

3-D WORLD

"We don't make them like we used to; we make them better!"

CADKEY and Craftsmanship Go Hand in Hand!



Two-person kayak and paddles, designed with CADKEY and CADKEY SURFACES, in competition.



Martin Dreadnought guitar, crafted by hand, with tooling designed using CADKEY.

Composite Engineering Builds Winning Aquatic Racing Gear

The stroke of a paddle... the lightness-with-rigidity of a canoe or kayak riding in the water... these, combined with the skill of the athlete, can make the difference between being a winner or an also-ran in competition. Composite Engineering of Concord, Massachusetts, fuses CADKEY® and CADKEY® SURFACES with hand craftsmanship to produce championship-level, aquatic racing equipment. Composite Engineering is supplying racing shells, canoes, kayaks, and paddles to the U.S. Rowing Team and the U.S. Canoe and Kayak Team participating in the 1992 Summer Olympic Games in Barcelona, Spain.

"If you have ever paddled a canoe or a kayak," said James Lawrence, Director of Engineering at Composite Engineering, "you know that when you insert a regular paddle into the water and pull it back, it propels the craft forward, but there are lots of little whirlpools around the paddle blade. Some of these vortices represent energy that has been lost, energy expended that does not move the craft forward." Composite Engineering's newest design for kayak paddles is a modification of the wing-shaped paddles developed since 1981 by Swedish and Norwegian canoeists Stefan Lindeberg, Lief Hakensson, and Einar Rasmussen. These

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Sound Makes Martin Guitars "the Stradivarius of Guitars"

C.F. Martin Company of Nazareth, Pennsylvania, travels in some very elite circles: historical, musical, and technological. C.F. Martin is one of a handful of companies in the United States that still operates under the active management of its original founding family, after more than 150 years. Its products, acoustic guitars, are renowned around the world for the quality of their sound and craftsmanship. Their sound has given Martin guitars a nickname as "the Stradivarius of guitars." And, the guitar makers of C.F. Martin Company combine their age-old tradi-

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Martin Guitars

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tion of high-quality hand craftsmanship with CADKEY to produce even better guitars.

Chris Martin, Chairman of the Board and CEO of C.F. Martin Company, is the great, great, great grandson of Christian Frederick Martin, Senior, who founded the company in 1833. Born in 1796, Christian Frederick Martin, Senior, belonged to a family of cabinet makers in the area of Markneukirchen, a town in the Ore Mountains of Germany bordering Czechoslovakia. However, he and his father, Johann Georg Martin, also made guitars. A dispute between the Martin family, who were members of the Cabinet Makers Guild, and the Violin Makers Guild, convinced Christian and his wife, Otilie, to emigrate with their children to the young United States in 1833, where they hoped to find better opportunities. Upon arriving in New York City, Christian and Otilie immediately opened a small retail music store which included a shop for making guitars. However, they were not comfortable living in New York. They missed German-speaking neighbors and the hilly terrain of the Ore Mountains. In 1839, Christian and Otilie moved their family and guitar-making business to Nazareth, Pennsylvania, a small town with a German heritage, in the rolling hills of the Blue Mountains. Nazareth remains to this day the home of C.F. Martin Company. Chris Martin, the current CEO, actively participates in the day-to-day management of the company. "He looks out for his company and his people," said

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Bob Headman, Mechanical Engineer at C.F. Martin.

Hand Craftsmanship, CAD and CAM?

"We still make all of our guitars by hand," Bob continued. "However, we use CADKEY to design the tooling to make the parts that go into a guitar." To design the tooling to make the parts requires designing the guitar first. Some 90 parts, not counting ornamentation, go into the making of a guitar. Nearly all of these parts are made of wood. "Our major use for CADKEY is to quantify what has historically been done through hand craftsmanship, and to improve the fit of the parts in the assembled guitar. We use CADKEY's 2-D and 3-D splines a lot. We use CADKEY to define the surface area that we need to cut. Then we use CADKEY to design the tooling, the fixtures, and the cutters that we need to do the cutting." C.F. Martin has its own computer-numerical-control machine shop to make the tooling and fixtures. Their CADKEY files serve as input to the CNC system.

Curves, and More Curves

"There are relatively few straight lines on a guitar," Bob added. "Everywhere a guitar has curves which often have very subtle radii, so subtle that the human eye frequently does not perceive them. But, these radii affect the aesthetic appearance of the guitar, its tonality through the stiffness of the wood, and the way it plays in the hands of the

musician. Many companies make guitars. The major difference in our guitars is the sound. We sell sound. Our guitars have become the standard definition of the acoustic guitar."

Bob gave examples of the subtle radii which affect the way a guitar sounds. "For example, a flat-topped guitar is not actually flat-topped," he said. "There is an arc to the top whose radius is, in reality, 42 feet long. You need to use a spline to design that. Another example is the back of our Dreadnought guitar. The perimeter of the body on the Dreadnought's back surface is a 62-inch 3-D spline. A third example is the guitar's bridge. The bridge is a matrix combination of 3-D splines both in the X and Y planes."

On an acoustic guitar, the interplay of the vibration of each string when plucked by the musician, the transmission of this vibration through the bridge into the wood of the guitar's top, the vibration of the top of the guitar's body, the reverberation of this vibration inside the guitar's body, the tonal qualities of the wood used in the guitar's body, the shape and depth of the body, the size and location of the bridge and sound hole, even the varnish, all affect the clarity, range, resonance, and volume of the guitar's tone. A deep body tends to emphasize the bass sounds and to increase volume. A shallow body tends to emphasize the treble sounds and to diminish volume. Producing the correct tonal balance in a guitar's performance depends upon the type of music to be played, as well as on the tastes of

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CADKEY 5 Delivers Innovative Drafting and Customization Capabilities

On April 15, 1992, Cadkey Inc. shipped CADKEY[®] 5 to our value-added resellers and dealers. Shipments of CADKEY 5 to maintenance customers took place on April 20, and shipments to new customers began on April 22. With new drafting and customization capabilities specifically incorporated to help engineers be more productive, CADKEY 5 aims squarely at fulfilling the growing need for CAD tools that work well with application-specific programs in a concurrent-engineering environment.

CADKEY 5 users create true three-dimensional wire-frame, surface and solid models with precision and speed. These models can proceed seamlessly into evaluation processes using CADKEY[®] ANALYSIS, and into machining using CUTTING EDGE[™], with complete data file compatibility.

CADKEY 5 continues Cadkey, Inc.'s well-known support for open software architecture through IGES (high end) and DXF (low end) translators. CADL[®] (CADKEY Advanced Design Language) also continues to provide flexible capabilities for communication between CADKEY and other CAD and CAM systems.

"Cadkey's focus as a company is to provide the designer with CADD tools which can be used effortlessly, without loss of data integrity," said Livingston Davies, President. CADKEY 5 makes any company more efficient by providing the ability to have virtually any application seamlessly integrated into CADKEY. This allows the user to focus on productivity, and on getting products to market faster and more efficiently.

Unlimited Potential for Customization with New CADKEY Dynamic Extensions

CADKEY 5's open architecture enhances the support of add-on CADD tools for desktop

concurrent engineering. In addition to the ability to customize CADKEY with keystroke macros and CADL, the new CADKEY[®] Dynamic Extensions[™] (CDE) make it possible to add complete, fully functional, complex applications, such as parametric modeling, progressive die programming, and detailed-dimensioning extensions to accommodate virtually any manufacturing need or local standard. Based on the C programming language, CDE integrates external programs seamlessly into CADKEY's existing functions and menu structure. CADKEY's third-party partners have already developed hundreds of applications programs, greatly expanding the variety of application solutions for users.

Complete Model-to-Drawing Associativity

New drafting features in CADKEY 5 include model-to-drawing associativity, assuring design integrity and allowing easy and accurate revisions. Whenever a 3-D model is changed, the related documentation is automatically updated. Dialog boxes, which appear as pop-up menus, document the changes quickly and easily. Final drawings can also be archived. CADKEY 5 can also accommodate numerous detailed drawings per model through its Drawing Layout facility.

New Productivity Features

In response to user requests, CADKEY 5 includes new dimensioning entities, enhanced *undo* functionality, improved support for printing and plotting, and on-line documentation.

New Graphic-Card Drivers

All CADKEY systems will also include new graphic-card drivers developed by Vibrant Graphics, Ltd. of Austin, Texas. These new protected-mode

drivers offer anti-aliasing and user-selectable fonts, and they support all popular graphic cards, including 8514A, S3, TIGA 1.0/2.0, and VGA/Super VGA graphic boards.

Note from the Editor 3-D WORLD and Reference Point Serve Different End Users

Readers of **3-D WORLD** and **Reference Point** will notice some changes with the Spring 1992 issues of these publications. Effective with the Spring 1992 issue, **3-D WORLD** has become Cadkey, Inc.'s corporate newsletter to the mechanical-design, engineering, and manufacturing professionals using our CADKEY[®], CADKEY[®] ANALYSIS, CADDInspector[™], and CUTTING EDGE[™] product families. Also effective with the Spring 1992 issue, **Reference Point** has become Cadkey, Inc.'s corporate newsletter to architectural-engineering and construction-engineering professionals using our DataCAD[®] product family. **Reference Point** will now be distributed to all DataCAD users.

These changes have come about in response to requests from the end users of our products and from CADKEY and DataCAD value-added resellers.

There may be some users of Cadkey, Inc.'s software products who want to receive both **3-D WORLD** and **Reference Point**. This is possible. Any customer using one or more of Cadkey's products, who wants to keep up to date with both **3-D WORLD** and **Reference Point**, must write directly to Frank Simpson, Editor of **3-D WORLD**, and Managing Editor of **Reference Point**, at Cadkey, Inc., 4 Griffin Road North, Windsor, Connecticut 06095-1511. Fax: (203) 298-6401. International Fax: (203) 298-6402.

Running CADKEY and CADKEY SOLIDS with DOS 5.0

DOS 5.0 and CADKEY Version 4.06

If you have tried to take advantage of the extended memory capability of DOS 5.0 to run CADKEY[®] 386, Version 4.06, and CADKEY[®] SOLIDS, Version 4.5, you have very likely encountered the error message: "Insufficient Memory," when you have tried to process a model in CADKEY SOLIDS. That should not happen, you say, because you really have more than enough memory! Then, why does it happen?

The source of this vexation is that CADKEY 386 includes its own memory manager. Unless you have assigned at least 3 megabytes of memory specifically to set up CADKEY and CADKEY SOLIDS, CADKEY takes all of the memory for itself.

The solution to this problem lies in your CONFIG.SYS file. Set up your CONFIG.SYS file to include the statements in the following example:

```
FILES=30  
DEVICE=C:\DOS\HIMEM.SYS  
DEVICE=C:\DOS\EMM386.EXE 3072
```

In this example, the number 3072 assigns 3 megabytes of memory to CADKEY and CADKEY SOLIDS. The number that you assign in this line of the CONFIG.SYS file can be no smaller than 3072. However, it can be greater, provided that you do not exceed the real-life memory in your computer. The more memory that you can make available for CADKEY, CADKEY SOLIDS, and CADKEY[®] SURFACES the better.

DOS 5.0 and CADKEY 5

In CADKEY[®] 5 the value that you enter into your CONFIG.SYS driver:
DEVICE=C:\DOS\EMM386.EXE ____ ought to be as large as possible.

For example:

```
DEVICE=C:\DOS\EMM386.EXE 6144
```

In this example, the number 6144 assigns 6 megabytes of memory to CADKEY and any other DOS Extender programs. The reason for entering a value as large as possible is that the more memory that CADKEY, CADKEY SOLIDS and CADKEY SURFACES have available, the less paging your system will have to do to operate.

CADKEY 5 prompts you through this situation in its CONFIG program, under section 5: *Set program options*. As part of setting up the options in CADKEY, CONFIG requests: "Will you be running other DOS Extender programs (such as SOLIDS or SURFACES) from CADKEY or from the DOS shell (Y/N)?"

If you answer Yes, CONFIG tells you: "Memory will have to be released by CADKEY to allow the other DOS Extender program to execute properly. It is recommended that at least 2048K be released for running SOLIDS or SURFACES. Enter the number of Kbytes to release (2048) =>" The default answer is 2048 kilobytes. However, you may choose to specify a greater number of kilobytes if you have additional memory available.



CADKEY

Neu in deutscher Sprache:

CADKEY5 - CADKEY Solids - CADKEY Surfaces - CADKEY Light - CADKEY Unix - EuroBOM, Zeichnungs- und Stücklistenmanagement - EuroTAB, Tabletoberfläche - Mechanic Tools 1-3, DIN-Bibliotheken Maschinenbau - PROFOLD, Blechabwicklung - CADKISS, Kinematik - HASCO Normalien - VDAFS - Profilworker, Profile - Typoworker, Fonts & Logos - Pipeworker, Rohre - zylindrisch, konisch.

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Composite Engineering

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Scandinavian paddles gave canoeists and kayakers a two-to-three second improvement in competitive performance in 500-meter events. This two-to-three second decrease in time, from the start of a race to its finish, represents an overall performance improvement of approximately 2% to 3%.

"Our design attempts to reduce the amount of human energy wasted with each paddle stroke," James continued. "The paddle is double ended, and each paddle blade is gull-wing shaped with an airfoil twist like an airplane propeller. Water passes across the blade in the same way that air flows over and under the wing of an airplane. The paddle slices the water. It gives forward motion to the kayak or canoe without disturbing the water unnecessarily. First, we entered the full 3-D path of a paddle into CADKEY from video camera measurements of U.S. Team kayakers. After analyzing this motion, we designed the paddle as a three-dimensional model in CADKEY, and we used CADKEY SURFACES to create the surface of the blade."

New Types of Boats

"CADKEY became part of our design process a long time ago," said Ted Van Dusen, President of Composite Engineering, "because CADKEY is the leader in 3-D CAD, and so much of the design of boat hulls requires 3-D. We use 3-D splines, in particular, to design planking thicknesses for the hulls."

When Ted Van Dusen, a former member of the U.S. Rowing Team, founded the Composite Engineering in 1976, he deliberately sought to combine engineering with manufacturing. "That way you can benefit from your designs," he said. Ted began experimenting with building

boats from advanced composite laminates which up to that time were only seeing service in aerospace projects. Ted found that a glued laminate of Dupont's honeycomb NOMEX™ (aromatic polyamid) sandwiched between layers of carbon fiber, cured using the vacuum-bag process, produced racing shells that were significantly improved in lightness, rigidity, and durability for competition. Vacuum bagging is a process that takes advantage of atmospheric pressure to create a uniform distribution of an adhesive, such as epoxy, bonding two or more materials firmly together. The materials to be glued together are enclosed in a plastic bag from which a pump draws out the air at 14-pounds-per-square-inch atmospheric pressure or more. At 14 pounds per square inch, there is one ton of atmospheric pressure over every square foot of surface. The bond that results in the laminated materials is very strong.

Athletes using racing shells, sculls, canoes, and kayaks designed and built by Composite Engineering have won more than 50 medals in international competitions. During the 1976 Summer Olympics in Montreal, Canada, Joan Lind won a silver medal rowing a single-person racing shell. In 1984, Carlie Geer repeated Joan Lind's success during the Summer Olympics at Los Angeles, California. Anne Marden did the same at the Summer Olympics in Seoul, Korea, in 1988. In the Summer Olympics of 1984, Brad Lewis and Paul Enquist won gold medals in the men's double-scull event, using a two-person racing shell. Composite Engineering expanded its design of boat hulls with CADKEY into racing kayaks for the 1987 Pan-American Games in Indianapolis, Indiana, and for the 1988 Summer Olympics in Seoul. Greg Barton and Norman Bellingham earned gold medals

in the kayaking competitions at Indianapolis and at Seoul. Now Composite Engineering is taking a similar approach with the design and manufacture of kayak paddles.

"Ted and I have different design techniques," James Lawrence said, "especially in the way that we use levels in CADKEY. To accommodate our different styles, we use level 255 exclusively as an index of what is on every other level in the file." "This index on level 255 can become extremely important," Ted added, "especially when we are working on a file with some 200 levels containing geometry."

"In addition to the usual mechanical design, with its link to manufacturing with drawings and plotting templates, CADKEY is an essential part of our engineering design," Ted said. "A considerable amount of fluid dynamic analysis forms the basis of our designs. This analysis includes test data, such as the resistance of several different-shaped boat hulls. We enter our test data points, in some cases numbering a few thousand, into CADKEY, and we cross fair the points in full 3-D. This procedure has been invaluable to us in removing the experimental scatter associated with testing, and in visualizing the trends suggested by the data. The easy transfer between CADKEY and our FORTRAN analysis programs, through CADL files, has significantly improved the quality of our design process."

New Types of Paddles

"An ideal paddle design is a compromise among four elements," James said. "A paddle can have (1) a perfect shape for insertion into the water, (2) a perfect shape for the path that it makes in the water, (3) a perfect shape for coming out of the water, and (4) a perfect shape for the time that the blade is in the air. Remember, a paddle blade spends half of its time in the air."

James illustrated how Composite Engineering's kayak paddles for the 1992 Summer Olympics went from design to production. "We used Einar Rasmussen's paddle as a model. Then we modified it for our initial paddle design. We found that the right-hand blade and the left-hand blade of Rasmussen's paddle did not work exactly the same way in the water. We used a computer-based measuring device created by John Lawson of Petersham, Massachusetts, for measuring boats, to measure the right and left blades of Rasmussen's paddle in detail. John Lawson's measuring device pinpointed minor, yet apparently significant, differences in the

design more quickly."

Enter CADKEY SURFACES

Composite Engineering focused its further design effort on 11 out of 24 cross sections or airfoil stations, approximately five centimeters apart, in the paddle blade. "Near the tip of the blade these stations are closer than five centimeters," James added. These cross sections/stations are parallel sets of 2-D cubic splines. "After we had defined the stations, we created a four-sided complex surface using the paddle blade's leading edge, its trailing edge, and all the intermediate airfoil stations. This surface intersects all of the splines at each station.



3-D model in CADKEY of the motion in a paddle stroke.

right and left paddle blades. We fed the data from John Lawson's measuring device into CADKEY; then we made our modifications to Rasmussen's design, creating blades that are exact mirror images of each other."

"Since the boats are extremely difficult to balance," Ted added, "it is an advantage to make the strokes perfectly symmetrical. The mathematical design of a paddle is extremely difficult because the flow changes dramatically through a stroke. We design for an improvement in efficiency through the main power phase of the stroke, but we must modify the design based on the paddler's evaluation of its handling. After we had created the basic design in CADKEY, it was much faster and more accurate to incorporate modifications to make new designs. This permitted us to try more ideas and to improve the

We then created an offset surface, that is a surface reduced from the original complex surface by the thickness of the laminate in the paddle blade. This feature of CADKEY SURFACES is truly amazing. We used the intersection function to generate quickly all of the intermediate stations needed to construct a male mold called a *plug*."

Composite Engineering plotted the top view of the paddle at full scale, and also the front views of all 24 airfoil stations. The plots of the front views of the stations served as templates for cutting the stations out of plywood. The plot of the top view served as a map for placing the airfoil stations, now cut from plywood, in their correct locations. "After they were correctly in place," James said, "we filled the spaces in between with plywood specifically cut to

make sure that the surface of the paddle fairs evenly in all directions, from one station to the next, throughout the length and width of the paddle blade. We then glued all of these pieces of plywood together to make the plug."

Handcrafted Manufacturing

Composite Engineering used the plug to produce a female mold from which they make the laminated kayak paddle blades with careful hand craftsmanship. A technician lays a layer of carbon fiber pre-impregnated with epoxy, by hand, in the mold. This material goes by the nickname *prepreg*. Next, he/she places a layer of foaming epoxy, one-tenth-inch thick, on top of the carbon fiber. Then, the technician adds a second layer of *prepreg* carbon fiber to complete the laminate sandwich, which now goes into the vacuum-bag process for heat curing. Composite Engineering uses heat, in conjunction with the vacuum-bag process, because heat assists the molecules of the epoxy resin and of the hardener to flow together evenly to form direct molecule-to-molecule bonds. After the epoxy has cured for approximately six hours at 250 degrees Fahrenheit, the technician removes the paddle blade and deburrs the edges.

"We are currently installing a 55-foot-long autoclave to enable us to improve our laminating capabilities and to cure thicker laminates," Ted said. An autoclave uses heat and positive pressure to cure a composite laminate, in contrast to the vacuum-bag process which uses negative pressure. "We shall be using both the autoclave and the vacuum bag in our manufacturing processes."

"Kayakers and canoeists are fussy about exactly how their paddles are assembled," James said. "So, we deliver the paddle blades and shaft as a kit for them to assemble themselves."

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Mechanical Design Redefined

me · chan · i · cal de · sign (mî-kân'i-kúl dî-zín) *n.* **1.** The creation and rendering of machines and mechanisms using a CADKEY® system equipped with DRAFT-PAK. **a.** Parametric generation of geometry for features, fasteners and mechanical elements from raw engineering data. **b.** Split-second insertion of dimensions, details, labels and symbols by supplying only the most essential information. **c.** Rapid production of multi-view CADKEY® drawings on minimal instructions from a designer or draftsman. **2.** The facility to maintain a consistent and accurate database throughout a design process. **a.** Instantaneous access to a vast computer library of ANSI/ISO and machine designer's standards and specifications. (see also, DRAFT-PAK Professional Tablet Overlay and Bill of Material Database Generator.)



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Martin Guitars

(Continued from page 2)

the individual musician. This interplay has led C.F. Martin to produce 25 different models of guitar made from varying combinations of ten, different, structurally sound, acoustic woods. "We are working at the extreme high end of woodworking craftsmanship," Bob said.

"We work our wood within plus or minus 5 one-thousandths of an inch," Bob continued. "We hold the holes and slots to even tighter tolerances. For example, the slots where the frets are inserted into the fingerboard are held to 1 one-thousandth of an inch. We have special saws to cut these slots, and we check the slots with Feeler Gauges."

Innovations Become Industry-standard Practice

In approximately 1850, Christian Frederick Martin, Senior, created a distinct improvement for strengthening the top of his guitars without sacrificing vibration: "X" bracing



A six-string guitar bridge. A simple part of lines and arcs? No, a complex part of 3-D splines.

on the underside of the top of the guitar, to prevent the top from pulling up, away from the body, due to the severe tension that the strings exert against the top. Christian Martin's invention has become standard practice among guitar makers. Luthiers (i.e., the makers of stringed musical instruments such as guitars, violins, mandolins, ukeleles, banjos, etc.) have historically shared their technical innovations quite freely, even with their direct competitors. Another Martin innovation that has become a standard is the large-bodied Dreadnought guitar, introduced in 1931. The Dreadnought guitar (named

after the big-gunned British battleships of World War I) features a body that is bigger and deeper than the bodies of any acoustic guitars made before 1931. The Dreadnought and its strong bass tones have become a hallmark of Martin guitars. It has also become the most popular size of guitar among acoustic guitarists. Today, all guitar makers offer a "dreadnought" model. The luthiers' tradition of openness continues today. The Association of Stringed Instrument Artisans (ASIA) gathers bi-annually for a Luthiers' Symposium. The 1991 symposium took place at Lafayette College in Easton, Pennsylvania.

First Quality Only

The C.F. Martin Company operates on the basis that quality can only be built into a product; that quality inspection adds no value. "Martin does not sell any *second-quality* guitars," Bob said, "not under its own name nor under any other name. All second-quality guitars are either used for research, or they are destroyed. During manufacture,

each guitar receives an individual serial number. If a guitar is destroyed because it is not first quality, that guitar's serial number is never used again."

Guitar Strings, Too

"We not only make guitars," Bob added, "we also make guitar strings. We use CADKEY here, too, to design the tooling to make the strings."

C.F. Martin is so proud of its continuation of a centuries-old tradition of fine craftsmanship fused with modern technology that the company conducts plant tours for visitors every work day, Monday through Friday, punctually at 1:15 p.m.

New CADKEY Users' Group Forming on Long Island

CADKEY[®] users from around Long Island will hold the initial meeting of their new CADKEY Users' Group at Sun Microsystems' office, 135 Pinelawn Road, Suite 350 North, Melville, Long Island, New York, on Thursday, May 28, 1992, at 7:00 p.m. All CADKEY users, especially those on Long Island, are welcome to attend. The agenda includes discussion of CADKEY 5, CADKEY[®] Dynamic Extensions[™], and third-party software products.

Any CADKEY user on Long Island who would like to participate in this new users' group, but who cannot attend this meeting, can contact John Horcher at Datamat Computer Graphics, 81 Westbury Avenue, Suite 236, Carle Place, New York 11514. Tel.: (516) 623-9341.

VPI Students Help To Design Olympic Bobsleds

Dan Ancona of Annandale, Virginia, and Dan Sheridan of Great Falls, Virginia, both freshmen at Virginia Polytechnic Institute in Blacksburg, had an intense interest in the two-man bobsled competitions that took place during the 1992 Winter Olympic Games at Albertville, France. For two summers they had helped Kevin Lynaugh and Bob Ames of the David Taylor Naval Research Center, Washington, D.C., in a project to improve the bobsled's speed. Kevin Lynaugh is a mentor in the George Washington University - U.S. Department of Defense Science and Engineering Apprenticeship Program (GWU-DoD SEAP) for high school students. Kevin Lynaugh is also chairman of the bobsled club at the David Taylor Naval Research Center. The bobsled club participated in a voluntary research project in preparation for the 1992 Winter Olympics. Engineers from Syracuse

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CADL Programs Can Become Customized Building Blocks

CADKEY users who are not yet completely comfortable in working with CADL[®] (CADKEY Advanced Design Language) often ask for simple examples of CADL programs as illustrations of how CADL works, and how they can construct successful CADL programs of their own.

LISTENT.CDL is a program that displays the parameters of only one entity in a CADKEY part file's database. This CADL program is printed here, in full, as an example of what a CADL program looks like. LISTENT.CDL prompts the user to select an entity for display. After the user has selected the entity, the program displays the number of floating-point variables, the number of integer variables, and the values of all strings in the entity. When it has finished its display, LISTENT.CDL allows the user to select another entity, or to exit the program.

```
rem listent.cdl
rem
rem Purpose: To display parameters of one entity in the database
rem 05 Mar 89 LD
```

```
:top
  getent "Select an entity for display", etype
rem Allow the user to exit with F10 or ESC
  if ((@error != 0) || (@key < -1 ))
    goto exit
  pause "Entity type=%d num floats= %d num ints= %d num strings= %d", etype, @numflt, @numint, @numstr
  if ((@error != 0) || (@key < -1 ))
    goto exit

rem Print out values of all floating point variables.
  count=0
:floats
  pause "float: %d value: %f", count,@flt[count]
  if ((@error != 0) || (@key < -1 ))
    goto exit
  count=count+1
  if (count<@numflt)
    goto floats

rem Print out values of all integer variables.
  count=0
:ints
  pause "int: %d value: %d", count,@int[count]
  if ((@error != 0) || (@key < -1 ))
    goto exit
  count=count+1
  if (count<@numint)
    goto ints

  if (@numstr == 0)
    goto top

rem Print out values of all strings.
  count=0
:strs
  pause "str: %d value: %c", count,@str[count]
  if ((@error != 0) || (@key < -1 ))
    goto exit
  count=count+1
  if (count<@numstr)
    goto strs
```

(LISTENT.CDL continued in box in next column)

(LISTENT.CDL continued)

```
rem Allow selection of another entity.
  goto top

:exit
```

LISTENT.CDL is a self-contained program, but it also serves as a building block for another CADL program, called LISTENTS.CDL, which displays the parameters of all of the entities in the CADKEY part file's database.

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ABCs of CDE

by
Usman Rashid

Introduction

CADKEY^(®) Dynamic Extensions^(™) (CDE) mechanism allows functions to be added to CADKEY at run-time. The building block of this mechanism is the *CDE module*, which contains the code and data for the functions to be added to CADKEY. Similar mechanisms in other systems are referred to as Dynamic Link Libraries (DLL), Run-Time Linking (RTL) and Shared Objects. However, the CDE mechanism has a much wider scope than these other mechanisms, allowing the extensions to take place across applications and in the future, even over a network. This article is first in a series that explains the CDE mechanism and its advantages.

Let's begin by stating what CDE is NOT. It is not a new programming language from Cadkey — all code for CDE modules is written in C language. It is not a new compiler from Cadkey — the source files for CDE modules are compiled with a commercially available C compiler. What the CDE mechanism provides is the ability to make function calls back and forth between CADKEY and the CDE module. The mechanism takes care of loading the code into CADKEY as it is running, and establishes the connections for the function calls. Once loaded, the functions inside the CDE will execute as if they were part of the original CADKEY code.

A CDE module can call various functions within CADKEY. Examples include geometric modeling functions similar to CADL, dialog box management functions and general system control functions like part and pattern filing and viewport manipulation. Functions for user-defined entities can also be provided through the CDE mechanism. Since CADKEY may not know how to manipulate a user defined entity for functions like TRIM, BREAK, X-FORM etc., the developer can provide extensions for these functions. Every time a CADKEY function encounters a user-defined entity, it calls the corresponding new function. This way, user-defined entities can be handled transparently along with CADKEY entities.

When a function in a CDE module replaces an existing CADKEY function, it retains the ability to call the function it replaced. This way, enhancements to CADKEY functions need not duplicate the code of the original function, but simply provide the added functionality.

The CDE Mechanisms

As mentioned earlier, CDE modules can link with CADKEY in different ways. In particular, a CDE module can be:

1. Dynamically loaded (the *CDE/DL* mechanism), adding all the code and data of the CDE module to CADKEY in memory.
2. Connected through inter-process communication (the *CDE/IPC* mechanism), where the CDE module resides as a separate application, but makes function calls and transfers data to and from CADKEY using shared memory.
3. Loaded over a network (the *CDE/NET* mechanism), where an application communicates with CADKEY through a network connection. This functionality will be available in the future.

Dynamic Loading (CDE/DL)

When you start the CADKEY program, the operating system loads all the code and data for CADKEY into system memory and starts executing it. CADKEY has a *CDE loader* in it that provides similar operation for CDE modules. The CDE loader brings the code and data in a CDE module into system memory and makes the connection between its function calls and CADKEY. This makes the functions in the CDE module an extension of CADKEY.

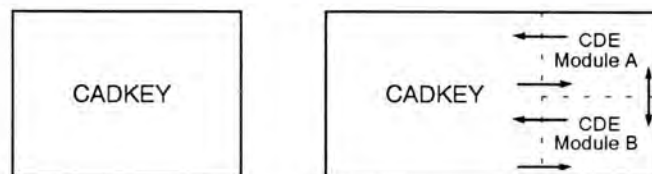


Figure 1: Dynamic Loading

Figure 1 shows a running CADKEY before and after loading CDE modules. Multiple CDE modules can be loaded depending on the available system resources like memory and disk space.

(Continued on page 14)

ABCs of CDE

(Continued from page 13)

Inter-Process Communication (CDE/IPC)

On systems that can run more than one application at a time, the CDE connection can be expanded to include inter-process communication. This means that another application can communicate with CADKEY using shared memory. The communication can take several forms. For example:

1. The application can simply call CADKEY and execute a function in CADKEY (the *Simple Model*).
2. The application may execute as a stand-alone program and also provide services to any client CADKEY (the *Client/Server Model*).
3. An application can establish a connection with CADKEY where both CADKEY and the application call functions from each other (the *Peer-to-Peer Model*).

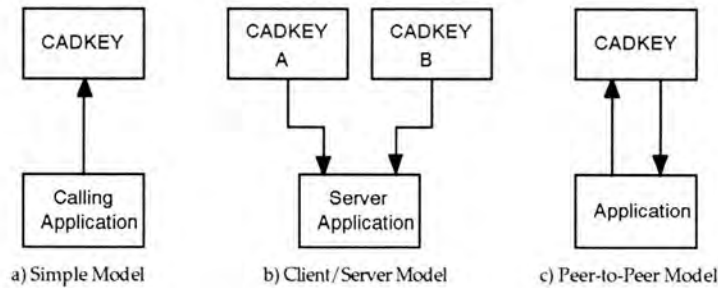


Figure 2: Inter-Process Communication Models

Figure 2 shows the various CDE/IPC models.

Network Loading (CDE/NET)

In the future, CDE loaders will also take advantage of a network connection for communications. The models described for inter-process communication will be available in situations where the application resides on a different node of the network. In this case, the network will serve as the means of communication between the processes.

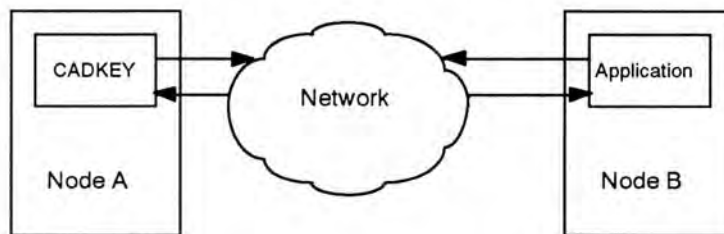


Figure 3: Network Loading

Figure 3 shows CDE loading across a network.

The CDE Advantage

The advantages of the CDE technology are three-fold. It provides a more productive channel for software development at CADKEY. It gives more power to the developers for their applications. This results in a much more versatile and responsive CADKEY for the user.

Advantages to CADKEY

With the CDE technology, Cadkey can work with a much shortened development cycle for changes and enhancements. Functionality provided through a CDE module requires development and testing of just that module, not the whole CADKEY. New versions of CADKEY can be developed in a distributed manner by developing and testing the different modules independently of each other. This also provides better error isolation. An error in one module only requires correction in that module.

Advantages to Application Developers

Since the functions in the CDE module have the same power and speed as CADKEY functions, a developer can build a large application without loss of performance. This application can be seamlessly integrated into CADKEY. Similar to CADKEY, the application developers can build modular applications to take advantage of distributed development and error isolation.

Advantages to the User

The CADKEY users will greatly benefit from having a modular CADKEY and a larger number of more powerful applications. The response time for error correction from CADKEY and from the application developers can be shortened. Due to the modular approach, the user can pick and choose the additions and applications, building a CADKEY with only the modules needed. Since the performance of the applications will be equal to CADKEY's performance, users can rely on them without loss of productivity.

The Future

As CADKEY becomes more "CDE-ized," the modular concept can become more important. CADKEY can effectively become a "Software Bus", with a plug-and-play approach to applications. Users can build a leaner CAD system, customized to their needs, with ability to expand at will. This software bus could extend over a network back-bone, with applications distributed across the network. Concurrent work on a project can be done, with the applications communicating with each other to assure correctness. The uses can range from a simple cut-and-paste between two CADKEY systems running simultaneously to stress analysis, in background mode, on a remote mainframe. The CDE mechanism gives an entirely new meaning to the concept "desktop concurrent engineering."

Working with CDE

If you intend to develop applications that take advantage of the CDE mechanism, you need the following:

Hardware

The hardware requirements for a CDE application are the same as those for CADKEY. For detailed information, see the *Hardware Requirements* section in the CADKEY User Guide.

Software

The CDE mechanism is available in CADKEY 5. To create CDE applications, you need CADKEY Software Development Kit (SDK) and the following development systems:

For CADKEY/386 SDK MetaWare High C compiler, release 2.31 or above.
Phar Lap DOS Extender Kit version 3.0 or above.

For CADKEY/UX SDK C compiler native to the required platform.

CADKEY SDK can be ordered from Cadkey by calling the customer support at (203) 298-8888.

Contacts at Cadkey

If you have technical questions regarding CDEs, contact Usman Rashid in Cadkey Inc.'s Applications Development group at (203) 298-8888. If you would like more information on how to become a registered developer, contact Jeff Hall or Johan Lavery at (203) 298-6463.

Editor's Note: Usman Rashid is Group Manager of Applications Development at Cadkey, Inc.

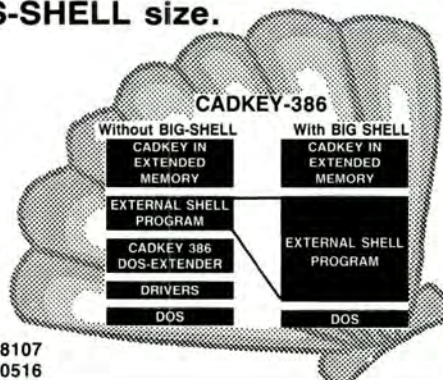
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functionality. Pressing the SHIFT key three times in succession toggles users between the DOS and SunOS environments.

Using surface-mount technology, in which both sides of the printed circuit board contain integrated circuits, the SPARCard and SPARCard2 are fully functional equivalents of Sun Microsystems' SPARCstation 1+ and SPARCstation 2. SPARCard and SPARCard2 comply 100% with SPARC International, Inc.'s SPARC Compliance Definition (SCD).

The Spring/Summer 1992 issue of CADPRO Chicago's newsletter, **OUTPUT**, will include an article entitled: **Opus SPARCard: a Sun in Two AT Slots**, describing CADKEY running on the SPARCard. To obtain a copy of this article, contact CADPRO Chicago, 2525 East Oakton, Suite C33, Arlington Heights, IL 60005. Telephone (708) 640-1853. Fax:

(708) 640-1868.

Information about CADKEY working with the SPARCard is also available through MLC CAD Systems, 7101 Highway 71 West, Suite 205, Austin, TX 78735. Telephone: (512) 288-9126. Fax: (512) 288-6645.

For more details about SPARCard and SPARCard2, contact Opus Systems, 329 North Bernardo Avenue, Mountain View, CA 94043. Telephone: (415) 960-4040. Fax: (415) 960-4001.

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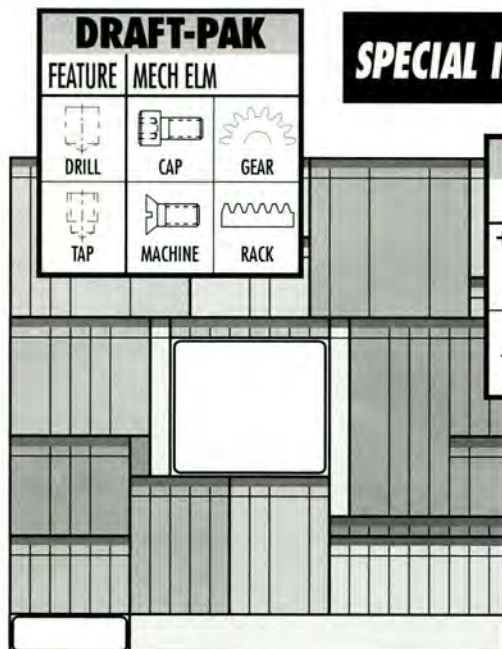
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THIRD-PARTY NEWS

IGESXpert and IGESVIEW Form a Powerful Team

IGESXpert™ and IGESVIEW™ from IGES Data Analysis (IDA) of Melrose Park, Illinois, offer a complete solution for the development, viewing, debugging, and testing of high-level IGES engineering applications.

IGESXpert is a comprehensive IGES file editor which uses the Open Software Foundation's Motif[®] graphical user interface. IGESXpert allows users to browse through IGES files, and to edit them, simply by pointing and clicking with a mouse. It has a mass-editing capability which allows you to fix IGES files quickly when you encounter the same known problems on a regular basis. At the same time, it automatically updates sequence numbers and pointer values any time that an IGES entity is changed. It also displays field names and values so that you do not need to count commas to locate

fields in the Global and Parameter sections of an IGES file.

IGESXpert allows you to work with multiple entities at one time, and to display the Directory and Parameter data at the same time, for easy analysis of the relationships between and among IGES entities. It maintains a bi-directional list of all pointers so that when an entity is deleted, all references to that entity are deleted.

IGESXpert's greatest value may be its graphical connection to IGESVIEW for interactive simultaneous operation.

IGESVIEW is an X-Window™-based, high-level, graphical viewing software that enables a user to display CAD/CAM data with or without access to a CAD system. It works with Motif, Open Windows[®], and Sun View[®] graphical user interfaces. IGESVIEW allows you to manipulate, mark up, integrate and

validate CAD/CAM engineering and design data. IGESVIEW's entity-selection capability provides the identification of the IGES entities being viewed in the file, to facilitate the quick isolation and correction of translation problems. IGESVIEW's mark-up/redlining feature allows engineering and manufacturing professionals to record comments without modifying the data. They can record one set or multiple sets of comments for each drawing. Any and all of these comments can be viewed and used to modify the design.

IGESVIEW includes a window that allows users (1) to summarize and modify the visibility and color of each IGES entity displayed, by type and by class, (2) to control English and metric units of measurement, and (3) to access manipulation features quickly.

Both IGESXpert and IGESVIEW will be released for most UNIX and VMS platforms in the second quarter of year 1992. Free software evaluations are available.

(Continued on page 18)

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IGESXpert

(Continued from page 17)

For additional information about IGESXpert, IGESVIEW, or IGES Parser/Verifier™, contact IGES Data Analysis, 2001 North Janice Avenue, Melrose Park, IL 60160. Telephone: (708) 449-3430.

Editor's Note: Motif is a registered trademark of the Open Software Foundation, Inc., Cambridge, Massachusetts. X-Window System is a trademark of the Massachusetts Institute of Technology, Cambridge, Massachusetts. Open Windows and Sun View are registered trademarks of Sun Microsystems, Inc., Mountain View, California.

THIRD-PARTY NEWS

MousTab Brings the Power of a Tablet to Graphical Display

Designers and draftspeople using CADKEY® have a new tool available: MousTab™. MousTab, a new product from CadTech Systems of Plainville, Connecticut, allows users to display a graphical screen of icons representing the MAIN MENU functions in CADKEY, by pressing ALT and one of the F1 through F8 function keys at the same time. Now, instead of entering three to five keystrokes, or having to remember several hot keys, the user presses one pair of hot keys and clicks the mouse to maneuver around CADKEY's menu system.

For example, to create a line, parallel, at a distance, all you need to do is press ALT and F1. The screen displays the icons for CADKEY's CREATE menu. Select with the mouse the icon of two parallel lines with arrow heads pointing toward each other (to indicate distance). After you have selected the icon, the CADKEY geometry redisplay, and you are ready to place the parallel line into the part file. These two steps replace the sequence CREATE (F1), LINE (F1), PARALLEL (F3), AT DIST (F2). (Continued on page 19)

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THIRD-PARTY NEWS

CADKEY Now Works with New "Liberated" CMM!

The Metrecom[®], a portable, state-of-the-art coordinate-measurement machine, can now supply three-dimensional, coordinate point data directly into CADKEY[®] through a computer's RS232 serial port. Because the Metrecom is portable, and its probe arm boasts six degrees of freedom, this coordinate-measurement machine has the nickname, "the *liberated CMM*." The Metrecom's portability makes it capable of gathering free-form design data from complex shapes and surfaces, as well as performing reverse engineering and quality-assurance checking, on site.

The heart of the Metrecom is its portable articulated arm which has six degrees of freedom. This gives the Metrecom a free-form "work-

envelope" diameter of 6 feet in all directions. The Metrecom is available in two standard models. The IND-01 measures within +/- .016-inch accuracy, and it features an adjustable, vertical aluminum tower and table clamp for easy mounting to a workbench or table. The IND-02 model measures within +/- .005-inch accuracy, and it also comes with a table-clamp attachment. Both models can also be mounted on a rolling theodolite stand for added convenience and portability, using a standard, 3.5-inch thread adapter. The Metrecom is also available in custom-application models to meet individual accuracy levels, ranges, and mounting configurations.

The Metrecom *liberated CMM* is the latest industrial application of technology

developed by Simon Raab, Ph.D., and Gregory Fraser, Ph.D., based on their collaborative work in biomechanics in the early 1980s. Their first products were computer-assisted, non-invasive, orthopedic diagnostic equipment. The medical diagnostic version of the Metrecom currently sees use in 700 hospitals, clinics, private offices, and teaching institutions around the world.

For additional information about the Metrecom and how it works with CADKEY, contact Faro Technologies, Inc., 125 Technology Park Drive, Lake Mary, FL 32796. Telephone: (800) 736-6063, (407) 333-9911. Fax: (407) 333-4181.

MouseTab

(Continued from page 18)

MousTab also has add-on modules for CADKEY[®] SURFACES, DRAFT-PAK[™] and KEYPLOT[™]. For additional information about MousTab, contact CadTech Systems, 28 Canal Street, Plainville, CT 06062. Telephone: (203) 793-8355.

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Variety of Entrants Sparks Drawing Contest

Fifty-two students in engineering and technical programs, at 13 colleges and universities around the United States, entered the **The First Annual Irwin Graphics Series Drawing Contest** sponsored by Richard D. Irwin Publishers and Cadkey, Inc. (See **3-D WORLD**, September/October 1991.) The contest included five categories: Freehand Technical Illustration, Mechanical Drafting (manual), Computer-Aided Design, Technical Computer Illustration, and Technical Computer Animation. (However, no one submitted an entry for Technical Computer Animation.) The judging took place November 3-5, 1991, during the mid-year meeting of the Engineering Design graphics Division of the American Society of Engineering Education (ASEE/EDGD) Gary Tindall of Portland Community College, Portland, Oregon, won first place in both the traditional Mechanical Drafting category and the CAD category. Gary used CADKEY Version 3.5. Bradley S.

De Forest of Spring Garden College, Philadelphia, Pennsylvania, won first place in the category of Technical Computer Illustration. Bradley used DataCAD Version 4.0. Tim Brummett of Purdue University won first place in Freehand Technical Illustration. Tim Brummett's freehand illustration was also honored as *Best of Show*.

Although Cadkey, Inc. co-sponsored the contest, participants were not required to use Cadkey products (CADKEY[®] or DataCAD[®]) in order to enter the CAD and Technical Computer Illustration categories of the contest. Twenty-one contestants submitted entries in these two categories. Six used CADKEY, four used DataCAD, eight used AutoCAD[™], and three used Hewlett Packard's ME30[™].

Robert Chin (East Carolina University), Linda Bode (University of Toledo), and Terry Burton (Purdue University) served as the panel of judges. Each of them judged each entry independently, assigning a grade on a 100-point

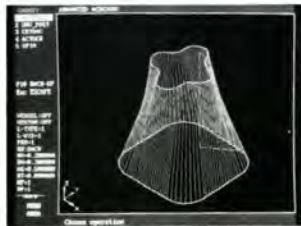
scale. Each entry could receive a maximum of 300 points.

The 52 contestants represented Berea College, Bucknell University, Indian River Community College, Morris County College, Old Dominion University, Okaloosa Walton Community College, Oklahoma Christian University of Science and Arts, Portland Community College, Purdue University, Ricks College, Spring Garden College, Valparaiso University, and Virginia Polytechnic Institute and State University.

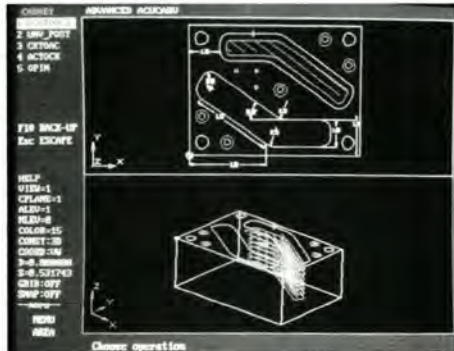
The response to this contest, on very short notice, was so enthusiastic that Richard D. Irwin Publishers plans to sponsor a second annual drawing contest in the Spring semester 1992. College instructors interested in obtaining additional information about the second annual drawing contest should contact Kelley Butcher, Developmental Editor, Richard D. Irwin Publishing, 20 Park Plaza, Suite 320, Boston, MA 02116. Telephone: (800) 522-2661 or (617) 451-1090. Fax: (617) 451-2437.

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New Brunswick Offers Unique Training Program

by Eric Cook

CADKEY and DataCAD users in the Province of New Brunswick, Canada, can take advantage of a unique, award-winning program in training and technology transfer: Customized On-Site Resource Training Services (CORTS). CORTS is an integral part of the Manufacturing Technology Centre of New Brunswick offered through sites at the University of New Brunswick, Fredericton, and New Brunswick Community College, Moncton. CORTS offers training in CADKEY and DataCAD, as well as in other software.

CORTS involves trainees in a 100-hour program: 20 hours of classroom instruction followed by 80 hours of on-site work, back at their companies, developing new skills. CORTS minimizes the loss of productivity due to trainees being away from their jobs for an extended period of time. And, it maximizes the effectiveness of the training because the students learn while they are working at jobs for which their employers pay them. CORTS generally works with pairs of trainees in the same company. The instructor customizes each training program to include company-related material and problems that the students encounter in their real work. Typically, the CORTS instructor builds each CADKEY training program around a job that the trainee's company has already completed manually. The instructor and students redo it using CADKEY.

CORTS Loans Training Equipment

CORTS provides each trainee with the necessary computer hardware and software for the duration of the program. The trainee's company does not have to use its own equipment. The students also progress at their own rates of speed under the

instructor's guidance. The instructor is on site at the company for 8 hours each week, usually four hours on two separate days. Experience has now demonstrated that students generally try to take as much advantage as possible of their own *hands-on* time with CADKEY or DataCAD. When the instructor returns for one full work day per week, the students frequently have advanced-level questions, thereby making better use of the instructor's ability.

A trainee does not need to have had any previous experience with computers. Instruction begins in the classroom with the computer equipment in packing boxes, as if it had just been purchased. The student is taught how to set up the computer, format the hard disk, install, and configure CADKEY or DataCAD. This first session includes basic instruction in using the software. The students then disassemble

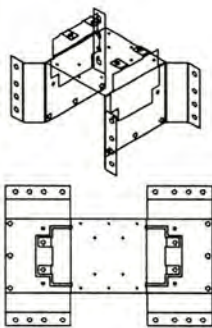
the computer and transport it to their work places. The instructor visits each site for eight hours per week to provide additional instruction and to answer questions. At the conclusion of the course, some 10 weeks later, the trainees are efficient CADKEY or DataCAD operators.

CORTS has benefitted many organizations in New Brunswick. Manufacturing companies that use CADKEY find it an effective means to train new employees, and to provide advanced customized training for their experienced employees. Companies that are considering the implementation of CADKEY or DataCAD can take the training without having to purchase the hardware and software right away, because the CORTS program provides them. This has proven to be an effective evaluation procedure. Most of the companies participating in the program make the decision to purchase hardware and software before the conclusion of the program.

(Continued on page 22)

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New Brunswick

Continued from page 21)

Interface Between Education and Industry

Dr. David Bonham, Professor of Mechanical Engineering at the University of New Brunswick, and Bill McGregor, currently Executive Director of the Canadian Institute of Industrial Technology, Winnipeg, Manitoba, founded the Manufacturing Technology Centre (MTC) in 1983, to serve as an interface between technical education and industry. MTC's goal is to encourage and assist industry to develop new manufacturing technologies through education (courses, seminars, workshops, and demonstrations), and through participation in research and design projects. MTC's charter of incorporation requires it to be a self-sustaining, educational business operation. It now has branches in the province at four community

colleges, the University of New Brunswick, the University of Moncton, Mount Allison University, and the Provincial Research Organization. In January 1988, John Hanusiak, MTC's current Executive Director, developed CORTS at New Brunswick Community College in Moncton, where he was serving as Department Head for Engineering, Drafting and Design. The area of Moncton, New Brunswick, is a substantial manufacturing center. CADKEY has been part of the CORTS program since its inception. The CORTS program has grown to include not only applications in mechanical engineering, but also in electrical engineering, architectural engineering, and quality assurance.

Recognized for its Effectiveness

In 1989, CORTS received Canada's Partnership National Award recognizing innovative

and effective educational partnerships between community colleges and industries.

The Department of Employment and Immigration Canada (EIC) supports CORTS through its Canadian Job Strategy Program which encourages the upgrading of employees' skills, and in many cases has subsidized the training costs incurred by eligible companies. EIC's support has allowed the CORTS program to expand, making it available to a greater number of companies, especially those not in a financial position to invest in employee training, and those remote from Fredericton, Moncton, Bathurst and Saint John. With EIC's support, the CORTS program has helped 240 students in 108 companies to adopt new technology and to become more competitive.

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Nova Scotia is setting up a CORTS-like program, too.

Editor's Note: Eric Cook is Director of the Manufacturing Technology Center at the University of New Brunswick, Fredericton, New Brunswick, Canada.

For additional information about the CORTS program, contact the Manufacturing Technology Center, Inc., P.O. Box 2100, Station A, 1234 Mountain Road, Moncton, New Brunswick E1C 8H9, Canada. Telephone: (506) 856-2247. Fax: (506) 856-2806. A copy of the report, *CORTS: A Partnership Program*, is available from the Manufacturing Technology Center, free of charge, on request.

THIRD-PARTY NEWS

Designer's TOOLKIT I and II for CADKEY

HLB Technology of Blue Ridge, Virginia, has added a series of Designer's TOOLKITS to its CADJET™ line of enhancement products for CADKEY®. Users can purchase each item of software individually, or in economical packages.

Designer's TOOLKIT I contains a collection of drafting and design aids such as 2-D and 3-D nuts, bolts, washers, geometric tolerancing, drafting symbols, QuikVIEW, plotter fonts, font manager, and CircleIT.

Designer's TOOLKIT II offers all of the aids in TOOLKIT I, except CircleIT, plus it includes welding symbols, X-sections, and AUTODraft.

A self-running slide-show disk (which does not require CADKEY to run) and a demonstration disk (which does everything that the real software does except PRINT and SAVE) are available, free of charge, upon request.

Both Designer's TOOLKIT I and II work with CADKEY Versions 3.5, 4, and 5.

For additional information about the Designer's TOOLKIT or about any of the CADJET enhancement products, contact HLB Technology, P.O. Box 527, Blue Ridge, VA 24064. Telephone: (800) 729-6520 or (703) 977-6520. Fax: (703) 977-6531.

Bobsled

(Continued from page 9)

University, Syracuse, New York, and from the Flight Research Institute, Seattle, Washington, also participated voluntarily in the project. The volunteer engineers worked on the project before and after business hours, and during lunch breaks. The student apprentices worked full time on the project.

An article written by David Reed of the Associated Press, and published in the *Roanoke Times & World News*, February 11, 1992, and in other newspapers, brought attention to the young men's contribution to this volunteer project to help U.S. Bobsled Team.

"We gathered the initial data for the bobsled using a theodolite," said Dan Ancona. A theodolite is a surveyor's

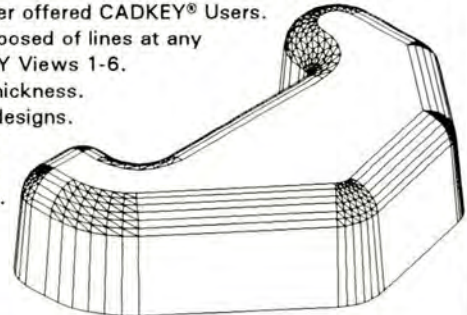
instrument for measuring horizontal and vertical angles. "We entered this data into AutoCAD™ where we did our first design work. Then, we used DXF to transfer the AutoCAD file into CADKEY®. I am continuing the work now in CADKEY."

The U.S. Bobsled Team's performance in the two-man bobsled events did improve over previous efforts, finishing in seventh and ninth positions. Dan Ancona's involvement in the bobsled project did not end with the closing ceremonies in Albertville. "This is an ongoing project," Dan says with enthusiasm. "I am preparing now for the 1994 Winter Olympics in Lillehammer, Norway, and then for the 1998 games which will be in Utah. Those Olympics will be great!"

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