

# MICHIGAN SKILLS USA AUTOMATED MANUFACTURING CAD/CAM/CNC CONTEST 2009 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 a pressure pad assembly used on aircraft 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 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.

- ✓ Two place decimal dimensions = +/- .010"
- ✓ Three place decimal dimensions = +/- .005"
- ✓ Angles = +/- 1°

## **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) Competition drawing
- (b) Competition booklet and 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) Super ProLight 1000, 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. 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 engineering change order if requested by judges.

### **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 if requested by judges.

### **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 if requested by judges.

### **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 Intelitek Super ProLIGHT series or similar as used in the national competition.
- (b) Machines will be setup on April 24th. 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 25th 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.
- (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.

# **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 (If judges request one.)**

- 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
4. Competition part drawing.

## **HARDWARE**

1. Printer/plotter from the community college will be available for shared, group use.

## **REGARDING 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, etc. 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, chipped edges 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.*

*There is no guarantee that the raw material provided is square and true on all six sides. It is highly recommended that you include a surfacing pass on the top portion of your block before machining the actual part.*

**The prototyping material is RenShape 450. Its cutting specifications are .004” per tooth and 300ft. per minute surface speed. Material chipping will be judged as surface finish errors. Control your speeds and feeds accordingly.**

## 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 or Number \_\_\_\_\_ 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 or Number \_\_\_\_\_ 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 or Number \_\_\_\_\_ Customer SKILLS USA \_\_\_\_\_

Date \_\_\_\_\_ Part Due Date \_\_\_\_\_

Part Description \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

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



# PART PRODUCTION QUALITY ASSURANCE FORM

Team Letter or Number \_\_\_\_\_ 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			

**NOTES:**

# SKILLS USA AMC NOTEBOOK

## CHECK OFF LIST

### CAD

#### STAGE 1, RAPID PROTOTYPE

1. CAD to CAM file (example: .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 10)
2. NC code, hard copy.

#### STAGE 2, PART PRODUCTION

4. Change order.
5. Process plan form. (Page 11)
6. NC code, hard copy.

---

### CNC

#### STAGE 1, RAPID PROTOTYPE

1. Fixturing description form. (Page 12)
2. Quality control form with team member signatures. (Page 13)
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 14)

# 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	=	100 pts
3rd Team	=	100 pts
4th Team	=	75 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

## Production Part 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 be awarded points per place they finish, see below:

1st Team	=	100 pts
2nd Team	=	100 pts
3rd Team	=	100 pts
4th Team	=	75 pts
5th Team	=	25 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 (for notebook)

## CAD

Team#

### STAGE 1, RAPID PROTOTYPE

Possible

1. Dimensioned orthographic & isometric of prototype - hardcopy

	200	
<b>CAD Subtotal</b>	<b>200</b>	

## CAM

### STAGE 1, RAPID PROTOTYPE

1. Process Plan form, prototype (Page 10)
2. NC-Code, hard copy

	20	
	10	

### STAGE 2, PRODUCTION PART

3. Process Plan Form (Page 11)

	20	
<b>CAM Subtotal</b>	<b>50</b>	

## CNC

### STAGE 1, RAPID PROTOTYPE

1. Fixturing Description Form
2. Quality Assurance Form (Page 13)

	50	
	50	

### STAGE 2, PART PRODUCTION

3. Quality Assurance Form (Page 14)

	50	
<b>CNC Subtotal</b>	<b>150</b>	
<b>Total Points for Notebook</b>	<b>400</b>	

# SKILLS USA JUDGING FORM

## Point Tally

Team # \_\_\_\_\_

Judge # \_\_\_\_\_

	Points <u>Earned</u>	Max. <u>Possible</u>
<b>1. RAPID PROTOTYPE</b>		
A. Hand-in time	_____	100 pts
B. Dimensional accuracy	_____	260 pts
C. Surface finish	_____	30 pts
SUBTOTAL _____		

<b>2. PART PRODUCTION (Two Parts)</b>		
A. Hand-in time (First production part only)	_____	100 pts
B. Dimensional accuracy	_____	520 pts
C. Surface finishes	_____	60 pts
SUBTOTAL _____		

<b>3. DOCUMENTATION NOTEBOOKS (From preceding page)</b>		
A. CAD	_____	200 pts
B. CAM	_____	50 pts
C. CNC	_____	150 pts
SUBTOTAL _____		

**Total Points** \_\_\_\_\_

**Possible Points: 1,470**