s **CAD/CAM/CAE User Satisfaction Survey** has been denied.

Is it Time to Renew your Maintenance?

The CADKEY and DataCAD Maintenance Program is renewable on an annual basis. We recommend it for anyone interested in continued maintenance and support from Cadkey, Inc. The program entitles you to telephone support from our Technical Support Group and any updates or revisions to your CADKEY or DataCAD software that become available during the period of one calendar year. As a Maintenance Customer, you may also receive any discounts made available on other CADKEY and DataCAD products and services. If you do not currently participate in the Maintenance Program and would like to take part, please contact your local dealer for more information, or call Cadkey, Inc., at (203) 298-8888 for the name of a dealer in your area.

NIST's *Shop of the '90's* and Phillips Plastics Participate

PBS to Televise Special Program: COMPUTER-INTEGRATED MANUFACTURING

The University of Wisconsin's College of Engineering and the Public Broadcasting System are collaborating to produce a special four-hour program dedicated to computer-integrated manufacturing. This special program will be broadcast on October 22, 1991, from 11:00 a.m. to 3:00 p.m., as four one-hour segments, on the Business Channel of the PBS Adult Learning Satellite Service.

One segment of the program will feature the PRODUCT PROCESS AUTOMATION program and the *Shop of the '90's* at the National Institute of Standards and Technology in Gaithersburg, Maryland. The *Shop of the '90's* currently has 12 CAD/CAM workcells using Zenith Data Systems, IBM-compatible, computers. Each computer is equipped with CADKEY™, Mastercam™, and Metcut™ (machinability) software. All of these systems are networked using Netware™ into one of two configurations: a token-ring network and a TCPIP network. Through the networks each systems also has access to material-requirements-planning software and to time-keeping software for the shop floor.

Another segment will feature Phillips Plastics of Phillips, Wisconsin. Phillips Plastics manufactures injection-molded thermoplastic parts and assemblies. Phillips also designs and manufactures injection molds for their customers using a combination of CAD and CAM software, that includes CADKEY.

Reception of this satellite broadcast will only be available to members of the Business Channel. For additional information about this special program, COMPUTER-INTEGRATED MANUFACTURING, or about becoming a member of the Business Channel of the PBS Adult Learning Satellite Service, call (800) 257-2578.

Editor's Note: Mastercam is a trademarked product of CNC Software, Inc., Tolland, Connecticut. Metcut is a trademarked product of Metcut, Inc., Cincinnati, Ohio. Netware is a trademarked product of Novell, Inc. Austin, Texas.

CADKEY/DataCAD Training in U.S. & Canada (continued)

State	CTC	Location	Course	Dates
Ohio	Owens Technical College	P.O. Box 1000 Oregon Road Toledo, OH Marty Weislak (419)666-0580, x454	*Intro. to CADKEY*	Sept. 20-21 Sept. 27-28
	Progressive Computing Corp., Inc.	6964 Spinach Dr. Mentor, OH Jean Kempton (216)255-0460 (800)473-0460	*Intro. to CADKEY* *Advanced CADKEY* *CADKEY SOLIDS* *CADL*	Sept. 4-5 Oct. 1-2 Nov. 5-6 Sept. 17-18 Oct. 15-16 Nov. 19-20 Sept. 10-11 Oct. 8-9 Nov. 12-13 Sept. 24-25 Oct. 22-23 Nov. 26-27
Ore.	CTR Business Systems	6420 SW Macadam Av. Portland, OR Sandi McNeil (503)293-8627	*Intro. to CADKEY* *Advanced CADKEY*	Courses offered every month. Call for schedule.
	Mount Hood Community College	26000 SE Stark Gresham, OR Michael Durrer (503)667-7294 (503)667-7470	*Intro. to CADKEY* *Advanced CADKEY* All courses: 30 hours.	Sept. 23-Oct. 23 Jan. 6-Feb. 10 92 Nov. 4-Dec. 11 Feb. 17-Mar. 18
Pa.	Computer-Land	1360 Harrisburg Pike Lancaster, PA Lori Fraser (717)291-2111	*Intro. to DataCAD* *Advanced DataCAD*	Scheduled on request, on site or in house.
	Lafayette College	Easton, PA Rebecca Rosenbauer (215)250-5000	*Intro. to CADKEY*	Oct. 5-7
	Micro Control Inc.	390 Middletown Blvd. Langhorne, PA. Marion Homan (215)752-5510	*Intro. to CADKEY* *Intro. to DataCAD*	Sept. 10-13 Sept. 18-20
S. D.	Northern State University	Industrial Technology Box 705 Aberdeen, SD Jerry Sauer (605)622-2571	*Intro. to CADKEY* *Intro. to DataCAD*	Continuous courses: 2-wk/M-F/day 4-wk/M,W,Th./ evening.
Tenn.	Southern College of Seventh Day Adventists	Computer Sci. & Tech. Box 370 Collegedale, TN John Durichel (615)238-2862	*Intro. to CADKEY* *Intermed. CADKEY* *Intro. to DataCAD*	Call for schedule.
Texas	AEC Software	2200 North Lamar Dallas, TX David Demarest (214)720-0270	*Intro. to DataCAD* *Advanced DataCAD*	Scheduled on request.

Give a Creative Person a New Tool to Play With, and Watch What Happens!

Richard Speight, of Silver Spring, Maryland, a practicing architect, converted to DataCAD a year ago. To learn DataCAD, Richard designed...what else...a house. That house, now named *The Patriot*, appears in a showcase in **Better Homes and Gardens HOME PLAN IDEAS**, Summer 1991, on page 24.

CADKEY/DataCAD Training in U.S. & Canada (continued)

State	CTC	Location/Contact	Course	Dates
Texas	MLC CAD Systems	5316 Highway 290 West Austin, TX Barbara Leesley (512) 892-6311 A = Austin D = Dallas H = Houston	*Intro. to CADKEY* Advanced CADKEY CADL	Sept. 10-12 H Sept. 17-19 A Oct. 8-10 D Oct. 15-17 A Nov. 5-8 H Nov. 12-14 A Dec. 10-12 D Dec. 16-18 A Sept. 24-25 A Oct. 22-23 A Nov. 19-20 A Dec. 19-20 A On request.
Utah	Utah Valley Community College	800 West 1200 South Orem, UT Rux Plott (801) 226-5000	*Intro. to CADKEY* *Advanced CADKEY*	Call for schedule.
Wash.	Everett Community College	801 Wetmore Av. Everett, WA Stu Barger Kathy Ardmore (206) 388-9429	*Advanced CADKEY*	Sept. 24-25
	Walla Walla College	School of Engineering College Place, WA Dale Visger (509) 527-2712	*Intro. to CADKEY*	Sept. 18-20
Wis.	CAD PROfessionals Inc.	120 Bishops Way, #136 Brookfield, WI Dan Warsh (414) 782-9199	*Intro. to CADKEY* *Intro. to DataCAD* *CADKEY SOLIDS*	2nd & 4th Tues. every month. *CADKEY SURFACES* *CADKEY RENDER*
	North Central Technical College	1000 Campus Dr. Wausau, WI Michael Clark (715) 675-3331	*Intro. to CADKEY*	Courses scheduled on request.

CANADA

Prov.	CTC	Location/Contact	Course	Dates
British Columbia	Pacific Marine Training Institute	265 West Esplanade North Vancouver, B.C. Mike Davison (604) 985-0622	*Intro. to CADKEY*	Courses scheduled on request.
New Brunswick	New Brunswick Community College	P.O. Box 2100, Sta. A CAD/CAM Dept. 1234 Mountain Rd. Moncton, N.B. Wayne Ritchie (506) 856-2169	*Intro. to CADKEY*	Scheduled on request. On-site courses available.
Ontario	Algonquin College	200 Lees Av. Ottawa, Ontario Peter Casey (613) 594-3888, x5904	*Intro. to CADKEY* *Intermed. CADKEY* *Advanced CADKEY*	Sept. 9-Oct. 2 M&W, 5-7 p.m. Oct. 7-30 M&W, 5-7 p.m. Nov. 7-27 M&W, 5-7 p.m.

(Continued on page 22)

First Annual Event

Post-Secondary Student Drawing Contest

Richard D. Irwin Publishers, and Cadkey, Inc. announce the **First Annual Irwin Graphics Series Drawing Contest** for students in post-secondary engineering and technical programs. This Drawing Contest will take place during the months of September and October 1991. The contest will include five categories: Freehand Technical Illustration, Mechanical Drafting, Technical Computer Illustration, Computer-Aided Design, and Technical Computer Animation. Students entering the competition must be sponsored by an instructor from their school, college, technical institute, or university. The deadline for the submission of completed entries is October 25, 1991.

Students who will be producing their entries using a computer and CAD or graphics software may use **any graphics or CAD software** to create their entries. The judging of contest entries will take place at the mid-year meeting of the Engineering Design Graphics Division of the American Society of Engineering Education (ASEE/EDGD), November 3-5, 1991, in Norfolk, Virginia. Winners will be notified by the end of November.

Cadkey, Inc. will award prizes of complete CADKEY(R) or DataCAD(R) systems to the winner in each category of the contest. The winners will have the option of selecting CADKEY or DataCAD software. The winners' colleges will also win. Cadkey, Inc. will make a parallel award of software to each winner's college or institute.

All winning entries, including honorable mentions, will appear in the Irwin Graphics Series with a credit line identifying the artist/designer, his/her instructor, and school. All winners will receive a complimentary copy of the book in which their drawings appear.

Students may submit as many individual entries, accompanied by an entry form signed by their instructor, as they desire. Students can obtain entry forms from their instructors. For complete information about the contest and to obtain entry forms, instructors should contact Kelley Butcher, Developmental Editor, at Richard D. Irwin Publishers, by telephone: (800) 522-2661 or (617) 451-1090.

Next year, Richard D. Irwin Publishers hopes that this contest can be expanded to include secondary school students.

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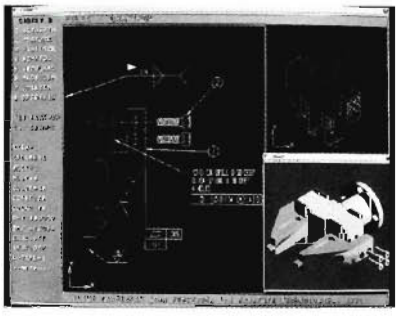

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CADKEY/DataCAD Training in U.S. & Canada (continued)

Prov.	CTC	Location/Contact	Course	Dates
	JB Marketing Associates	82 Spruceside Cresc. Fonthill, Ontario John Bradford (416)892-8025	*DataCAD I* *DataCAD II*	Scheduled on request.
	Klear Concept Data	465 Rogers St. Peterborough, Ontario John Punshon (705)742-3354	*Intro to CADKEY*	Customized training scheduled on request.
	Naylor-McLeod Group	1425 Bishop St. Unit 8 and 9 Cambridge, Ontario Brian Naylor (519)622-4495	*Intro. to CADKEY* *Advanced CADKEY* *CADL*	Customized training scheduled on request.
	Ryerson Polytechnical Institute, C.A.T.E.	350 Victoria Street Toronto, Ontario K. Doddridge (416)979-5106	*Intro. to CADKEY*	Scheduled on request.
Québec	APPLICAD	11956 Blvd. Laurentien Montréal, Québec Walid Hadid (514)336-5959 (514)335-4145	*Intro. to CADKEY* *Advanced CADKEY* *Intro. to DataCAD*	Sept. 10-11 Sept. 17-18 Sept. 29-30

CADKEY and DataCAD Training Centers that would like dates of scheduled training courses to appear in 3-D WORLD, contact Paul Mailhot, Educational Programs, CADKEY, INC., 440 Oakland Street, Manchester, CT 06040-2100. Telephone: (203) 647-0220. FAX: (203) 646-7120.

Colorado State University Correspondence Course in CADKEY Fundamentals

(Versions 1, 1.4, 2.06M, 2.11, and 3.5), Self-paced introduction to CAD. Developed by Terry T. Wohlers and Dr. Paul J. Resetarits. Contact: Division of Continuing Education, Colorado State University, Spruce Hall, Fort Collins, CO 80523. Tel.: (800) 525-4950.

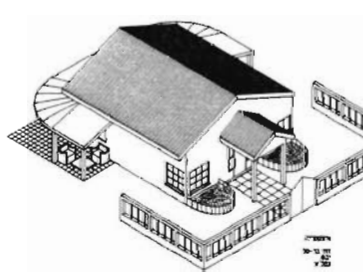
Architectural Competition

(Continued from page 24)

announced the competition, for the Winter Term, to students in Israeli high schools, 16 to 18 years old, who study architecture and DataCAD as part of their curriculum. The contest was a completely extracurricular activity. The contest began in November 1990, and participants had to submit their completed entries by April 1991, for judging in May.

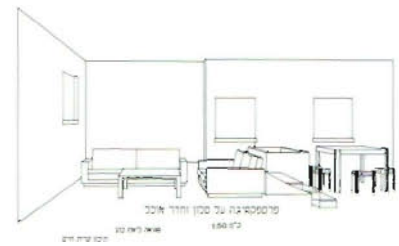
Half of the high schools in Israel that offer Architecture as a technical course in their academic program use DataCAD for classroom teaching. Twenty-five students entered the six-month-long competition that required producing floor plans, sections, elevations, detailed drawings, and three-dimensional models in perspective of a small dwelling unit.

"The competition was about how to use DataCAD 128 most effectively in the design of a small dwelling, and to present all the working drawings and presentation drawings needed to build the unit," Zvi added. "The results were a surprise both to the teachers and to us in R.S. CAD, too."

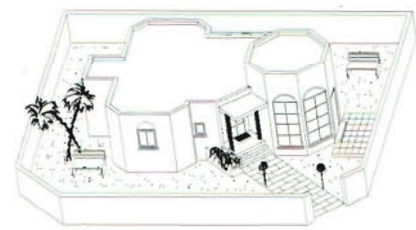


Perspective of house by David Bartal

Perspective of house by Yael Shabtay



Interior room of house by Liat Cohen



Perspective of house by Dana Sterenberg

The presentation of third prize to Liat Cohen was a very poignant moment in the award ceremony at the Holon Technical Center on July 11. Liat suffers from dyslexia and has serious difficulty in writing or drawing clearly by hand. "Before starting DataCAD, Liat was at the bottom of her class," Liat's teacher Edna Shay said. "After she learned to use the computer and DataCAD, she showed lots of talent. Liat is now first in her class in Architecture at Kiryat Haim."

Look for a story about the student who won the VICA U.S. Skills Olympics 1991, using CADKEY, in the next issue of **3-D WORLD**.

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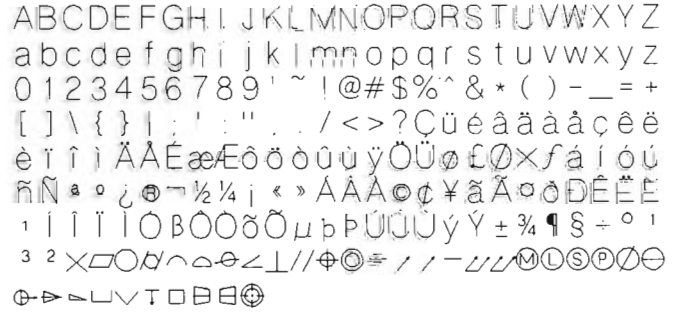

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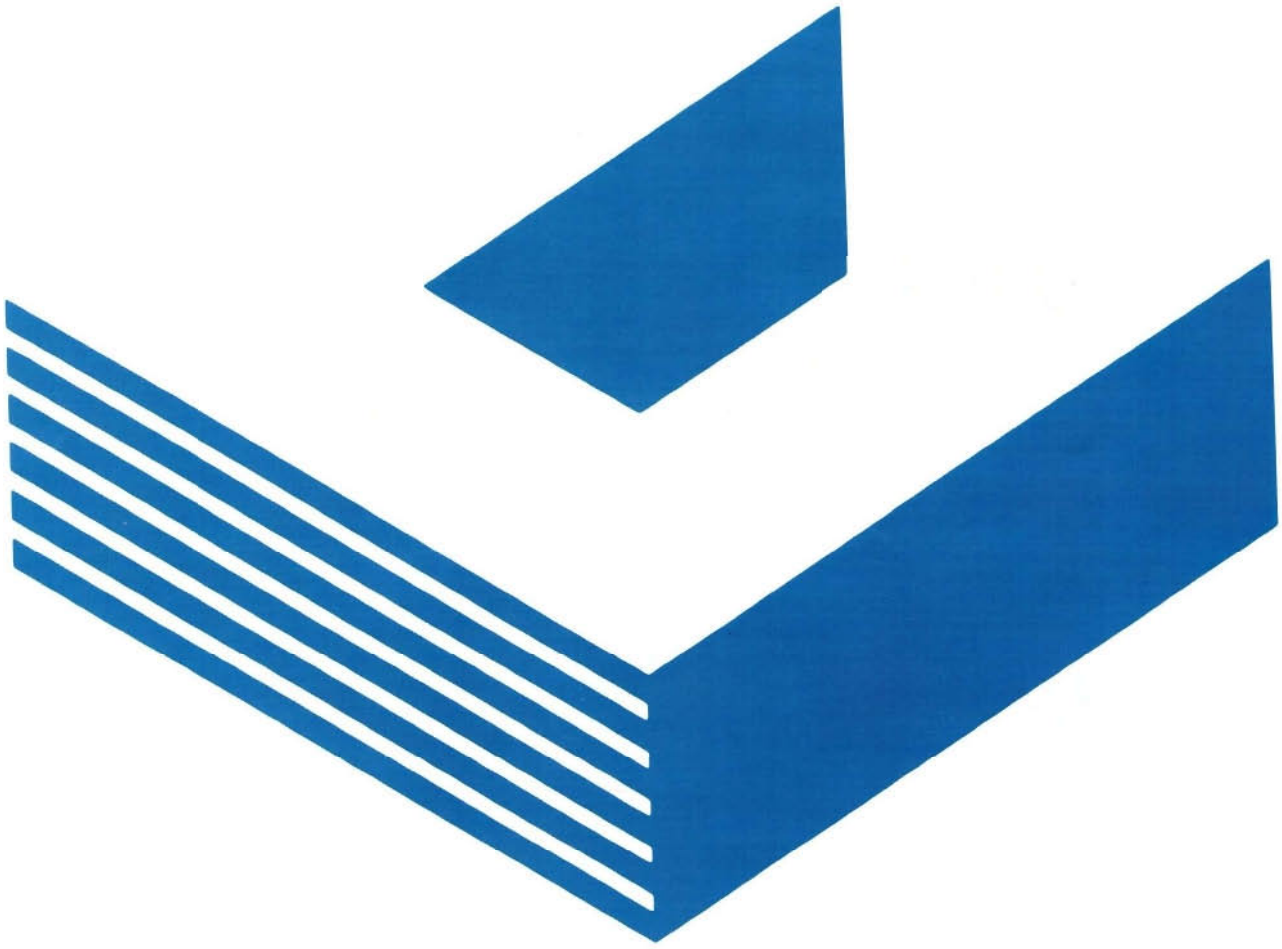

Architectural Design Competition Features DataCAD 128

On July 11, 1991, David Bartal, an 18-year-old student at Amal A High School in Petah Tiva, Israel, received first prize in the first national competition in computer-aided architectural design among Israeli high school students, sponsored by the Ministry of Education and R.S. CAD Ltd. of Herzelia. All of the designs were drawn using DataCAD 128™. First prize was complete package of DataCAD(R) Version 4.0 software.

Winning second, third and fourth prizes were three young women: Yael Shabtay of Amal A High School (second prize); Liat Cohen of Kiryat Haim High School (third prize) and Dana Sterenberg of Amal A High School (fourth prize).

"Architecture is a popular technical course among young women in high school," said Zvi Springer of R.S. CAD. "Half of the students in Architecture and many of the teachers are women."

During the 1990-1991 academic year, the Ministry of Education and R.S. CAD

(Continued on page 22)