



TECHNICAL DESCRIPTION

CNC Milling



1. INTRODUCTION

1.1 Name and description of skill

1.1.1 The name of the skill is [CNC Milling](#).

Description of skill

[CNC Milling](#) covers the processing of work-pieces through metal cutting with "Computer Numerical Control" (CNC) milling machines. The abbreviation (CNC) refers to a computer ("control") that reads instructions ("G-code") and drives the machine tool, a powered mechanical device ("milling machine"), used to fabricate components by the selective removal of material. The (G-code) is created with the use of a Cam system by drawing the part and selecting the process and tooling. With the increased automation of manufacturing process with CNC machining there have been considerable improvements in consistency and quality achieved. CNC also allows for flexibility in the way parts are held in the manufacturing process and the time required changing and making new set-ups.

1.2 Scope of application

1.2.1 Every expert and competitor must know this Technical Description.

1.2.2 In the event of any conflict within the different languages of the Technical Descriptions, the English version takes precedence.

1.3 Associated documents

1.3.1 As this Technical Description contains only skill-specific information it must be used in association with the following:
WSI - Competition Rules
WSI - Competition Manual
WSI - Online resources as indicated in this document
Host Country - Health and Safety regulations

2. COMPETENCY AND SCOPE OF WORK

The competition is a demonstration and assessment of the competencies associated with this skill. The Test Project consists of practical work only.

[The Test Projects for the Competition](#) covers practical work to be done on one Vertical machining centre using a commercial CAM system that is known throughout the world.

[Work pieces shall be worked on two or three faces.](#)

[Programming shall be carried out with MASTERCAM, version 10.](#)

[The programming software of the machines \(such as Fanuc, Siemens, Heidenhain\) must be carried out on a commercially available CAM Control system known throughout the world.](#)

2.1 Competency specification

Instruction

[Notions about:](#)

- Quality Standards
- Standards for the environment, safety, hygiene and prevention at work
- Computer operating systems

Knowledge of:

- Mathematics – calculation and geometry
- Metrology
- Properties and behaviour of materials

Deep knowledge of:

- Technical design and process planning
- CNC equipment technology
- CAM system programming ability
- Cutting technology according to the cutting parameters, the material, the equipment and the cutting tools

Execution Skills

- Interpretation of drawings, standards, tables and other technical specifications
- Selection and use of measuring tools and checking instruments
- Selection of types and systems of fixing pieces for the operational requirements
- Selection of the cutting tools, adequate to the materials and the required level of machining
- Use of the processes for mounting the tools and accessories on the CNC milling machine
- Identification and designation of the different machining operations on CNC milling machine
- Identification and designation of functional parameters for operations on CNC milling machine
- Definition of cutting parameters as a function of the operational sequence, material type, type of operation and CNC machine tool
- Use of the different programming techniques for CNC milling machine (CAM included)

2.2 Theoretical knowledge

2.2.1 Theoretical / underpinning knowledge is required but not tested explicitly.

- Professional interpretation of drawings.
- CAM knowledge, MASTERCAM and knowledge of CNC programming.
- Knowledge of the materials used and their machining properties.
- Knowledge and usage of setting tools, measuring tools.
- Knowledge of International systems or norms for the metal machining branches.

2.2.2 Knowledge of rules and regulations is not examined.

2.3 Practical work

The Competitor must carry out the following work independently:

- Creation of the CNC programs based on drawings with the use of a CAM system
- Any optimisation work and program changes may also be made using the machine.
- Program data is transferred to the machine using the DNC of the CAM system.

The Experts decide at the Competition, whether, none, one or all of the modules should be read into the programming system directly. All Competitors are bound by the same conditions.

Competitors must select and mount the tools for machining themselves. Tooling offset

measurements are performed on the tool setter provided for this purpose during the time allowed for this work. All data of the machining tools must be entered manually into the tool carrier of the CNC machine (tool offset).

The program must be optimised and corrected by the Competitor independently.

3. THE TEST PROJECT

3.1 Format / structure of the Test Project

The Test Project will comprise three separately assessed modules.

3.2 Test Project design requirements

Details of Module 1 MILLING

Initial Data	<ul style="list-style-type: none"> . Material: Aluminium AlMgSi1 3.2315. . Raw Size: 100x100x50 . Time Allowed: 4.15 hrs . 2D Finished Drawing with a 3D Shaded view (paper) . Work on 2(two) Faces 	
Machining Process	<p>The following features must be Included: Milling Channels, figurative pocket, external contour, through hole boring, internal or external thread milling</p>	<p>The following features may be Included (optional): Circular pocket, rectangular pocket, Drilling, Reaming & Tapping</p>
Additional Information	<ul style="list-style-type: none"> . The total of aspects for criterion <u>A-Main dimensions</u> must be between 20min.-23max. . The total of aspects for criterion <u>B-Secondary dimensions</u> must be between 17min.-20max. (the remain dimensions are assessed in criterion D - conformity to drawing) . The total aspects for criterion <u>C-surface quality</u> must be between 5min. - 8max. (must be possible to check all aspect with Surface roughness tester similar to Mitutoyo - 178-954-3A) 	
Tasks schedule	Part Programming CAM Activity (1.30 h) <i>Note: Around 10min project Studying included</i>	Machining Tool Preparation (15 min) Machining (2.30 h)

Details of Module 2 MILLING

Initial Data	<ul style="list-style-type: none"> . Material: Steel Ck 45 1.1191 . Raw Size: 100x150x50 . Time Allowed: 6.15 hrs . 2D Finished Drawing with a 3D Shaded view (paper) . Work on 2(two) Faces 	
Machining Process	<p>The following features must be Included: Milling channels, figurative pocket, external contour, through hole boring, nose, circular pocket, internal thread milling, reaming</p>	<p>The following features may be Included (optional): Rectangular pocket, drilling sample, island milling, tapping</p>
Additional Information	<ul style="list-style-type: none"> . The total of aspects for criterion <u>A-Main dimensions</u> must be between 25min.-28max. . The total of aspects for criterion <u>B-Secondary dimensions</u> must be between 20min.-23max. (the remain dimensions are assessed in criterion D - conformity to drawing) . The total aspects for criterion <u>C-surface quality</u> must be between 5min. - 8max. (must be possible to check all aspect with Surface roughness tester similar to Mitutoyo - 178-954-3A) 	
Tasks schedule	Part Programming CAM Activity (2.30 h) <i>Note: Around 10min project Studying included</i>	Machining Tool Preparation (15 min) Machining (3.30 h)

Details of Module 3 MILLING

Initial Data	<ul style="list-style-type: none"> . Material: Steel Ck 45 1.1191 . Raw Size: 100x150x50 . Time Allowed: 7.30 hrs . 2D Finished Drawing with a 3D Shaded view (paper) . Work on 3(three) Faces 	
Machining Operations	<p>The following features must be Included: Drilling, blind hole boring, external contour, figurative pocket, island milling, external thread milling, tapping, Ribs (**)</p>	<p>The following features may be Included (optional): Circular pocket, rectangular pocket, gudgeon.</p>
Additional Information	<ul style="list-style-type: none"> . The total of aspects for criterion A-Main dimensions must be between 30min.-33max. . The total of aspects for criterion B-Secondary dimensions must be between 20min.-23max. (the remain dimensions are assessed in criterion D - conformity to drawing) . The total aspects for criterion C-surface quality must be between 5min. - 8max. (must be possible to check all aspect with Surface roughness tester similar to Mitutoyo - 178-954-3A) <p>(**) Rib feature: Thickness=<8mm; 1 or 2 ribs maximum</p>	
Tasks schedule	<p>Part Programming</p> <p>CAM Activity (3 h)</p> <p><i>Note: Around 10min project Studying included</i></p>	<p>Machining</p> <p>Tool Preparation (15 min)</p> <p>Machining (4.15 h)</p>

Additional details for the modules

- The following additional details must be included in the module: machine chamfers 0.2 to 0.3 mm x 45 degrees
- It must be possible to complete the modules with the machining tools detailed in the Technical Description.
- It must be possible to check the Modules with the measuring equipment and checking devices described in the Technical Description.
- Measurements of work pieces will be performed on a co-ordinate measuring machine.
- The Organising Committee of the host country will nominate a technician who will be responsible for operating the coordinate measuring machine.

Tolerances

The following tolerances apply to the Modules:

- Main dimensions: range from 0.02 to 0.04 mm, IT₇≥7
- Reamed bores IT7
- Hollow out bores IT7
- General tolerances +/- 0.1
- Surface quality N6 to N8 / root mean square average = Ra 0.8 to 3.2
- Depth of thread 0+2 mm
- Depth of bore 0+0.5 mm
- Form and positional tolerances as per DIN ISO 1101

3.3 Test Project development

Test Projects MUST be submitted using the templates provided by WorldSkills International (<http://www.worldskills.org/competitionpreparation>). Use the Word template for text documents and DWG template for drawings.

3.3.1 Who develops the Test Project

The Test Project is developed as a joint effort by all Experts.

3.3.2 How (and where) is the Test Project developed

The Test Project is developed independently by each expert, 1 module as per the Chief experts decision

Task for Experts

Each Expert must bring one complete module to the Competition. This module must meet the following requirements:

- Drawing ISO E, Autocad & Inventor (*)
- Drawing ISO A, Autocad & Inventor (*)
- Inventor solid file (*) and an IGES or STEP file (3D surface and wireframe model)
- Component model made from the material to be used for the module (conform to drawing) and a measurement report
- Subjective and Objective Marking forms in the format MS Excel in one of the three official languages
- 4 paper copies of the module (no copies and printouts can be printed at the competition site)
- The modules must be created with filename conventions (including filename extensions) as module example sent by the chief expert 6 months before the competition.
- All CDs or Memory stick must be labelled.
- Modules not meeting these requirements shall not be used for the rest of the competition.
- Experts who do not bring a module to the Competition will be excluded from further work on the modules. These Experts will assist the Chief Expert in different skill-related/organisational tasks that will be decided on the spot.
- Before the Competition, the modules must NOT be accessible to the Competitors.

(*) The version will be determined 6 months before the competition

3.3.3 When is the Test Project developed

Test Project module proposals are prepared by Experts before Competition and brought to the competition for selection:

. Six months before the chief expert will organize the countries by groups (one group for each module) for the test project development. Each participating country will be asked to develop one module as described in this document

3.4 Test Project marking scheme

Each Test Project must be accompanied by a marking scheme proposal based on the assessment criteria defined in Section 5.

3.4.1 The marking scheme proposal is developed by the person(s) developing the Test Project. The detailed and final marking scheme is developed and agreed by all Experts at the Competition.

3.4.2 Marking schemes should be entered into the CIS prior to the Competition.

3.5 Test Project validation

The Test Project module must comply to the project design requirements as is detailed in Paragraph 3.2 and 3.3 The Expert must also supply a component model made from the material to be used for the module when submitting the Test Project module proposal. These projects will be confirmed by a committee of experts.

3.6 Test Project selection

The Test Project is selected as follows: By vote of Experts at the current Competition.

Module presentation before the Competition

The modules brought by the Experts will be presented by the Experts themselves. The modules will be checked for completeness and for compliance with the project design criteria during the Experts' first working day. Modules that do not meet the design requirements under paragraph 3.2 and 3.3 will be excluded.

All Experts have 15 minutes to study the different proposals, followed by the secret vote. The project with the most votes will be chosen.

In the event of a tie, the other projects are eliminated and a new vote between the tied projects takes place. If by any chance, there is still a tie between 2 or more projects, the final selection is made by ballot, which will then settle the vote.

Completion of the final modules by the Experts before the Competition

Development of the module on the basis of the design criteria in paragraph 3.2 and 3.3 with due consideration of machining criteria, the material quality, the methods of machining and the working time.

3.7 Test Project circulation

The Test Project is circulated as follows: Not circulated.

3.8 Test Project coordination (preparation for Competition)

Coordination of the Test Project will be undertaken by the Chief Expert and Deputy Chief Expert.

3.9 Test Project change at the Competition

Not applicable.

3.10 Material or manufacturer specifications

The Host Country undertakes to provide information on the following twelve months before the Competition as per the Competition Rules:

- The machines
- The machine control systems
- The tool holders (e.g. Sk40 DIN 69871, BT 40)
- Release bolts for the tool holders
- Machine vice
- CAM programming station, software version, PC keyboard
- Machine control Training software
- Possibility of practicing operating the machines intended for the Competition

4. SKILL MANAGEMENT AND COMMUNICATION

4.1 Discussion Forum

Prior to the Competition, all discussion, communication, collaboration and decision making regarding the skill must take place on the skill-specific Discussion Forum (<http://www.worldskills.org/forums>). All skill-related decisions and communication are only valid if they take place on the forum. The Chief Expert (or an Expert nominated by the Chief Expert) will be moderator for this forum. Refer to Competition Rules for the timeline of communication and competition development requirements.

4.2 Competitor information

All information for registered Competitors is available from the Competitor Centre (<http://www.worldskills.org/competitorcentre>).

This information includes:

Competition Rules
 Technical Descriptions
 Test Projects
 Other Competition-related information

4.3 Test Projects

Circulated Test Projects will be available from [worldskills.org](http://www.worldskills.org) (<http://www.worldskills.org/testprojects>) and the Competitor Centre (<http://www.worldskills.org/competitorcentre>).

4.4 Day-to-day management

The day-to-day management is defined in the Skill Management Plan that is created by the Skill Management Team led by the Chief Expert. The Skill Management Team comprises the Jury President, Chief Expert and Deputy Chief Expert. The Skill Management Plan is progressively developed in the six months prior to the Competition and finalised at the Competition (agreed by Experts and submitted to the Chair/Vice Chair of the Technical Committee). The Chief Expert is to regularly share updates of the Skill Management Plan via the Forum.

5. ASSESSMENT

This section describes how the Experts will assess the Test Projects. It also specifies all processes, procedures and requirements for marking.

5.1 Assessment criteria

This section defines the assessment criteria and the number of marks (subjective and objective) awarded. The total number of marks for all assessment criteria must be 100.

Section	Criterion	Marks		
		Subjective (if applicable)	Objective	Total
A	Main dimensions		54	54
B	Secondary dimensions		21	21
C	Surface quality		9	9
D	Conformity with drawing	10		10
E	No additional material used		6	6
Total		10	90	100

5.2 Subjective marking

Scores are awarded on a scale of 1 to 10 – with 10 for the highest mark and 1 for the lowest.

5.3 Skill assessment specification

A – Main dimensions

Dimensions range from 0.02 to 0.04; Reamed bores: IT7; Hollow out bores: IT7; inside thread and outside thread: IT6

Form and positional tolerances as per DIN ISO 1101

B – Secondary dimensions

Dimensions with general tolerance +/- 0.1; depth of thread: 0/+2mm; depth of bore: 0/+0.5mm; radius: +/- 0.2; angle: +/-0.5°

C – Surface quality

Surface quality N6 to N8 root means square average = Ra 0.8 to 3.2

D – Conformity with drawing

Point D is made up of the following elements		
	For project with 2 faces	For project with 3 faces
D1 Chamfering edges by machine	2 marks	2 marks
D2 Chamfering edges manual	1 mark	1 marks
D3 Contour damage	1 marks	1 marks
D4 Conformity with drawing – face 1	3 marks	2 marks
D5 Conformity with drawing – face 2	3 marks	2 marks
D6 Conformity with drawing – face 3	-	2 marks
Total	10 marks	10 marks

E – No additional material used

The use of extra material may occur and is assessed in the following way according to objective criteria: i.e. candidates who use no extra material get the full points; candidates who use extra material are penalized and get 0 (zero) points accordingly.

5.4 Skill assessment procedures

The definitive Subjective and Objective Marking Forms will be finalised by the Experts before the Competition.

Makeup of the marking groups and use of data

- Objective marking - A, B, C and E
- Coordinate measuring machine – CMM, objective marking
- 3 Experts for supervision and minute-keeping

Subjective marking - D

- 5 Experts for the evaluation
- 1 spare Expert and minute keeping

Working groups for subjective assessment: For subjective marking the Experts will be divided in 4 working groups.

Formation of Expert groups: The groups shall be nominated by the Chief Expert and the Deputy Chief Expert. The group must be a mix of experienced senior Experts and Experts who are new in their functions.

Each group is responsible for the complete assessment of one module realized by all Competitors.

6. SKILL-SPECIFIC SAFETY REQUIREMENTS

The competition must be in full compliance with the Host Country Health & Safety regulations and with the Competition Rules.

In addition:

- All Competitors must use safety glasses when using any hand, power or machine tools or equipment likely to cause or create chips or fragments that may injure the eyes.

- A first-aid kit must be available throughout the Competition.
- Experts will use the appropriate personal safety equipment when inspecting, checking or working with a Competitor's project.
- The documentation 'Safety and Fairness' will be prepared by the Experts.
- The Competitor must comply with the machine manufacturer's safety instructions.

7. **MATERIALS & EQUIPMENT**

7.1 **Infrastructure List**

The Infrastructure List lists all equipment, materials and facilities provided by the Host Country.

The Infrastructure List is online (<http://www.worldskills.org/infrastructure/>).

The Infrastructure List specifies the items & quantities requested by the Experts for the next Competition. The Host Country will progressively update the Infrastructure List specifying the actual quantity, type, brand/model of the items. Host Country supplied items are shown in a separate column.

At each Competition, the Experts must review and update the Infrastructure List in preparation for the next Competition. Experts must advise the Secretary General of any increases in space and/or equipment.

At each Competition, the Technical Observer must audit the Infrastructure List that was used at that Competition.

The Infrastructure List does not include items that Competitors and/or Experts are required to bring and items that Competitors are not allowed to bring – they are specified below.

7.2 **Materials, equipment and tools supplied by Competitors in their toolbox**

Tools ∅

Item	Description	
1	NC Centre Drills 90°	∅10.00
2	Drills (DIN338/345)	∅5.00, ∅8.50, ∅9.80, ∅10.00, ∅11.80
3	Machine Reamer	∅10H7, ∅12H7
4	Machine Tap (Blind Holes)	M6, M10
5	Machine Tap (Through Holes)	M6, M10
6	End Mill (roughing) (DIN844)	∅6x13, ∅8x19, ∅10x22, ∅12x26, ∅16x32, ∅20x38
7	End Mill (finishing) (DIN844)	∅6x13, ∅8x19, ∅10x22, ∅12x26, ∅16x32, ∅20x38
8	Ball Nosed End Mills	∅12
9	Chamfering cutters 90°	∅10
10	Internal thread mill, pitch 1.5mm	M30x1.5 (max. length = 1.5 x ∅)
11	External thread mill, pitch 1.5mm	M42x1.5 (max. length = 1.5 x ∅)
12	Boring head	∅8 to 50mm
13	Surface Milling Head	∅63
14	Right-angle milling head	∅20, ∅50
15	Spare reversible carbide tips.	

Test & measurement instruments

Item	Description	
1	Vernier calliper DIN 862	0-150mm
2	Depth micrometer	0-75mm
3	Depth Vernier caliper	0-150mm
4	Outside micrometers DIN 863/1	0-25, 25-50, 50-75, 75-100, 100-75mm
5	Inside Micrometers	5-25, 25-50 mm
6	Disc micrometers	0-25, 25-50 mm
7	Three-point hole Micrometers	5-25, 25-50 mm
8	Screw thread micrometer for pitch	1.5mm (M30x1.5, M42x1.5)
9	Thread plug gauges for good and rejected products	M6, M10, M30x1.5
10	Plug gauge	∅10H7, ∅12H7
11	Thread Ring Plug Gauge go/no Go	M42x1.5
12	Chamfering tester 45°	
13	Instrument for angular measurement, plain protractor	
14	Set of slip gauges	
15	Indicating micrometer with magnetic stand	
16	Dial indicator with magnetic stand	
17	Radius gauge R3-25 mm	
18	High-accuracy 90° angle, arm length 80 mm	
19	Straight edge 100 mm.	

Competitors may carry their own tool holders. However, these must be compatible with the clamping system of the machine (Specifications of the host country to be considered.)

7.3 Materials, equipment and tools supplied by Experts

Not applicable

7.4 Materials & equipment prohibited in the skill area

IT-based information (e.g. data, programs etc.) and equipment allowing wireless contact outside the skill area (mobile-phones, laptops, etc.):

- Are prohibited for Competitors.
- May be used by Experts in the Skill Area as defined by the Chief Expert before the Competition.

The use of any other PC than that provided during the Competition is strictly prohibited. Competitors must only work with the software provided.

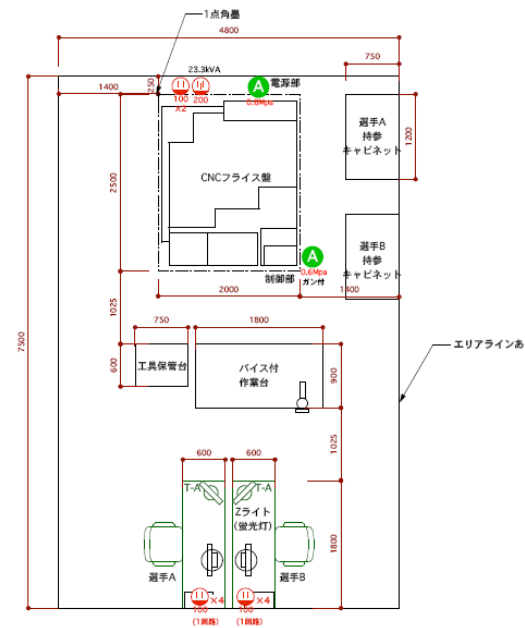
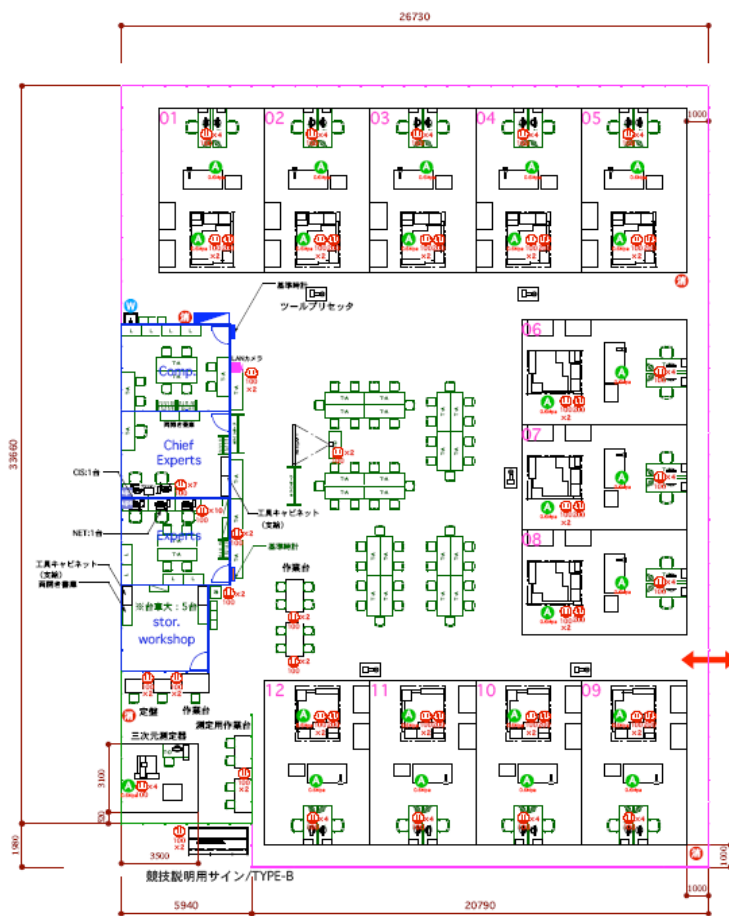
Important Information:

The using of angular machine vice is NOT ALLOWED.

7.5 Sample workshop layout

Workshop layouts from Calgary WSC2009 are available at:
http://www.worldskills.org/index.php?option=com_halls&Itemid=540

Workshop layout from Shizuoka WSC2007:



8. MARKETING THE SKILL TO VISITORS AND MEDIA

8.1 Maximising visitor and media engagement

The following ideas may be considered to maximise visitor and media engagement:

- Display screens (video of CNC Milling Machining)
- A show spot with a complete test project (description, parts and drawings) from past competitions that make easy the understanding of competitor activity
- Competitor profiles - For each Competitor team provide a sticker with the national flag, the name of the Competitor and a brief description of their studies.
- Daily reporting of Competition status
- Demonstration videos provided by the machine and CAD/CAM sponsors showing parts machining which are of interests to the public: aerospace, automotive, etc.
- A small expositors around the competition site where various objects of everyday life such as a bottle; a mobile telephone; a toy; automotive part; aerospace part are exhibited with an explanation how it is produced and the role of CNC milling machines.

- A person who has detailed knowledge about CNC milling explains our competition with samples and videos. (Using former completed projects and technical drawings and a video showing a dry machining process of one module).
- Terminals nearby the competitors work place showing the CAM activity
- Live web cam in the machine with projection to a big screen

8.2 Sustainability

The following ideas may be considered:

- At the end of competition create a several individual project sets (part, drawing and programs) from the parts machined by the competitors and donate them to vocational schools as teaching materials. (The program is chosen from the highest scorer of each module)