MICHIGAN SKILLS USA
AUTOMATED MANUFACTURING
CAD/CAM/CNC CONTEST 2005
LANSING, MICHIGAN

OVERVIEW
CAD/CAM/CNC is the technology of today and the future in U.S. manufacturing and productivity. To remain competitive, companies worldwide must be able to access and apply current and emerging technologies in the Design and Manufacturing process. With today's complex issues and problems, no one person can or will have all the answers, therefore making it beneficial to combine the resources and abilities of a team to resolve the problem. As workers in the field of Automated manufacturing, we have found success using the team approach and, in order to emulate industry as closely as possible, the AMC contest will be using the "team" concept.

You have the opportunity to demonstrate how successful businesses and educators apply these technologies. You have the opportunity to show the world what you are made of and what you can make. Be proud. Be professional. Be quality. Have fun and have a successful competition.

STATEMENT OF THE PROBLEM
You are the Automated Manufacturing CAD/CAM/CNC team, Precision Technology Incorporated. SKILLS USA AMC Incorporated (hereafter referred to as the Client) has come to you with the sketch of a part for an automotive brake assembly that they wish to have you prototype and manufacture.

The Client's problem is that each manufacturer/job shop produces the part differently. The end user is not happy with this non-uniformity. The part signatures are all different, the prices vary too much and the lead-time is unacceptable. Rapid prototyping and the ability to make engineering changes at any point of the process are critical. As the Client wishes to find the best shop to have his or her parts prototyped and manufactured, you will be competing for this lucrative contract with several other firms.

DIRECTIONS
Your assignment for this Client is to:

Stage 1
Build a prototype part from a dimensioned hand sketch. The Client will provide the prototype material. The Client requires that each stage of the CAD/CAM/CNC process be well documented, including CAD dimensioned print. After the prototype is cut and has passed internal quality control, it will be submitted to the Client's Quality Assurance Group. The Client has specified accuracy, finish, and the turn-around-time for the prototype to produce the prototype mode.

Stage 2
The Client will review the prototype and may require one or more changes. The Client and his customers require quick updates to product design throughout the development process. The Client will require you to produce two final production parts out of provided material. The Client has specified accuracy, finish, uniformity between parts and efficiency in part programming (minimum part run-time).

Your Engineering Project Manager has provided the base outline of the materials within this document to begin your planning and manufacturing process. Your success on this project is based upon the following criteria:

GUIDELINES

(a) Providing complete documentation of the design.
(b) Providing complete documentation of the process plan, tooling, setup, and CNC code.
(c) QA approval for engineering changes.
(d) Proper use of the technology for the preparation of product documentation, setups, design, and machining.
(e) Packaging the complete project with accompanying documentation in an orderly, professional presentation.
(f) Effective use of teamwork and using concepts of Group Technology in managing this product/project.
(g) Safety in the manufacturing process.
(h) Efficient use of time, materials, and resources.

QA AND DESIGN RESTRICTIONS

Specifications provided on drawing take precedence. If required accuracies are not specified on the drawing then the following are minimums.

- ✓ Hole locations =+/-.005"
- ✓ Hole Diameter =+/-.025" on finished holes
- ✓ Hole Depths =+/-.005"
- ✓ Pocket locations =+/-.0005"
- ✓ Angles = +/- 2º

TEAM GUIDELINES

(a) Your team is organized and documented for primary responsibilities and duties.
(b) There will be a team captain identified to report to the judges.
(c) Your breaks are based upon team decisions.
(d) Breaks are to be taken within individual work areas.
(e) Bathroom breaks are to be scheduled with either the Technical Committee or Judges. Only one member of a team is permitted to leave at a time.
(f) In the case of a software, hardware, or machine failure problem, the team leader will communicate any problem(s) to the judges so that the running time clock will be stopped for that team. In the case of a stopped time clock, all work will stop for all three team members until the problem is resolved.

PURPOSE

To evaluate each school's preparation of students for employment in the emerging arena of automated manufacturing and the team approach to the problem solving work environment. To recognize outstanding performance in the use of new work styles and technology by students and schools.

ELIGIBILITY

Open to active SKILLS USA members enrolled in programs with precision machining, automated manufacturing, or CAD/CAM or CNC as the occupational objective.

EQUIPMENT AND MATERIALS

(Supplied by the technical committee)

(a) Computers with CAD/CAM software upon advance request by Team.
(b) All necessary information and furnishings for judges and technical committee
(c) Stopwatches

(Supplied by contestants)

(a) Calculators
(b) Measuring Tools
(c) Safety Glasses
(d) Edge Finder
(e) Suitable computer(s) pre-loaded with CAD/CAM software.
(f) ProLight 1000 or TMC-1000 CNC Machine and computer with control software. Other machines may be acceptable, however, prior acceptance by the SKILLS USA Technical Committee will be required. For machines other than the ProLight 1000 or TMC-1000 there are three general considerations. 1) The rapid feed rate should not exceed 50 ipm, linear feed rate should not exceed 25 ipm. 2) No cutting tool of a larger diameter than the maximum size tool specified by the technical committee shall be used. 3) The machine should be able to accommodate the standard work holding fixture and raw material size specified by the Technical Committee.
(g) Tool holders and hand tools.
(h) All necessary cutting tools.
(i) All necessary part or fixture hold-down hardware

SCOPE OF THE CONTEST

Teams of three will demonstrate their ability to perform, exhibit, and compile skills and knowledge necessary from the following list of competencies determined by the SKILLS USA Technical Committee Members.

The team will make the necessary changes to the part program. Teams will be provided with a dimensioned hand sketch of a part to prototype. The team will hand in the finished part to the Client (Judges) and then the team may receive a change order. The team will make the necessary changes to the part program and produce two identical parts out of Ren Shape 450.

A. PERFORMING MATHEMATICAL AND MEASUREMENT CALCULATIONS

1. Measure work piece to the nearest .0001".
2. Calculate CNC speed and feeds.
3. Calculate stock utilization and setup.
4. Calculate tolerances.

B. DESIGNING, SKETCHING, PLANNING MACHINE WORK

1. Transfer information from provided sketch to CAD drawing.
2. Create CAD file for manufacturing.
3. Begin manufacturing documentation process.
4. Process plan.
5. Plot CAD file #1.
6. Export CAD file.
7. Process ECO (Engineering Change Order).

C. CREATE TOOLPATH (CAM FILE), CNC CODE

1. Create process plan (job plan).
2. Read in CAD export file.
3. Create toolpath.
4. Verify toolpath.
5. Create CNC code.
6. Send CNC code to machine tool.
7. Process engineering change order.

D. PERFORM CNC MACHINING FUNCTIONS

1. Verify CNC file existence.
2. Verify toolpath.
3. Setup part on mill.
4. Set all offsets and tooling.
5. Adjust speeds and feeds as needed.
6. In-process quality assurance.
7. Perform tool changes.
8. Perform multiple machining operations in one setup.
9. Verify (TQM) process and part.
10. Process engineering change order.

E. INSPECTION OF PART TQM PROCESS

1. Verify part to standards.
2. Verify part to engineering change order standards.
3. Document process.

GROUP ORGANIZATIONAL GOAL

This is a group competition and all members may interact at will. It is our hope that the competition will run much like industry. The CAD operation will construct the part geometry, the CAM operator will generate the toolpaths, and the CNC operator will do the setup and machine the part. We expect that when a group member has spare time, he or she will help others in the group.
It is our hope that one person will not dominate a team. We do not want one person doing the CAD drawing, the CAM tool path, and running the CNC machine while using the other members simply as support. We have taken this course to promote creativity in organization of production responsibility. All group members are responsible for double checking each other's work and quality control.

GENERAL INFORMATION

(a) CNC milling machines and tooling will be Light Machines ProLIGHT series or similar.
(b) Machines will be setup on April 23rd. Each team is responsible for making sure that the machine they use in competition is ready and working for the competition. The machines may be available for a short time before the contest begins on April 24th at 8:00 AM.
(c) Teams are encouraged to bring their own computers loaded with CAD and CAM software that they feel comfortable in using. Team may only use TWO computers at any given time during the competition.
(d) The Prototype and final parts will be machined in Ren Shape 450.

GOALS

1. Every team succeeds; finishes the process in the allotted time.
2. Eliminate all subjective evaluation if possible.
3. Produce accurate finished part.
4. Documentation for manufacturing the part.

NOTEBOOKS

Each Team will be issued a 3 ring binder specific to the competition. This binder will include a check-off sheet of required documents listed in order of suggested manufacturing process to help organize the students. These forms will not be highly specific, but will coach the student. There will also be plastic disk holders in the 3 ring binder for diskettes containing computer files.

SKILLS USA SUGGESTED AUTOMATED MANUFACTURING ORGANIZATIONAL FLOW

I. RECEIVE THE PART SKETCH

A. CAD operator confers with the CAM operator and only draws what is necessary for the CAM operator to program a tool path. Once that drawing is ready, with no dimensions necessary at this time, the CAD operator transfers the drawing to the CAM operator.
B. CAM operator, after consulting with the CAD operator, consults with CNC operator and fills out the Job Sequence Plan, defining machining order, tool paths, tool definitions and sequencing surface.
C. CNC operator squares up the vise and CNC operator confers with the CAM operator on tool definition and sequencing. CNC operator sets and mounts selected tools in holders and sets tool length offsets in the control. CNC operator then sketches the fixture.

II. CAD OPERATOR HANDS OFF FILE TO CAM

A. CAD operator copies CAM transfer file to diskette to be transferred to CAM operator, then begins work on documenting the part with all necessary views.
B. CAM operator transfers in CAD file and double checks against sketch. Cam operator begins programming tool paths and, if necessary, documents any changes to the Job Process Plan.
C. CNC operator helps either CAD or CAM operator, staying aware of CAM tool path sequencing and tool changes. CNC operator could also study part for most efficient tool paths.

III. TRANSFER OF NC-CODE TO CNC MACHINE

A. CAD operator continues to document part and prints a hard copy plot of the drawing.
B. CAM operator transfers NC code to CNC operator. CAM operator prints a hard copy of NC code and helps CAD operator in spare time.
C. CNC operator loads program, runs simulation, sets touch-off point, then runs the program.

IV. PROTOTYPE COMPLETE, QUALITY CONTROL

A. CAD/CAM/CNC operators inspect the part and fill out inspection sheet and each sign it. If errors are found, they are documented and part is handed in.

V. RECEIVE CHANGE ORDER

A. CAD operator continues documenting prototype and begins 3-D isometric pictorial.
B. CAM operator and CNC operator review change order and develop a new Job Process Plan reprogramming or editing tool paths and feed rates as deemed necessary.
C. CNC operator loads program, runs simulation, sets touch off point, and then runs the program.

VI. MANUFACTURE TWO IDENTICAL PARTS

A. CAD operator finishes up all part documentation and hard copies.
B. CAM operator assembles part documentation booklet and helps CAD and CAM operators.
C. CNC operator manufactures and inspects parts.

VII. QUALITY CONTROL AND FINAL HAND IN

A. CAD, CAM, and CNC operators, part inspection, documentation, organization and clean up.

SKILLS USA PROVIDED ITEMS AND MATERIALS

COMPETITION NOTEBOOK

1. Notebook
2. Cover sheet
3. Forms

HARDWARE

1. Printer/plotter
2. Diskettes

SOFTWARE PROGRAMS

1. Information will be made available upon request regarding software programs that may be used in contests. Typical software tools that are considered appropriate include, MasterCam, SpectraCam, SmartCam, SurfCam, AutoCad, AutoCadLT, AutoSketch and Cadkey. It is conceivable that other CAD and CAM software packages could be appropriate. Please contact a member of the Technical Committee for verification if you would like to use a program other than those listed here.

MATERIAL BLANKS

1. Rapid prototype - Ren Shape 450.
2. Automated part production -Ren Shape 450

AWARDS

DONATIONS

JUDGING

1. Stopwatches
2. Judging forms

EVALUATION

MAJOR CATEGORIES

1. CAD Documentation Notebook
2. CAM Documentation Notebook
3. CNC documentation Notebook
4. Stage 1, Rapid Prototype
5. Stage 2, Part Production (See Breakdown)

Part Production Breakdown

1. Contest Finish Time
2. Surface Finish
3. Dimensional Accuracy

SURFACE FINISH RUN-TIME DILEMMA

At what point is surface finish sacrificed for better run-time? This may very well separate first place from second place. If consideration is given to the above point weighing for surface finish, the only choice is not to sacrifice surface finish for a better part run-time, but rather use more efficient tool path techniques to bring your part run-time down.

Some standard errors that points will be deducted for include chatter marks, ledges, scallops, waste stock left, burn divots, surface roughness, scratches, pocket floor roughness and dents. *Even though the material provided is soft and easy to work with, you are encouraged to control your machine speeds and feed rates to reduce chipping of the material and other surface defects.*

SAFETY

Proper safety practices are vital in all stages of this competition. Points will be deducted for unsafe practices in the work area. This includes the wearing of safety glasses by any team member who is in the work area of a running CNC machine.

JUDGING SEQUENCE

Stage 1, Rapid Prototype

1. Judge-record part hand in time.
2. Judge dimensional accuracy.
3. Judge surface finish.

Stage 2, Part Production

1. Judge-record part hand in time.
2. Judge dimensional accuracy.
3. Judge surface finish.
4. Judge documentation notebooks, all items included neat, well organized, and correct. All documentation is due at the end of the competition except the Prototype Quality Assurance form that will be handed in with the prototype.

JUDGING UNIFORMITY

One judge judges **all entries** in one category, another judge judges all CAD notebooks, another judge judges final parts, so that individual judge's standards are reflected uniformly, etc.

RAPID PROTOTYPE
PROCESS PLAN FORM

Team Letter_____ Customer__SKILLS USA_____

Date_____ Part Due Date_____

Part Description_____

File Name_____ Units_____ CNC Machine_____

Blank Size_____ Material_____

Operation #	Operation Description	Tool #	Tool Description	Spindle Speed	Feed Rate	Plunge

NOTES:

PART PRODUCTION
PROCESS PLAN FORM

Team Letter_____ Customer__SKILLS USA_____

Date_____ Part Due Date_____

Part Description_____

File Name_____ Units_____ CNC Machine_____

Blank Size_____ Material_____

Operation #	Operation Description	Tool #	Tool Description	Spindle Speed	Feed Rate	Plunge

NOTES:

SKILLS USA FIXTURING DESCRIPTION FORM

Team Letter_____ Customer__SKILLS USA_____

Date_____ Part Due Date_____

Part Description_____

_____

Sketch part in fixture (rough isometric view) with tool touch-off point indicated.

RAPID PROTOTYPE
QUALITY ASSURANCE FORM

Team Letter_____ Customer_SKILLS USA_____
Date_____ Part Due Date_____
Part Description_____
File Name_____ Units_____ CNC
Machine_____
Blank Size_____
Material_____

Object #	Object Description	Defined Tolerance	Met Tolerance		Amount Off	Finish Errors	
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			

PART PRODUCTION
QUALITY ASSURANCE FORM

Team Letter_____ Customer__SKILLS USA_____

Date_____ Part Due Date_____

Part Description_____

File Name_____ Units_____ CNC Machine_____

Blank Size_____ Material_____

Object #	Object Description	Defined Tolerance	Met Tolerance		Amount Off	Finish Errors	
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			
			Yes	No			

NOTES:

SKILLS USA AMC NOTEBOOK
CHECK OFF LIST

CAD

STAGE 1, RAPID PROTOTYPE
1. CAD to CAM file (.dxf) on disk.
2. Dimensioned isometric and plan view of prototype, hard copy.
3. Dimensioned isometric and plan view of prototype, on disk.

CAM

STAGE 1, RAPID PROTOTYPE
1. Process plan form, prototype. (Page 9)
2. NC code, hard copy.
3. NC code, file on disk.

STAGE 2, PART PRODUCTION
4. Change order.
5. Process plan form. (Page 10)
6. NC code, hard copy.

CNC

STAGE 1, RAPID PROTOTYPE
1. Fixturing description form. (Page 11)
2. Quality control form with team member signatures. (Page 12)
3. Prototype part.

STAGE 2, PART PRODUCTION
4. Two manufactured parts per change order.
5. Part run-time form.
6. Quality assurance form with team member signatures. (Page 13)

SKILLS USA JUDGING FORM
Rapid Prototype Hand-In Time

Team #_____ **Judge #_____**

Hand-In Time_____ **Rank Order_____**

POINTS WILL BE AWARDED AS FOLLOWS:

The first prototype handed in that has a reasonable finish and looks to be dimensionally accurate with no gross errors will receive 100 points.

Each successive team handing in a prototype, provided the prototype meets reasonable finish with no gross errors, will receive points as follows:

1st Team	=	100 pts
2nd Team	=	75 pts
3rd Team	=	50 pts
4th Team	=	25 pts
5th Team	=	20 pts
6th Team	=	15 pts
7th Team	=	10 pts
8th Team	=	8 pts

All other teams turning in a part will receive 4 pts

Teams not handing in prototypes will receive 0 points. All teams handing in prototypes after 9th Team receive 1 point.

Possible Points: 100 **Total Points_____**

SKILLS USA JUDGING FORM
Part Production Hand-In Time

Team Letter_____ **Judge #**_____

Hand-In Time_____ **Rank Order**_____

POINTS WILL BE AWARDED AS FOLLOWS:

The first part handed in without gross errors will receive full points. Teams will lose two points per place they finish, see below:

1st Team	=	100 pts
2nd Team	=	75 pts
3rd Team	=	50 pts
4th Team	=	25 pts
5th Team	=	20 pts
6th Team	=	15 pts
7th Team	=	10 pts
8th Team	=	8 pts

All other teams turning in a part will receive 4 pts

Teams not handing in prototypes will receive 0 points. All teams handing in prototypes after 9th Team receive 1 point.

Possible Points: 100 **Total Points:**_____

SKILLS USA JUDGING FORM

Part Production Dimensional Accuracy & Surface Finish

Team #________________ **Judge#**______________________

QA AND DESIGN RESTRICTIONS

1) Hole locations =+/-.005"
2) Hole diameter =+/-.0025"
3) Hole depths =+/-.10"
4) Slot and Shoulder loc. =+/-.010"
5) Angles = +/- 2º
6) ***Tolerances stated on drawing always take precedence*.**

Any team outside of stated tolerance will lose all points for that item.

Item	**Description**	**Error Description**	**Points Deducted**	**Points Awarded**		
				1	**2**	**3**
			ACCURACY TOTALS			

Identify errors on print with the item number and an arrow pointing to the position.

Possible Points: 1,875

SKILLS USA JUDGING FORM (for notebook)

CAD

Team#

STAGE 1, RAPID PROTOTYPE

	Possible	
1. CAD to CAM file on disk (e.g. .dxf file or similar)	10	
2. Dimensioned orthographic & isometric of prototype - hardcopy	180	
3. Dimensioned orthographic & isometric of prototype on disk	10	
CAD Subtotal	**200**	

CAM

STAGE 1, RAPID PROTOTYPE

1. Process Plan form, prototype (Page 8)	10	
2. NC-Code, hard copy	10	
3. NC-Code, file on disk	10	

STAGE 2, PART PRODUCTION

4. Change Order (Handed out at competition)	1	
5. Process Plan Form (Page 9)	10	
6. Revised NC-Code, hardcopy	5	
CAM Subtotal	**16**	

CNC

STAGE 1, RAPID PROTOTYPE

1. Fixturing Description Form	50	
2. Quality Control Form	50	
3. Prototype Part (Handed in to judges)	4	

STAGE 2, PART PRODUCTION

4. Two manufactured parts per change order	10	
5. Quality Assurance Form	50	
CNC Subtotal	**165**	
Total Points for Notebook	**381**	

SKILLS USA JUDGING FORM
Point Tally

Team #_____ **Judge #**_____

	Points Earned	Max. Possible
1.**RAPID PROTOTYPE**		
A. Hand-in time	____	100 pts
B. Dimensional accuracy	____	625 pts
C. Surface finish	____	30 pts
SUBTOTAL_____		
2.**PART PRODUCTION (Two Parts)**		
A. Hand-in time (First production part only)	____	100 pts
B. Dimensional accuracy	____	1250 pts
C. Surface finishes	____	60 pts
SUBTOTAL_____		
3.**DOCUMENTATION NOTEBOOKS (From preceding page)**		
A. CAD	____	200 pts
B. CAM	____	16 pts
C. CNC	____	165 pts
SUBTOTAL_____		

Total Points _____

Possible Points: 2,546