Techno-isel Servo CNC Milling Center Used At Prairie HS To Teach State-Of-The-Art Manufacturing Skills

Cedar Rapids, Iowa -- Because College Community Schools are located in a highly industrial area with companies like Rockwell, Midland Forge, Square D, General Mills, Kodak, ADM, Evergreen and PMX, three years ago the district began to focus on the needs identified by local industries as critical for entry level employment. As a result, Prairie High School, Cedar Rapids, IA, has moved away from the traditional Industrial Technology instructional programs toward a focus on the skills needed to work in manufacturing, power and energy, pre-engineering, and related technologies careers. Most program decisions have been guided by the incorporation of quality concepts, team involvement, and a continual quest for improvement in teaching these technologies. With a commitment to those needs, the instructional staff, supported by a 35-member advisory committee, worked with administration to set new direction for the Industrial Technology program. Career options have been structured to promote the process of self-directed learning, and instructors in the vocational technical areas have promoted a continuous improvement philosophy where students are not expected to reach minimum standards, but to excel beyond all others. Although some activities are completed to a second-best level, the goal for all students is to be and to do their best.

Having computer based learning of technology is not a new concept in the district, but the level of technological capability has increased. In the past students learned the concepts of computer numerical control (CNC) based on desktop machines; unfortunately, they were too small and did not reflect simulations of the actual work environment. Concepts of CNC working in six inches of travel in an X, Y, Z could be taught, but they did not represent a true industrial setting. With the purchase of the new Techno-*isel* CNC milling machine in 1995, students gained the opportunity to learn on state-of-the-art equipment that is found in small businesses with process capabilities similar to those on the typical shop floor.

The Techno-*isel* Servo CNC milling center has an operational range of 41 inches by 49 inches with a plunge depth of 7 inches. The resulting machining center that was set up has been used to develop programs that students could use to build items that are not only useful, but have value when completed.

Students begin by designing a program that is simple, using a CAD environment and post-processed in Master Cam 5.5 software to a DOS CNC servo driver package. Projects vary—something like a nameplate, sign, or illustration—to prove that the machine can make a part from a drawing. Once oriented to the machine, students can make projects of their own choosing.

Students are also given training on operating computers with CAD. An IBM-compatible Gateway 2000 system works exceptionally well for teaching computer skills as well as current technology. Because of the software utilized, students learn how to generate drawings, create files, transfer files and post them for production. Because of a statewide site license, students can use VersaCad 8.1 to make the drawings and translate their 2-D files to IGS files which import through MasterCam to the NC controller unit easily.

Once a project is approved by the instructor, the students can prototype the product and prepare to manufacture. Some of the related activities for their production may include ramming a mold in the foundry, machining the mold part square, turning a part on the lathe, cutting and welding metal, and forming sheet metal. Because of the number of students and the variety of tasks, the milling center has become a major component/workstation in the production processing. The size of the Techno-*isel* table makes it possible for a number of students to have multiple set-ups and production activities nested simultaneously.

The milling center at Prairie High School has been incorporated into the curriculum of the Construction Technology II class and Manufacturing I & II classes. User-friendly as the Techno-*isel* system is, there is high demand in classes for skill development in this area, and students aggressively seek time on the work station. When students qualify as operators of the CNC workcell, they become team leaders, possessing skills in setup, CAD, computers, and material processing.

Students in the program still learn how to program longhand. Using word processing and ASCII file transfer format, each student has an opportunity to learn "G-codes" and "M-codes." Because they are able to do multiple setups, students usually make some form of fixture to position on their part of the bed. They nest their production activity and are assigned a "home" area and asked to work around others. Present production activities range from CD-racks, gun racks, school clocks, parking signs, and personalized signs and engravings. Each product is designed with the precept that they are manufactured using team concepts and made in small batch quantities of 20 or less. Students are instructed in statistical process control and only quality work is allowed to move forward. The accuracy of the Techno-*isel* milling machine allows the group to see, as well as manufacture, superior quality products. The tasks of prototype development, engineering and re-engineering are tedious, but the Techno-*Isel* milling center has rejuvenated the Industrial Technology program at Prairie High School and has rapidly become an important and intergal part in teaching state-of-the-art manufacturing skills to the next generation.

Techno isel

AFFORDABLE CAD/CAM SERIES

For High School in Ontario, Techno System is Head of the Class

When Cochrane High School in Ontario, Canada, wanted to advance and improve their Technology Education program, they chose Techno to help them make the grade. The school has a number of separate technical departments including a drafting department, a woodworking shop, a welding shop, and an auto shop. However, students were losing interest in the programs, and enrollment was beginning to decline. The government awarded the school money to integrate the various departments, thereby improving the program. The school used some of the money to purchase a Techno Gantry system, and the Techno machinery has made a drastic improvement in the education that manufacturing students now receive at Cochrane.

The school purchased a Techno Series III Gantry system with X,Y, and Z axes. The motion of the axes is controlled by a machine controller which receives its signals directly from an ordinary PC. The Techno system allows for all kinds of milling, routing and engraving, and makes such procedures simple to execute. A user draws whatever design he or she wishes to cut, using AutoCad, MASTERCAM®, or another design program. This file is then translated into a code which is understood by the controller. Once the material is mounted on the table, and a bit attached to the Z axis, the milling, routing, or engraving can be executed at the touch of a button. Whatever was drawn can now be created.

It is this instant conversion from picture to product which has made the Techno machine such a success with the Cochrane students. Previously, students did learn AutoCad in their design classes. However, once they had designed something, they were done. The students could go no further than produce a two dimension picture of what a product would look like. But now, they can actually create the product, and according to Gary Martin, a manufacturing teacher at Cochrane, that has made a huge difference. Students are much more enthusiastic now that they can actually see real, finished products. As a result, enrollment for the courses is up.

A number of factors made the Techno system Cochrane's choice. The biggest factor was the size of the table. With the Techno gantry, the students can cut panels as large as 40"x50". In addition, they can get travel on the Z-axis up to 7". Other available machines are table-top models which are much smaller. Such machines are only useful for producing wax prototypes of products. With the Techno machine, the students can create products which they can conceivably sell in the market place; and, in fact, the exact same Techno system which the students are using is actually used in the woodworking, engraving and other manufacturing industries. This realism was also a major selling point for Cochrane , since it truly prepares the students for the "real world" of manufacturing. Yet even though the Techno machine is a professional tool, the price was still acceptable for the high school to make the purchase. And the educational benefits of the machine have made the purchase more than worth it.

The students of Cochrane High have already used the Techno machine for a wide variety of projects. Sophomores have used the machinery to make personalized chests of drawers. They drew personal emblems using AutoCad and then used the Techno system to engrave these onto the chests. They then used the Techno machine to cut dado joints into the

side panels which could then be used to put the chests together. The juniors used the system to create plaques out of Melamine. Again using AutoCad, the students created designs for their plaques and then, with the Techno system, cut grooves into the Melamine. After coloring the grooves with grease pencils, the juniors had plaques decorated with images ranging from suns to cartoon characters. Perhaps the biggest project attempted has been by the seniors who have used the machine to build kayaks. The kayaks require two halves of a continuous curve cut out of plywood sheets just under 1/4" thick. Previously, this would be done by use of a template, a handsaw, and a plane, and was not an easy procedure. Now, the seniors can draw the pattern directly on AutoCad and cut the kayak instantly on the table.

The fact that they can create finished products so easily has allowed the students to make things outside of their required projects. One group of students used the Techno system to design and create a miniature backboard which could be attached to a garbage pail for impromptu basketball games. Martin affirms that the machine has opened up new ideas for students, because they are enthusiastic about creating something that looks professional. Increased enthusiasm means increased learning – and this has indeed been the case. Martin cites one instance where a student wanted to engrave a taxi sign for his father's taxi stand. Despite the fact that the student had not yet learned the programming codes to do this, the student learned by trial and error, motivated by the desire to create and the knowledge that he could create the finished product.

In addition to increasing enthusiasm, and hence increased learning and enrollment, the Techno machinery has allowed Cochrane to integrate their Manufacturing courses as they planned. Drafting courses and woodworking courses have been clearly integrated since students can now learn AutoCAD in design class, and use the program they made there to create a project in woodworking class. Martin sees the transportation department soon becoming integrated also. Previously, students in transportation classes only learned about automobiles. However, the curriculum will soon extend to other modes of transportation since models of these modes can be created using the Techno gantry. Down the line, Martin sees even nontechnological courses, such as English and marketing, being linked to the manufacturing courses thanks to the machine. Since the students can produce professional-looking products on the machinery, and since the school is located in a tourist community, the students may soon begin selling the things they make on the Techno machine. This will allow the school to teach such areas as economics and advertising with real life examples. Integrating all these subjects is a goal which Cochrane now finds within its reach with the Techno system.

At a reasonable price, Cochrane has been able to incorporate a machine used extensively as a tool in manufacturing fields as a teaching tool in the field of education. The Techno system allows students to easily convert drawings into finished, professional-looking products. Enthusiasm is up, as is enrollment. In addition, the Techno machinery has allowed Cochrane to update its courses as well as integrate its curriculum. In all, thanks to the Techno system, Cochrane has been able to improve the quality of its students' education. And that means Techno passes with honors.

Techno isel

AFFORDABLE CAD/CAM SERIES

Gantry Mills... BOEING Scale

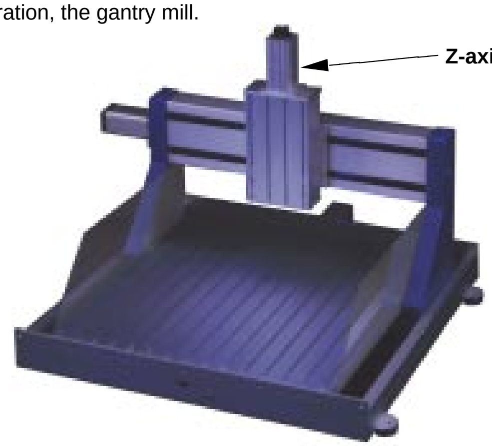
First, Boeing's designers create the plan, then the rest of the company works on the challenge of bringing their vision to life.

For example, Boeing decided the way to make the strongest possible wing spars (the internal structure of the wing) and wing skins (the outer surface) was to do each as a continuous piece. This design can withstand constant stress better than many previous ones. Traditionally, wing spars and wing skins have been manufactured in many small parts and then assembled. Every attachment point has a possibility of fatigue and failure that is higher than the rest of the structure.

In theory, wing spars and wing skins made in one continuous piece sound great, but they are two of the largest parts on some of the largest airplanes built today. They require raw blanks of metal measuring up to 105 feet by 21 feet. That's a lot of aluminum! To get a perspective on the size of blank needed, a college basketball court is 90 feet long and 50 feet wide.

To compound the difficulty, spars and skins are also highly sculptured 3-D surfaces requiring precision tolerances. The solution to the problem of accurately machining these huge pieces of raw material took some innovative thinking and resulted in one of the world's largest Computer Numeric Control (CNC) machines.

A standard CNC mill has a fixed length arm extending over a table. The table can move the stock in two directions, referred to as the X- and Y- axes. To cut a wing skin, the spindle would have to hang over 12 feet from the column, losing precision and strength. Boeing's answer was to build a completely different CNC mill configuration, the gantry mill.



A gantry mill from Techno-isel. Note that the Z-axis is supported by both sides, thus eliminating the problem of deflection due to large countilevered overhangs found on standard CNC mills

Boeing contracted Ingersoll Rand to build these gantry machines. Instead of one vertical column supporting the spindle and cutter, there are two on the gantry. The spindle rides back and forth and up and down on the cross bar, and the whole gantry rides back and forth on rails embedded in the platform. The gantry's lack of vertical column gives it much more flexibility for cutting and fixturing various stock sizes. Gantry mills have long been a standard in industry for cutting large parts, but monsters of this scale had never been made. This design is so successful that 22 of these giant machines reside in Boeing's Auburn Valley plant alone.

Theory and design are exciting, important, and are often pushed to the forefront of manufacturing; yet the most important issue that drives manufacturing is the product itself. The finished part in hand generates the reward, and makes the whole process worth the effort. The goal of producing the best plane on the market drove the designers to make the specifications that forced a new manufacturing solution.

When this attitude is applied to educational projects, the results can be just as fruitful. Creation and ownership are two successful student motivations. Instructors are consistently successful in coaxing their students through long educational processes when the end result is viewed as desirable by the student.

Over 1500 secondary and postsecondary schools annually purchase tabletop CNC milling machines. Some schools have five or six machines. Why? Because students want to own what they design and produce. Many things that students can imagine and design are difficult or impossible to make manually. Computer-controlled machines can bring their ideas to reality. Teachers can effectively harness this tool to motivate students and drive many divergent curriculums.

What Are Schools Doing With CNC Milling Machines?

First, the student uses CAD to create the geometry for a design. Then they generate the toolpath and NC-Code for the CNC mill in the CAM software. Finally, when the NC-Code is communicated to the CNC Mill, the student's design is accurately cut out of an acrylic blank. Beyond providing simple aesthetic satisfaction, these activities expose students to high tech manufacturing job opportunities and are good practical problem-solving experiences. Each week, for example, students can concentrate on a different subject to make more sophisticated parts.

Mr. Pete Sorinson and his colleagues at Lake Washington HS, Kirkland, WA use their CNC machines in a number of different courses. CAD class uses it to produce the prototypes that are designed in the mechanical CAD curriculum. Designing and producing a part on a CNC machine gives real application experience for a mechanical CAD student. It is comparable to architectural CAD students building a balsa stick frame house.

The Technology Exposure class is given the challenge of making an assembly out of Legos that will perform a specific task. But the solution requires the design and production of a missing part. This part must interface with the standard Lego components. For this exercise, students work in teams to learn group dynamics and problem-solving.

Or consider Mr. Bob Koll, of Junita HS, Kirtland, WA. This year, he and his class were dissatisfied with the wheels provided in their CO_2 car kits, so they designed new wheels using CAD/CAM software. They cut the wheel pattern out of wax on the CNC mill and used a cold mold process to produce the wheels. They tried using plastics of different resiliencies to get the performance they wanted.

Students and instructors get excited with the possibility of producing commercial quality products on the CNC mill, and are creating articulations among marketing, CAD design, and technology classes for the purpose of establishing student companies to sell student creations. The CNC mill allows intricate items to be mass-produced from a single design.

How To Buy An Entry-Level CNC Milling Machine
So, your supervisor has given you the go-ahead to purchase a piece of CNC equipment. Of course, as the euphoria of the news wears off, you realize there are some serious questions that need answers.

First of all:
1. What are the educational objectives?
2. Will it meet the objectives?
3. Will it fit into the budget?

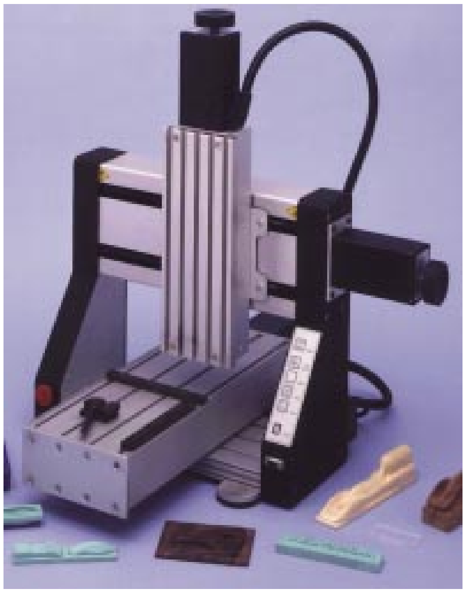
To help answer those questions, here are some things to consider: Is this to be a precision machining program or do you just want to explore the basics and integrate the curriculum with math and science?

1. Is the machine cast iron, aluminum, or polymer composite?
   Cast iron construction offers a higher level of rigidity and longer wear, but is heavy. Will you move the machine around a lot? If you will, consider aluminum, it is lighter and almost as rigid. The polymer composites are light, also.
2. Does it use industry standard ISO G&M codes?
   Fanuc® is currently industry standard in the US and many parts of the world.
3. Stepper or servos, what's the difference?
   The axis motor drive types on the market are called stepper and servos. Servos are more accurate than steppers and cost much more. The true servo system strength is that the system checks its position at each move against an independent measuring device, such as a glass scale. This is a closed loop system. Steppers are open loop systems executing a chain of commands without checking their position against an independent device. There is no question that servos are more accurate, however, steppers could be adequate, it depends on how repeatably accurate your final product needs to be.
4. Does it provide Unlimited Program Lengths through drip feed capability?
   Precision machining may call for more complicated, longer programs. Drip feed allows longer programs to be run.
5. How big is the work envelope?
   This is the total area that the mill can possibly cut. Perhaps a more accurate definition could be the largest possible part that could be cut. Is it big enough to accommodate the work you envision? Many small CNC machines boast Y-axis travels of 4+ inches, when in reality it is much less if a vice or stock over 2" high is used. If you want to use clamps, t-nuts, vices, fixtures, vacuum tables, etc., make certain they fit in the work area.
6. What is the axis feed rate?
   Feed rate is how fast a machine can move while cutting stock. High feed rates might be crucial to the success of your program, as the production schedule usually must fit into a 50 minute class period. For example, the Techno DaVinci's maximum machining feed rate is 140 IPM (inches per minute), while some small CNC mill's maximum machining feed rates are in the 16-30 IPM range. You need to determine how long it will take to mill the pieces you plan to make. If a CO_2 car body takes 15-20 minutes to machine at 80 IPM; at 16 IPM, one car could take well over a class period to complete. How many students do you have?
7. How about spindle speed?
   For nonferrous metals, wood plastics, and prototype material, high spindle speeds are recommended. Without high spindle speeds on soft materials, the flutes on the endmills will load up with stock and ruin the part. The only way to avoid gumming up the cutters in soft materials at low spindle rpm is to lower the feed rate. Is that a problem? See #6 above to determine if it is.

Something simpler?
If you are planning an exploratory program into CNC technology, the questions you need to ask are somewhat different:

1. Are there easy-to-use and complete curriculums available?
   The curriculum needs to be something you and your students feel comfortable with and that will meet sound educational objectives. Does it integrate math, science and technology concepts? Are the suggested activities engaging to students? It might be a good idea to recruit some student evaluators for this part.
2. Is the machine easy-to-use? Does it have a "Machine Hard Home"? Does it require additional interface cards to be installed or is it a direct RS-232 connection?
   A machine that does all this will be easier for the instructor to supervise. Part offsets can be saved as files and recalled quickly when the machine is turned on. This will save valuable "on-task" time for students and instructors. Besides, that's how it works in industry. Additional cards that have to be installed in the computer limit the flexibility of being able to use other computers to drive the mill.
3. Are limit switches on each axis for greater safety and control? Is it fully enclosed with an interlocking guard? Is it well lighted? Can you see the work in progress and still be protected?
   Obviously, safety for the operator and for the machine are important features.

Don't forget the computer program
One final note: the CAM system should be full 3-D and include full 3-D CAD functionality. It should be an educational and industrial standard, so that support is available from other teachers and book publishers. Carefully examine the CAM package. It is the interface to the machine. Remember, the machine can only run what is sent to it, and that the students will spend more time on the CAM package than any other component of the system. Finally, while selecting your program's CNC mill, make sure to talk to another teacher who is using that specific machine and find out what works and what doesn't in his or her program. If you are having trouble finding a teacher using the mills you are considering, ask the manufacturer for schools that use their product.



Boeing's solution on a smaller scale is reflected in the design of Techno-isel's tabletop gantry milling machine

CO_2 Racer Sparks Students' Interest
And Smokes The Competition at Nationals

Educators and school administrators are constantly challenged by students who have "been there, done that." Revitalizing the classroom so that kids are invigorated by learning and enthusiastic about coming to school requires fresh ideas and creative approaches to teaching. The emphasis should be on providing educational tools to motivate, inspire, and focus on teaching skills rather than simply teaching the student how to use the tool itself.

Middle and high school technology education programs have turned to the IMS CO_2 System from Techno (also known as the DaVinci CO_2 System) to ignite the spark of interest in the classroom. This unique system allows students to quickly, easily, and inexpensively design and produce finely machined CO_2 metric 500 racing cars that meet the specifications for Technology Scholastic Association (TSA) competition.

The idea for the DaVinci CO_2 System came to Richard Wong in 1995, when South Florida technology educators approached him about how to best use their newly acquired CNC machines in the classroom. The teachers were hoping for a brand new project that could be used on this cutting-edge technology to excite and motivate students about learning CAD/CAM and design. Wong saw an opportunity to replace the difficult and frustrating task of hand carving CO_2 race cars using a combination of CAD design, CAM toolpath generation, and CNC machining. He devised a kit, incorporating specially fitted hardware, interface software, instructional videos and fabrication templates, that simplified the design and manufacture of CO_2 cars on the fastest of the CNC machines, the Techno DaVinci. Students could now produce better cars in much less time, with none of the frustrating and tedious hand carving.

The CO_2 car kit is sold as part of the DaVinci CO_2 System, which also includes the Mastercam CAD/CAM software and the Techno DaVinci three-axis machine that is used for fabricating the cars. The entire system can be purchased from Techno for under $9,600. The wheel kit, which is optional, can be ordered with the system or separately.

Instructors using the DaVinci CO_2 System report that students find the Techno CO_2 car and wheel kit systems simple to learn and use. They work through the steps on their own, or with each other, in small groups, using the instructional videos as their guide. The teacher is free to facilitate independent learning

Carlos Ramos (Thomas Jefferson HS, Miami, FL) winner of the 1996 TSA National CO_2 Race Car Contest. Car built with the Techno System.

and peer instruction, encouraging their students' interest in discovery and their enjoyment of learning. The students concentrate on learning about CAD, CAM, CNC machining and aerodynamic design, rather than spending hours on hand carving.

On their PC's, students use the 3D Mastercam software to draw the cross sections of their design within the work zones and generate the toolpath of their car. Using the Techno Mastercam interface software to direct the DaVinci machine, they drill the holes for the wheels, then route the first side of the car. When the car is flipped over in the special clamping hardware, it is already perfectly aligned for routing the second side. When routing is complete, the car is cut from the blank and painted, and the wheels are mounted. Because it takes less than one hour to complete a car, students are motivated to experiment with different styles and materials. According to Richard Wong, students get hooked on using the system in the hope of making "the fastest car in the world".

Before Hialeah High School (Florida) discovered the IMS CO_2 System from Techno, students in Ron Torres-Gatherer's technology education class used pencil and paper to design their metric 500 race cars, and then carved them by hand. Ron finds that, in line with his goals of developing critical thinking through problem solving, the Techno CO_2 system frees up time formerly spent on manual labor to learn design concepts and modern technological methods.

The hand carving was often a long and frustrating process for many students who were also frequently disappointed with the results of their efforts. With the DaVinci CO_2 System, every car has a smooth finish and is perfectly symmetrical whether hard or soft wood is used.

In Miami's Thomas Jefferson Middle School,

The Techno System is used in technology education to motivate students about learning CAD design, CAM toolpath generation and CNC machining.

where a traditional woodshop has been converted into a technology lab, the IMS CO_2 System from Techno has enabled two of William Baltazar's technology education students to place first and second in the TSA Nationals this June. In April, his students also took first and second place in the Florida TSA State Competition, and 12 of his students were among the 16 finalists in the Dade County Youth Fair Metric 500 Competition.

The CO_2 system was prototyped at this school and has been a focus of the technology education program there since the beginning of this year. Up to then, students at Thomas Jefferson were designing and carving their cars manually, but many of these youngsters lacked the manual skills or patience to finish the project. The DaVinci CO_2 system has allowed students to spend their time learning, and to finish the project successfully, providing positive reinforcement and encouragement.

Proud to boast about his two prize-winning students from Barbara Goleman Senior High, Tom Cummings gives much of the credit to the IMS CO_2 System from Techno. "The machinery and fixture used were of the highest quality. Every operation we performed worked simply, effectively, and accurately. The equipment proved to be very reliable," he says. One of Cummings' students took second place, and the other, a special education student, took fourth, in the 1996 Research and Design Competition at Florida's TSA State Leadership Conference. Both cars were designed and fabricated using the IMS CO_2 System from Techno.

According to Cummings, working with this new, dynamic system has provided many invaluable learning experiences, not all of which have been technology-related. He and his students have enjoyed using sophisticated industrial technology and, as he puts it, once they "began working with the software, it was captivating to the entire class". But, he says that "real life" skills such as brainstorming, working as part of a team, and sharing ideas, learned while using the system, have been as important as the acquired knowledge about how to design the cars, use the software, and operate the Techno CNC machine. To Cummings, the value of the CO_2 racing car project – from inception of design, through watching the cars being cut, to adding the wheels and finishing touches – lay in the process itself, rather that the product. With this system, students learn lifelong skills involving organization and follow-through on a project from its planning stages through execution and beyond, to competition.

Students and teachers, parents and families, and the technology industry itself have benefitted from the increased interest in practical applications of modern technology at the middle and high school level. The IMS CO_2 System from Techno has helped to energize students with a renewed passion for learning and a sense of caring and responsibility for outcomes and their own futures. Whether they design and make one CO_2 car or many, students are given the opportunity to learn about and use the exact same software and hardware that is being used in hundreds of industrial sites around the country. It is this opportunity that will give them the racer's edge, not only at the TSA Nationals, but at the starting gate of their adult lives as well.

Car blank before the finishing touch

Two of the winning cars; the body style varies with student's imagination