Introduction to STEP-NC
A standard providing data for modern NC-machining enabling enhanced functionality

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Abstract

All areas of business have the need to store, exchange and process information as fast and secure as possible. The one who is able to handle these tasks best is considered to increase his productivity, to reduce time to market, to avoid redundant work and thus become more competitive.

The basis for the necessary information technologies (IT) are data models and exchange formats. They define how information is represented and they predict what can be processed in which way. The economic benefits of these data models and exchange formats as such can not be directly calculated because they provide the basis for further developments instead of explicit functionality which can be sold as a product. Especially the definition of internationally accepted standards is time and cost consuming: Different interests have to be considered while a universal definition that is practical for a long period has to be determined. ISO 10303 (STEP) is considered to meet all this requirements for product data. It mainly covers the exchange of product information within the planning and management departments of producing industries.

To close one of the last gaps in a complete and continuous information flow ISO 14649 provides a standard including an interface for the shop floor with its work flow. By referencing the ISO 10303 series existing IT developments for EDM and CAx can be used further on and integrated into the numerically controlled production. Functionalitys based on complex information are thus no longer limited to off-line working systems. Control vendors as well as software and system suppliers can realise more integrated, intelligent and powerful applications which are at the same time easy to handle due to high level graphical user interfaces.

After introducing the standard ISO 14649, its current status (Milling: FDIS since January 2003) and the related international projects, within this presentation the additional potentials and demands on behalf of an autonomous production cell are presented. Autonomous production depends on complete information as input for sophisticated tool path algorithms. Whilst the NC controller demands digital, complete and fast to access data, the user who has to observe the process and who needs to take decisions in case of problems or a breakage, requires a graphical user interface displaying a minimum but sufficient set of information.

Welcome to the STEP-NC seminar

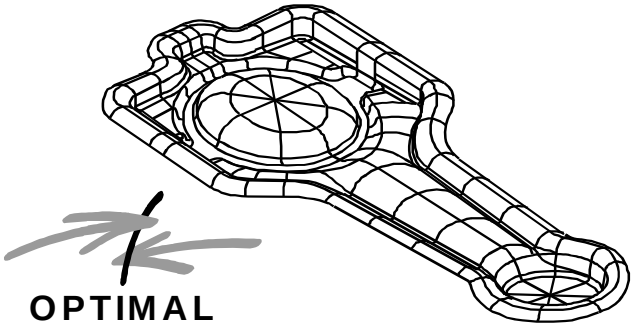
TC184/SC1/WG7

- **Introduction to STEP-NC**
  - Idea of ISO 14649
  - The standard and its data model
  - Requirements for realisation and use
- **The expectations**
  - End-user's expectations
  - Vision of an integrated data flow
  - Augmentation of the shop floor's ability and flexibility
- **First experiences**
  - STEP-NC projects
  - Practical benefits
  - Implementation issues
- **Practical demonstration**
  - Executing STEP-NC data

Introduction to STEP-NC

- **Need for STEP-NC**
  - Shortcomings of current NC-programming
  - Easy access and exchange of consistent data
  - Complete data for autonomous functionality
- **The Standard of ISO 14649**
  - History
  - Engaged partners
  - Data model and format
  - Relation to STEP (ISO13399)
  - Considered technologies and limits
- **Use of STEP-NC**
  - Use case
  - Necessary systems and environment
  - Difficulties

Activities of WZL in STEP-NC



Optimised Preparation of **Ma**nufacturing Information with Multi-Level CAM-CNC Coupling
- 1994 – 1997
- ESPRIT project 8643 OPTIMAL
- Siemens, Fidia, Strässle, Grunewald, Franci, Progetti, WZL
- Focus on freeform machining based on surfaces and Splines

TC184/SC1/WG7

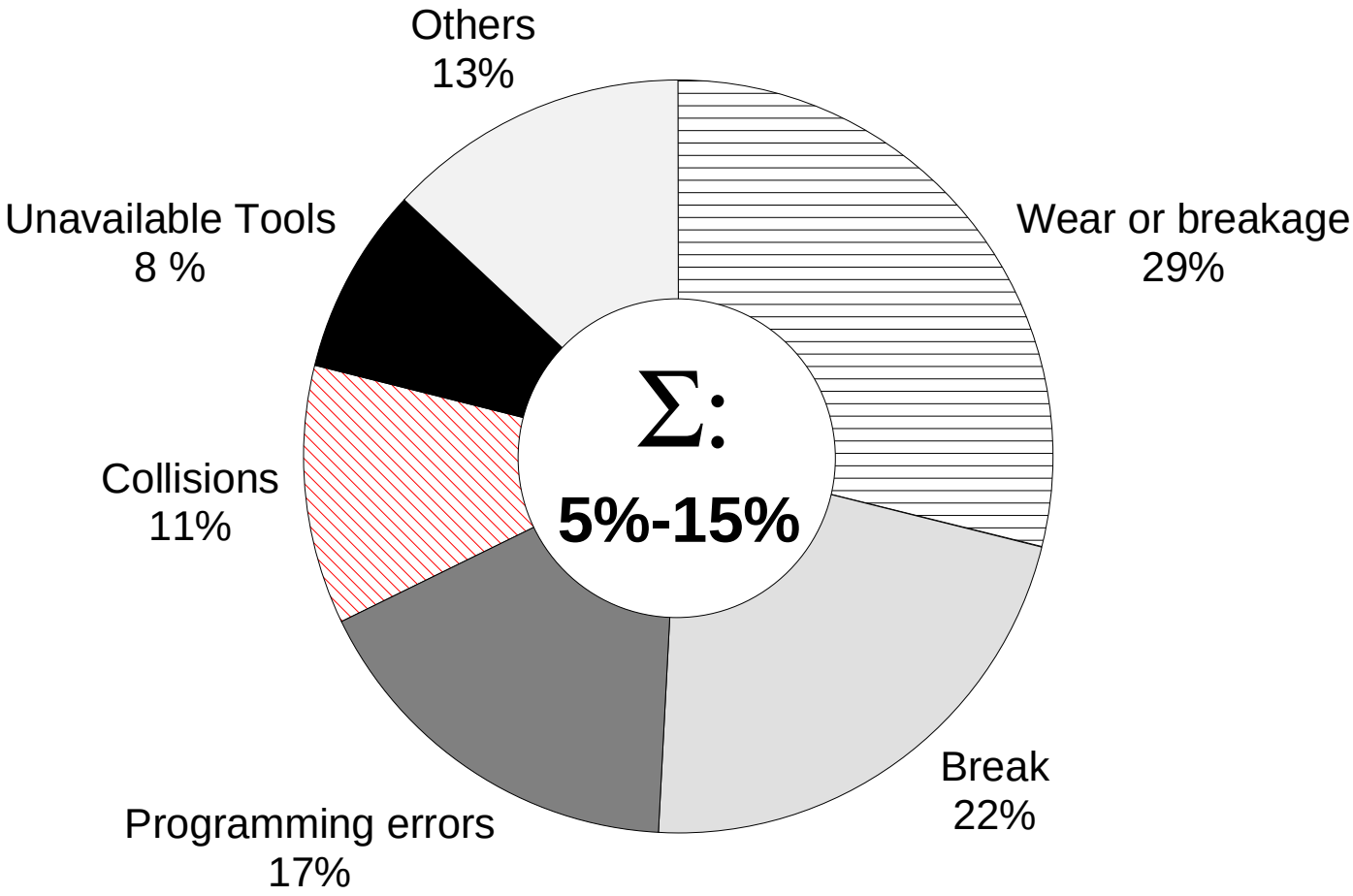
STEP-NC: ISO 14649
- since 1995
- Convenor: Mr. F. Glantschnig (AMT Switzerland)
- WZL document owner for milling and contour cutting
- Siemens, WZL, ISW, NIST, STEP Tools, Komatsu, DaimlerChrysler, ...
- Geometry exchange between CAD, CAM and NC
- Powerful NC Programming interface

Activities of WZL in STEP-NC

European STEP-NC Project
- 1999 - 2002
- ESPRIT project 29708
- Focus on 2.5D milling, EDM and turning
- WZL active in milling and contour cutting
- Siemens and WZL as project management

IMS STEP-NC Project
- 2002 - 2004
- Europe, Korea and USA
- Milling, EDM, turning, rapid prototyping
- WZL help to introduce inspection into STEP-NC

Motivation: Reduction of down-times



Down-times due to NC program errors and inflexibility

Need for STEP-NC

Support during set-up
- Part position detection
- Flexible positioning
- Offsets for raw part
- Complete tool data
- Frame concepts

Autonomy and flexibility
Task oriented process control
- Flexible tool selection
- Break and restart functionality

Vision of autonomous, easy to use machine tools

Ability
- High speed cutting
- 5-axes machining

Accuracy
- Adequate NC data like Volumes and Splines
- No data conversion

Easy to operate tools
- Feature as well as task oriented NC-programming
- CAD coordinate programming
- Geometry import and computation
- Self-proposing solutions and parameters

Safety
- Simulation
- Safety areas
- Plausibility checking
- Collision detection, avoidance

State of the art of conventional NC-programming

Current Situation

Business Level NC Planning

CAD / CAM

ISO 6983

%
N05 G54
N10 G91
N15 G00 X400 Z200
N20 S1200 F200 T2 M66
N25 G01 Z100 M3
N30 G01 Z200
N35 G00 X400 Z400
N40 M30

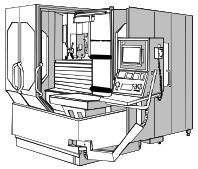
Post-Processor

Shop-Floor Machine Tool

Vendor Specific Formats

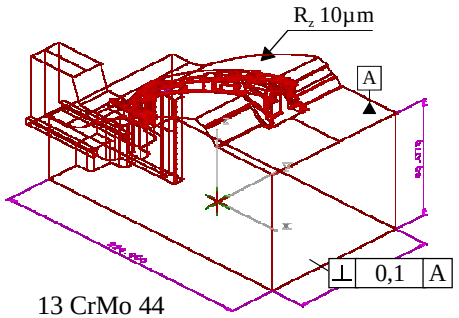
- Vendor Specific Adaptation & Extension
- No Standard
- Limited / Restricted Set of Data Elements
- Specific for some NC & Machine Tool Set-Up

NC Controller

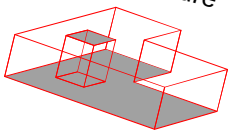


- Simple Geometries & Switching Instructions
- No Support for Splines
- No Volume Information

Raw & Finished Part

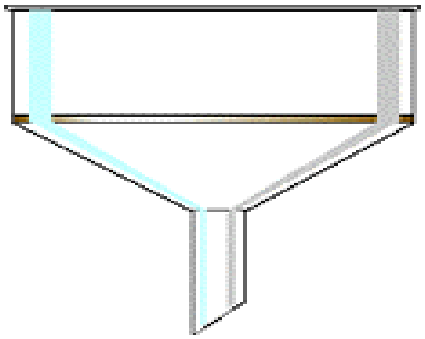


Feature



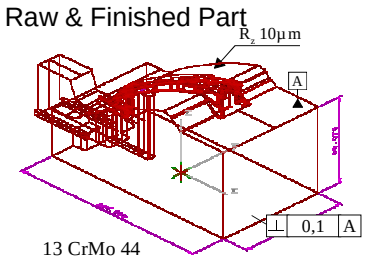
Technology

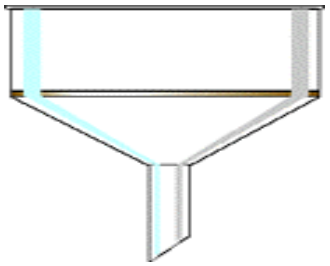
Speed: 2000 U/min
Feed: 20 m/min
Cutting Depth: 1 mm
Cutmode: clockwise
...

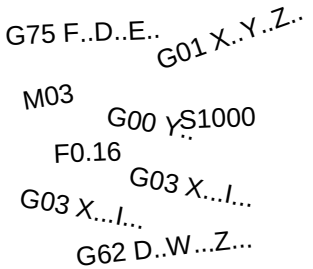


G75 F..D..E..
G01 X..Y..Z..
M03
G00 Y..
F0.16
S1000
G03 X...I...
G03 X...I...
G62 D..W...Z...

Shortcomings of conventional NC-programming







- **Limited NC-Programming interfaces**
  - Simple geometry formats: lines, arcs
  - Primitive switching commands
- **No link to CAD data and technology know-how**
- **Missing information at shop-floor level**
  - For optimisation at the machine tool
  - Autonomous decisions by the machine tool
  - Modifications at the machine tool
- **Insufficient for controls as well as machine tools**
  - Additional functionality needs to be controlled
  - Vendor or customer specific commands
- **Restricted exchangeability**
  - Necessity for postprocessors

Bottle Neck between Planning and Shop-Floor

Horizontal Integration

Vertical Integration

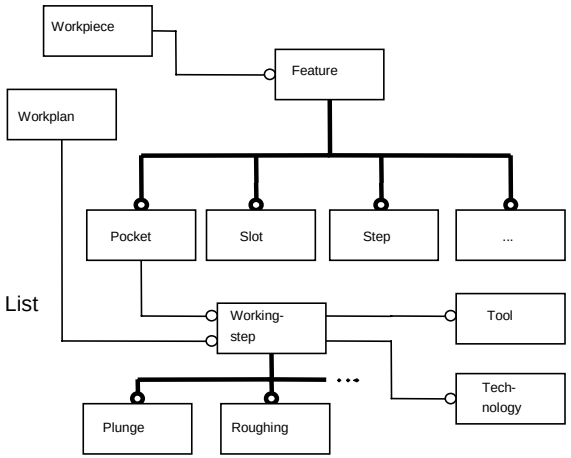
Computer Aided Design	Mechanical-Engineering	Electrical-Engineering	Software-Engineering	Planning …

Computer Aided Planning

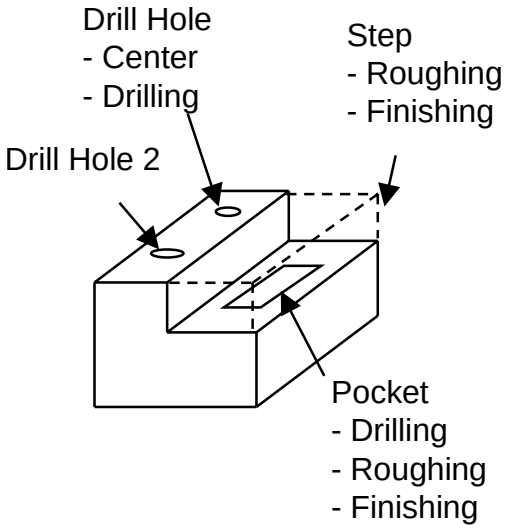
NC Controller

Demands for a modern NC-Programming Interface

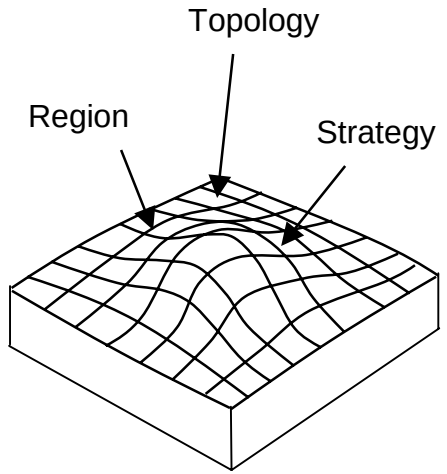
- ***Common Standard***
- ***Information Provision***
- ***Object Oriented Structure***
- ***Preserved Data Context***
- ***Bi-Directional Data Flow***



- ***Shop-Floor Integration***
- ***High Level Visualisation***
- ***Feed-Back of Shop-Floor Know-How***
- ***Reuse of NC-Program Information at different Machine Tools***



- ***High Level Geometry Formats: Spline, Shape***
- ***Loss-free Exchange of Geometrical Elements***
- ***Reduction of Data Conversions***



STEP-NC, a comprehensive NC-programming interface

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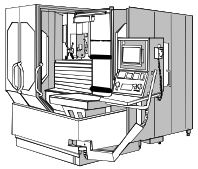
Shop-Floor Machine Tool

NC Controller



- Simple Geometries & Switching Instructions
- No Support for Splines
- No Volume Information

STEP-NC Interface

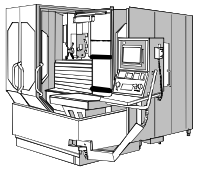
CAD / CAM

#1=Workpiece('WP1',…,#3,…);
#2=Axis2Placement3D(…);
#3=Block(…);
#4=Workplan(…(#5,#6));
#5=Workingstep('id',..#7,..#8);
#6=LoadTool('T10',…);
#8=Drilling();

ISO 14649 (STEP-NC)

- ISO Standard
- Vendor Neutral
- Object Oriented
- Context Preserving
- Capsules Data: Geometry, Technology, Set-Up, Organisation

NC Controller



- Considers STEP Geometry
- Splines Supported
- Volume & Surface Information
- Deposited Strategies

- Substructure for Structured Extension

The Standard of ISO 14649

TC184/SC1/WG7

- **Engaged industries and partners**
- **Concept of ISO 14649**
- **Relation of ISO 14649 and ISO13399**
- **Considered technologies and limits**

ISO 14649: Industries and Universities contributing to WG7

ISO 14649: STEP compliant NC programming interface

Part 1: Introduction (DIS)

Part 10: General Process Data (DIS)

Milling, Drilling	Turning	Wire EDM	Contour Cutting
Part 11:	Part 12:	Part 13:	Part 14:
• **DaimlerChrysler** • **Dassault Systems** • **ISW**, Stuttgart • **Komatsu** • **NIST** • **Open Mind** • **Siemens** • **STEP Tools Inc.** • **Volvo** • **WZL**, Aachen (DIS)	• **ISW**, Stuttgart • **POSTech,** Pohang • **Siemens** • **WZL**, Aachen (CD)	• **AGIE CHARMILLES** • **AMT** • **CADCAMation** • **EIG i-tech** • **EPFL**, Lausanne (Swiss Region) (CD)	• **CMS** • **EPFL**, Lausanne • **ISW**, Stuttgart • **OSAI** • **WZL**, Aachen (draft model)

ISO TC184/SC1/WG7
Convener: Mr. F. Glantschnig (AMT, Switzerland)

ISO/DIS 14649: Current Status

- **August 2000: Draft International Standard was released**
  - Part 1, Part 10 (general data elements), Part 11 (milling), Part 111 (Tools for milling)

- **March 2001: International comments as a result of voting on DIS**
  - 14 out of 19 national member bodies voted on ISO/DIS 14649
  - Disapproval due to Comments: Canada, France, Sweden, United Kingdom, USA (Mainly concerning harmonisation with STEP AP224. Solved until Spring of 2002.)

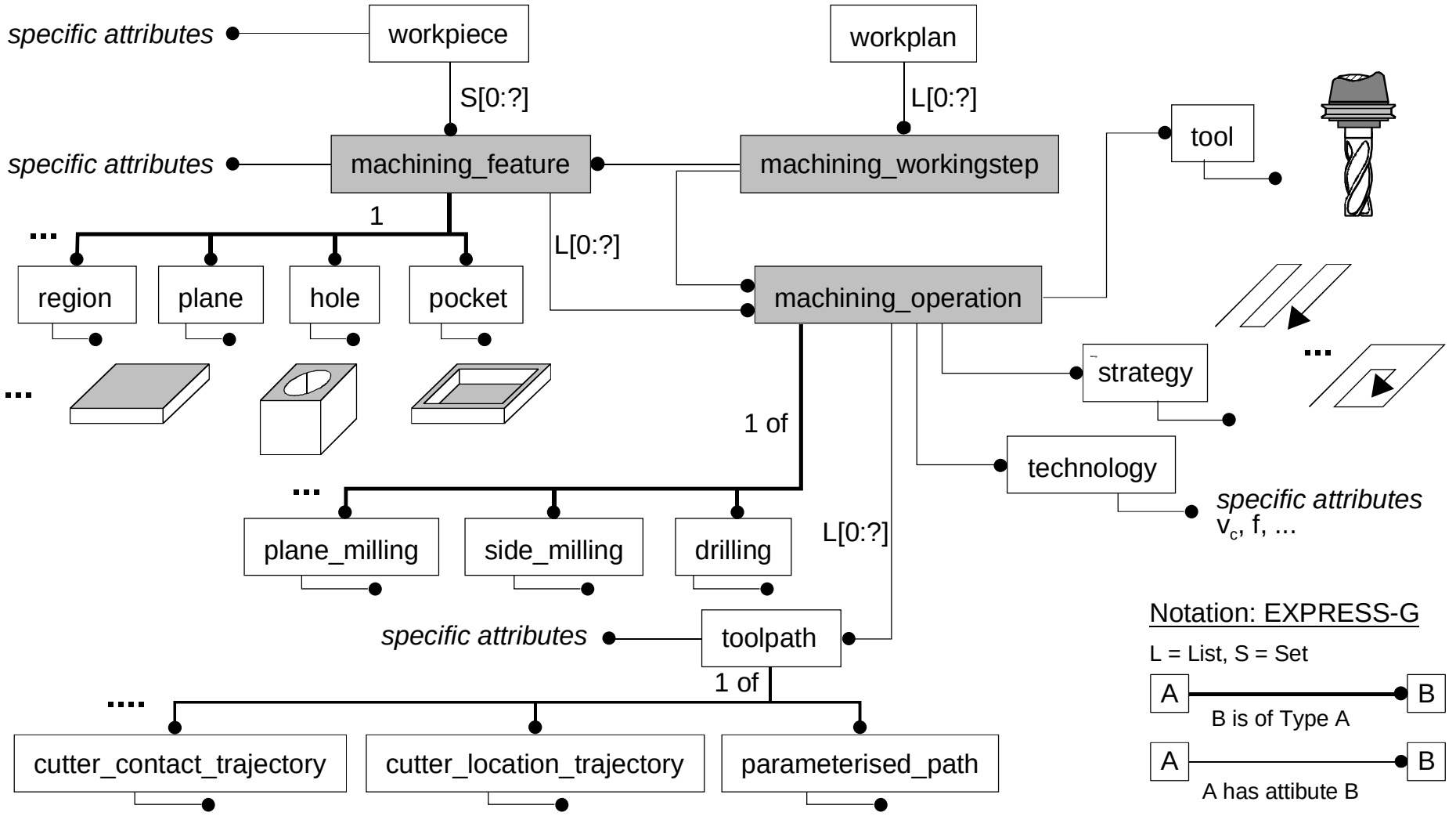
- **February 2002: STEP SC4 starts an initiative to extend the ISO 14649 working step idea.**
  - AP 240 “Process Planning” is started as a new work item
  - STEP-NC is considered as exchange format at the shop floor and next to the machine tool

- **September 2002: International voting on drafts for data models for turning and EDM**
  - After resolving few comments the data models will become CD

- **2003: Within the EU STEP-NC project inspection is considered as a new work item**

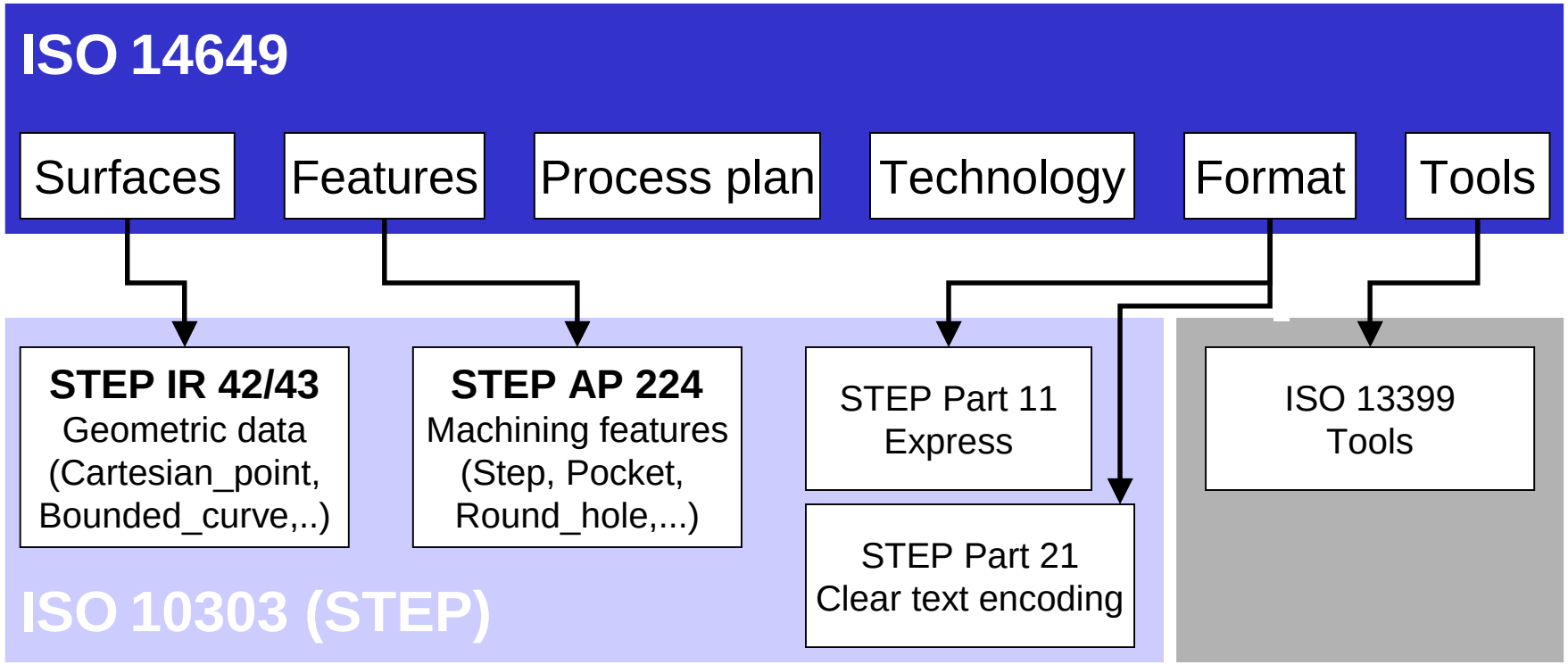
- **January 2003: International voting on FDIS status of data model for milling**
  - Deadline for part 111 (milling tools) is postponed

ISO 14649 capsules geometry, technology and process sequence



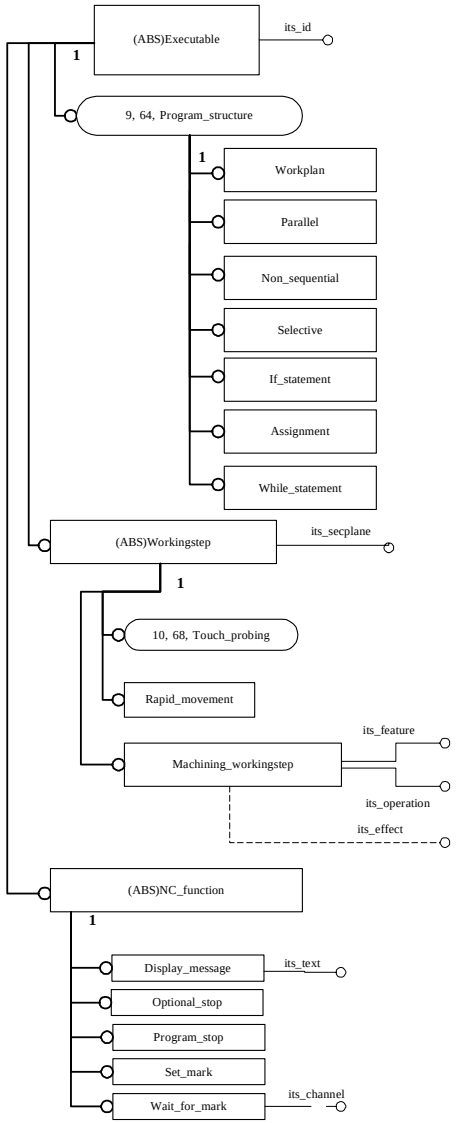
Relationship between ISO 14649 and STEP (ISO10303)

- STEP is the Standard for the Exchange of Product Model Data, whose application areas are rapidly extending.



- Harmonisation with ISO/TC184/SC4 for feature description and material model
- Ongoing harmonisation with new ISO/TC29 (ISO 13399) for cutting tools

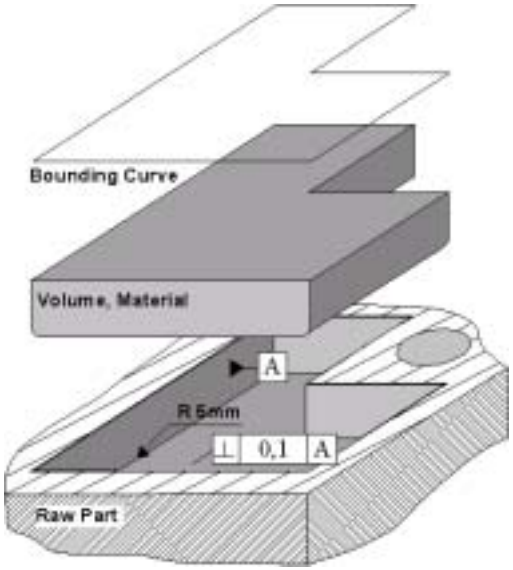
Executable: What to do



- **Workingstep**
  - Complete task based on one element and one operation
  - One technology, one tool, one geometrical element
  - E.g. assigns an operation to a feature
  - machining_workingstep, rapid_movement,touch_probing
- **NC Function**
  - To control additional non geometry related functionality
  - display_message, optional_stop, program_stop, exchange_pallet, index_pallet, index_table, unload_tool, set_mark, wait_for_mark
- **Program structure**
  - Defines sequence of executables
  - Flexibility by logical elements
  - workplan, parallel, non_sequential, selective, if_statement, while_statement, assignment

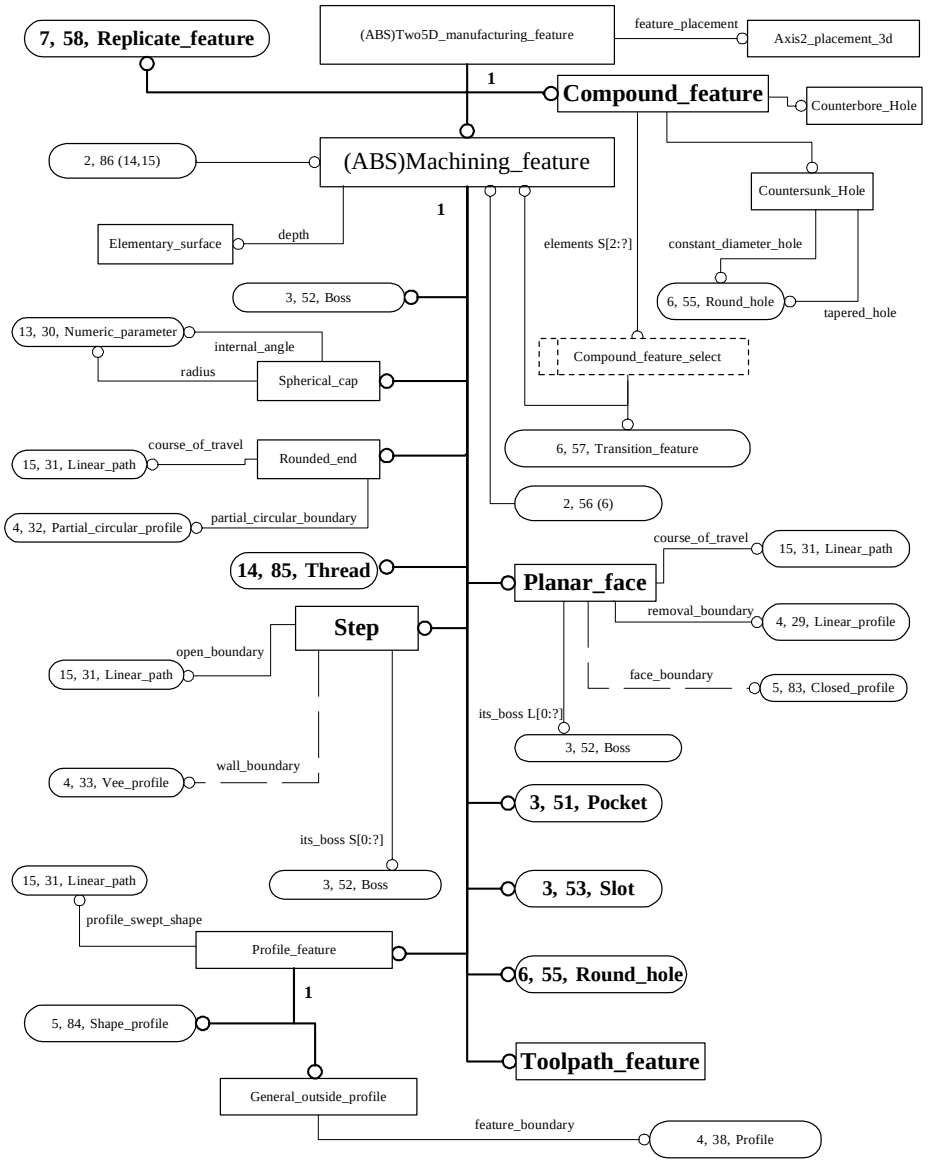
Feature: Where to machine

- **Features to describe geometry**
  - Logical unit used in design (CAD) and machining (CAM)
  - Often specific functionality is related to a feature
  - Complete, consistent data for autonomous functionality
- **Use in CAD, CAM systems**
  - Parameterised, scalable description for classified shapes
  - Internally CAx-systems often use volumes similar to features
  - Pure geometry is interpreted by a feature recognition
  - Classification of elements and operations
  - Machining operations are defined based on features
- **Features in NC machining**
  - Today's NC cycles are often based on features
  - Suitable for simulation and visualisation
  - Used for logical association of machining tasks
  - Help to structure the workpiece and its machining



Features in ISO 14649

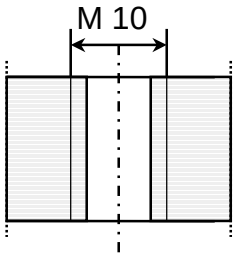
(excerpt of ISO 14649-10)

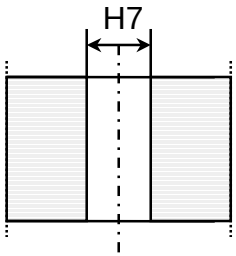



```
ENTITY machining_feature        (* m1 *)
        ABSTRACT SUPERTYPE OF (ONEOF(planar_face, pocket, slot,
        step, round_hole, toolpath_feature, profile_feature, boss,
        spherical_cap, rounded_end, thread))
        SUBTYPE OF (two5D_manufacturing_feature);
        depth:                  elementary_surface;
END_ENTITY;
ENTITY pocket  (* m1 *)
        ABSTRACT SUPERTYPE OF (ONEOF(closed_pocket,
        open_pocket))
        SUBTYPE OF (machining_feature);
        its_boss:               SET [0:?] OF boss;
        slope:                  OPTIONAL plane_angle_measure;
        bottom_condition:       pocket_bottom_condition;
        planar_radius:          OPTIONAL
        toleranced_length_measure;
        orthogonal_radius:      OPTIONAL toleranced_length_measure;
END_ENTITY;

ENTITY closed_pocket            (* m1 *)
        SUBTYPE OF (pocket);
        feature_boundary:       closed_profile;
END_ENTITY;
```

Different feature definitions



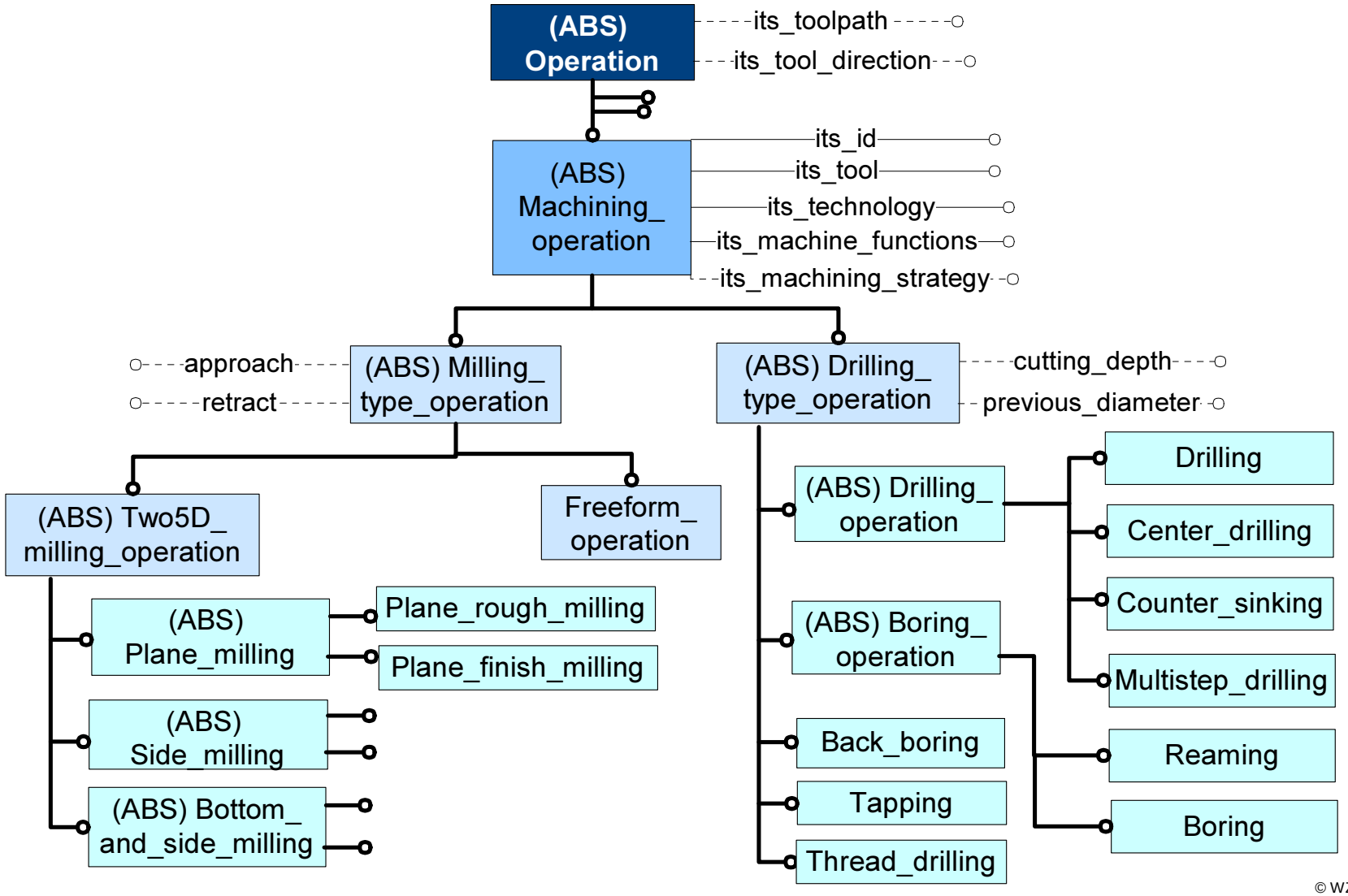


- **Design**
  - Single item as part of the final shape
  - Optical, logical or functional idea or requirement

  ⇒ Design feature depend on the final part, its functionality and its design shape
- **Machining**
  - Implies a volume to be removed, modified or generated
  - Basis for calculation of tool paths and axes movements
  - Related to a specific technology or type of operation
  - Can span several design features or be a sub element
  - Intermediate shape depending on the workplan

  ⇒ Machining feature depend on the selected way how to generate a design feature
- **Inspection**
  - Task oriented element: diameter + reference plane

Operation: How to machine

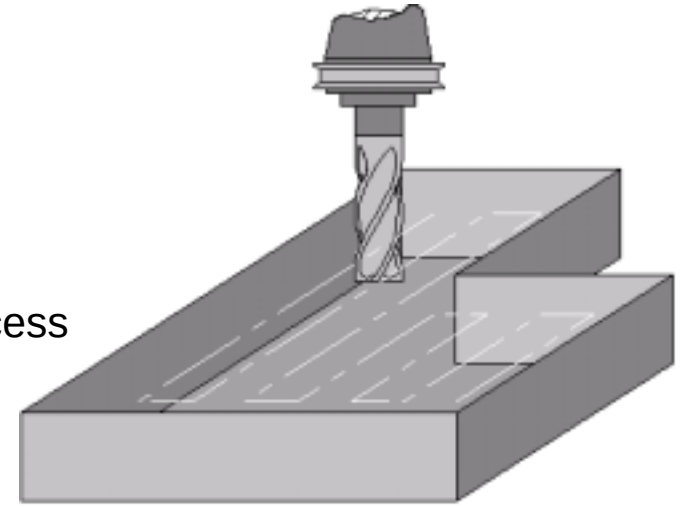


Strategy

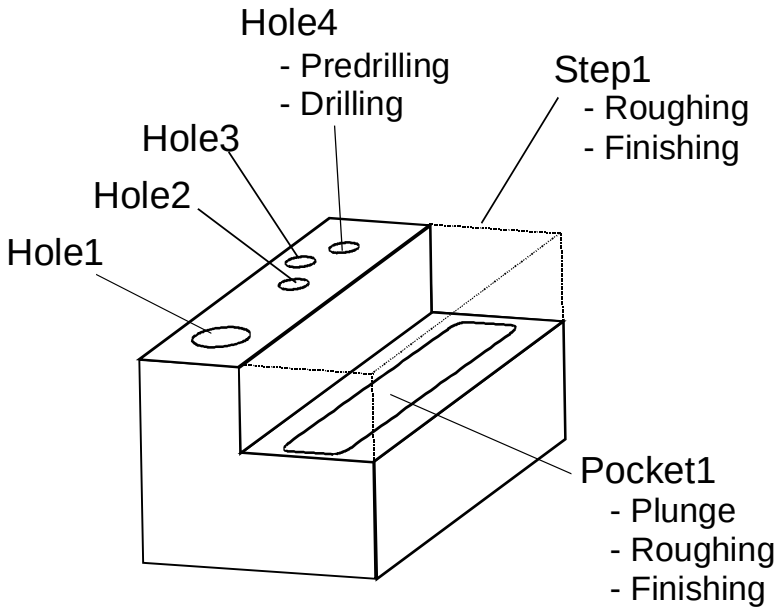
Several strategies have been realised by various CAM or SFP systems in vendor and customer specific NC-Cycles. But they cannot be exchanged!

- **ISO 14649 makes strategies exchangeable**
  - Former proprietary NC-Cycles based on G-Code become standard elements
  - Common directives to process parts can be exchanged between different CNCs

- **Uniform strategies for process evaluation**
  - Strategies and tool paths become comparable
  - Strategies integrated into the NC controller represent a constant basis to realise strategy dependent functionalities: cutting depth modification close to process



Simple example



Workpiece for 2.5D-Manufacturing can be described using features, the manufacturing sequence is expressed in workingsteps.

```
// header
ISO-10303-21
HEADER;
ENDSEC;

DATA;
// workpiece and work plan
#1=WORKPIECE(...);
#2=MATERIAL(...);
#3=WORKPLAN('name',(#10,#11,...),.....);

// working steps
#10=MACHINING_WORKINGSTEP('hole1',#20,....);
#11=MACHINING_WORKINGSTEP('Pocket1_plunge',....);
                    ⋮
// manufacturing features
#20=ROUND_HOLE(...,#1,#30,#40,...);
                    ⋮
// geometric data
#30=CARTESIAN_POINT(...);
                    ⋮
// operation data
#40=DRILLING(...,#50,);
#41=BOTTOM_AND_SIDE_ROUGH_MILLING(...);
                    ⋮
// tool data
#50=CUTTING_TOOL('spiral_drill_9mm'...);
```

Example: Drilling

#5=ROUND_HOLE('HOLE1',#1,(#19,#20),#43,#63,$,$,$,$,#64,$,#6,$,$);

Identifier

Part

Operations

Location (WCS)

Depth

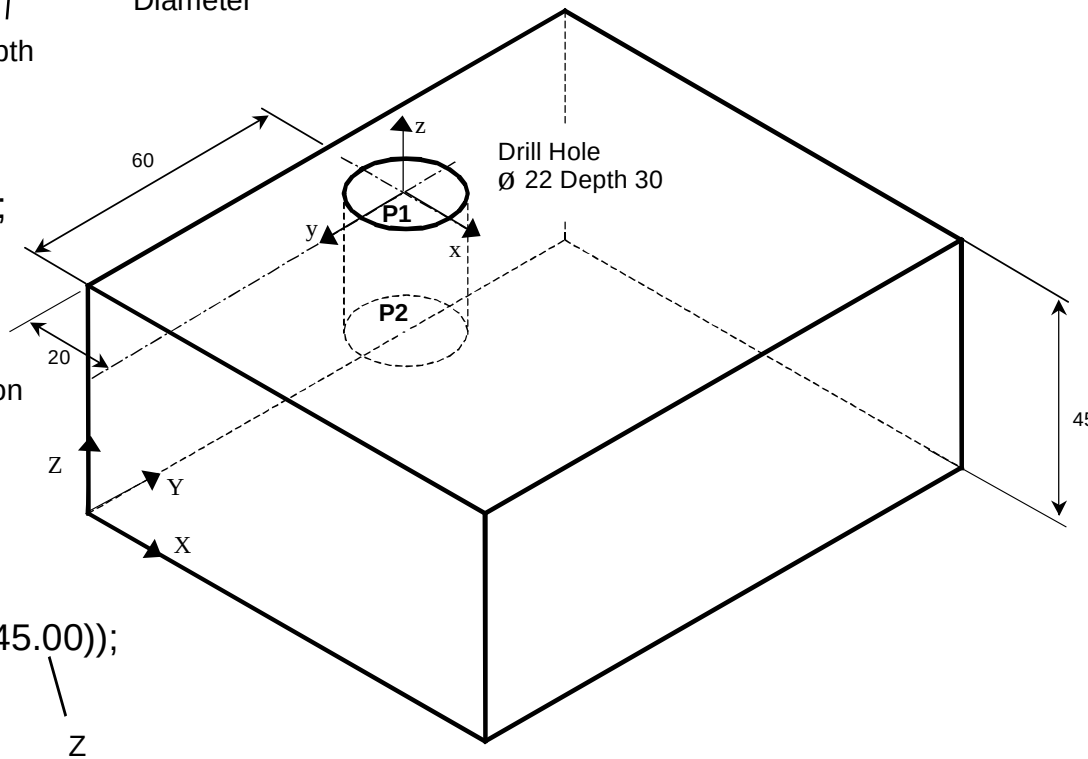
Diameter

Type of hole bottom

#43=AXIS2_PLACEMENT('HOLE1',#86,#87,$);

Position

axis direction



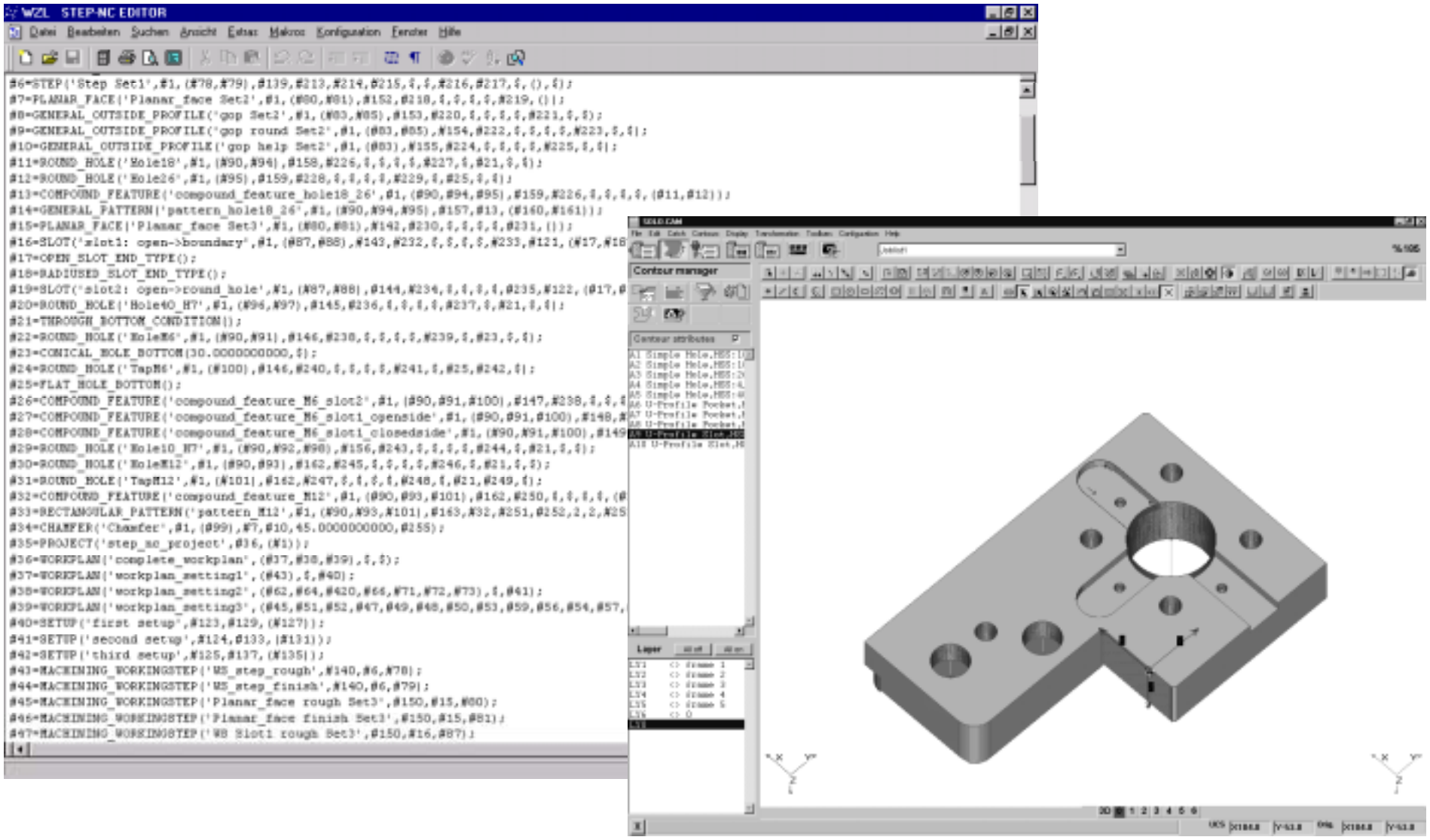
#86=CARTESIAN_POINT('HOLE1',(20.0,60.0,45.00));

X

Y

Z

Example for an ISO 14649 program



Example for an ISO 14649 program

```
. . .
#1=WORKPIECE('testpiece',#4,0.0100000000,#2,$,#3,());
#2=WORKPIECE('rawpiece',#4,0.1000000000,$,$,$,());
#3=BLOCK(#126,185.0000000000,120.0000000000,50.0000000000);
#4=MATERIAL('ST-50','Steel',(#5));
#5=PROPERTY_PARAMETER('E=200000 N/mm2');
#6=STEP('Step Set1',#1,(#78,#79),#139,#213,#214,#215,$,$,#216,#217,$,(),$);
#7=PLANAR_FACE('Planar_face Set2',#1,(#80,#81),#152,#218,$,$,$,$,#219,());
#10=GENERAL_OUTSIDE_PROFILE('gop help Set2',#1,(#83),#155,#224,$,$,$,$,#225,$,$);
#11=ROUND_HOLE('Hole18',#1,(#90,#94),#158,#226,$,$,$,$,#227,$,#21,$,$);
#12=ROUND_HOLE('Hole26',#1,(#95),#159,#228,$,$,$,$,#229,$,#25,$,$);
#13=COMPOUND_FEATURE('compound_feature_hole18_26',#1,(#90,#94,#95),#159,#226,$,$,$,$,(#11,#12));
#14=GENERAL_PATTERN('pattern_hole18_26',#1,(#90,#94,#95),#157,#13,(#160,#161));
#15=PLANAR_FACE('Planar_face Set3',#1,(#80,#81),#142,#230,$,$,$,$,#231,());
#16=SLOT('slot1: open->boundary',#1,(#87,#88),#143,#232,$,$,$,$,#233,#121,(#17,#18));
#17=OPEN_SLOT_END_TYPE();
#18=RADIUSED_SLOT_END_TYPE();
#19=SLOT('slot2: open->round_hole',#1,(#87,#88),#144,#234,$,$,$,$,#235,#122,(#17,#18));
#20=ROUND_HOLE('Hole40_H7',#1,(#96,#97),#145,#236,$,$,$,$,#237,$,#21,$,$);
#21=THROUGH_BOTTOM_CONDITION();
#22=ROUND_HOLE('HoleM6',#1,(#90,#91),#146,#238,$,$,$,$,#239,$,#23,$,$);
#23=CONICAL_HOLE_BOTTOM(30.0000000000,$);
#24=ROUND_HOLE('TapM6',#1,(#100),#146,#240,$,$,$,$,#241,$,#25,#242,$);
. . .
```

Projects evaluating and enhancing ISO 14649

- **European project MATRAS**
  - 1998
  Focussing on freeform machining
- **European STEP-NC project: ISO 14649**
  1999 - 2004
  Focussing milling, EDM, contour cutting and turning
- **Korean Laboratory for STEP-NC Technology**
- **US-American Super Model Project: ISO 14649**
  2000 - 2003
- **IMS STEP-NC Project**
  2002 - 2004

Third party projects

- **Japanese Digital Master Project**
  Komatsu Industry, Fanuc, (?)
- **Bosch Rexroth**
  STEP-NC interface for Indramat MTC control
- **AMTC - Loughborough University**
  Process planning based on Delcam (PowerMill)
- **ANDRON, TU Dresden**
  STEP-NC interface for ANDRON control
- **Delft University of Technology**
  STEP-NC for cost planning
- **IWB – TU Munich**
  Consideration of STEP-NC in DESINA

ISO 14649: Related projects

- **STEP-NC Project:**
  - first part 1999 until 2001
  - extended until 2004
  - 19 active industrial partners and universities
  - European and Swiss region
  - focussing on milling, wire EDM, contour cutting and turning
  - physical data exchange based on ARM and Part 21-format

- **Super Model Project:**
  - 2000 until 2003
  - STEP Tools Inc. as project coordinator
  - about 30 active and observing industrial partners
  - focussing on data exchange by mapping mechanisms
  - physical data exchange based on XML and partly on AIM

- **IMS STEP-NC Project**
  - Partners: Korea, European and Swiss regions, USA
  - 2002 – 2004
  - Cooperation and exchange within the ongoing regional STEP-NC projects

STEP-NC Project, Super Model Project, IMS Project

Europe

- Siemens (NC)
- OSAI (NC)
- Open Mind (CAM)
- Dassault Systems (CAM)
- CMS (CAM, Machine Tool)
- DaimlerChrysler (User)
- Volvo (User)
- WZL Aachen (University)
- ISW Stuttgart (University)

. . .

Switzerland

- AMT (Consultant)
- CADCAMation (CAM)
- EIG (Polytechnic)
- EPFL (University)

. . .

USA

- STEP Tools
- Boeing
- GM
- Gibbs
- Monarch Machine Tools
- NIST

. . .

Korea

- Hyundai (NC)
- Daewoo (MT)
- Cubictech (CAM)
- ERC-ACI (University)
- KITECH (University)
- POSTECH (University)
- . . .

First STEP-NC Project (Europe)

European Consortium

Control Vendor
- Siemens (D)
- OSAI (I)

Machine Tool Vendor
- CMS (I)
- AGIE (CH)

CAM
- Open Mind (D)
- Dassault (F)
- CADCAMation (CH)

Universities
- WZL (D)
- ISW (D)
- EPFL (CH)
- EIG i-tech (CH)

- CECIMO (B)
- AMT (CH)

End User
- DaimlerChrysler (D)
- Volvo (S)
- Franci (I)
- Progetti (I)
- Derendinger (CH)
- Wyss (CH)

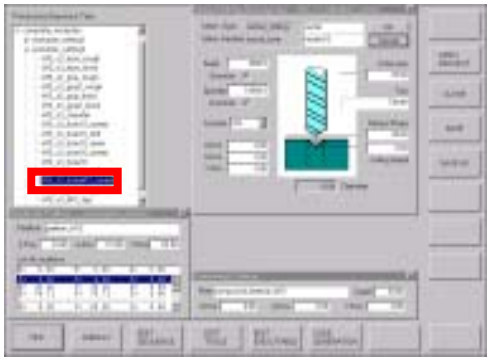
Focus of the European STEP-NC Project

- ISO 14649: Milling, Turning, Contour Cutting, EDM
- Validation of ISO 14649 NC-programming interface and extension of the standard and its data model
- Realisation and testing of more general path-algorithms
- Realisation of a bi-directional data exchange CAM $\leftrightarrow$ NC
- Software tools for milling technology: CAM, NC, User Interfaces

First STEP-NC Project (Europe)

- **Running prototypes for 2½D- Feature + freeform milling technology:**
  Industry:
  - Siemens (ShopMill), OpenMind (hyperFact), DassaultSystems (Catia V5)
  - Items: Hole, Planar Face, Pocket, Slot, Step, Outside Profile

  University:
  - WZL (WZL-NC, SFP Tool), ISW
  - Items: Hole, Planar Face, Pocket, Slot, Step, Region
  - Concepts for data feedback (WZL, ISW)



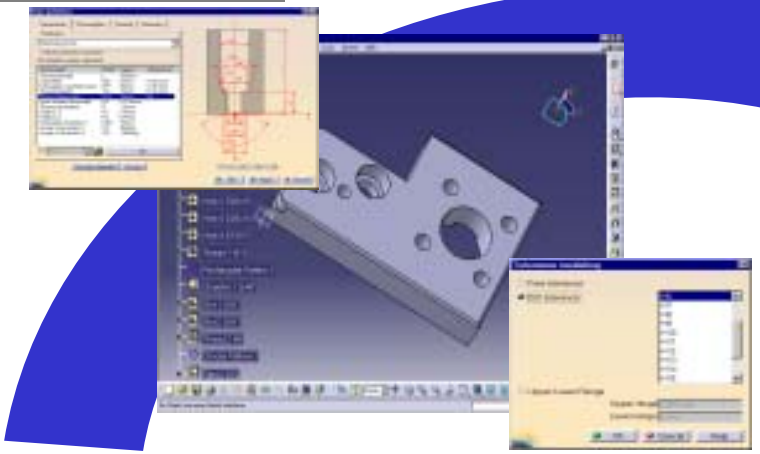
- **Data models and implementation for further technologies:**
  EDM:
  - First draft of data model is to be finished by EPFL, CADCAMation, AGIE/Charmilles
  - CADCAMation and EPFL started implementation

  Contour Cutting (Wood, Glass, Stone)**:**
  - Data model prepared by WZL, CMS and OSAI
  - Start of implementation by OSAI (NC), CMS (CAM) and WZL (Support)

  Turning:
  - Data model developed by ISW, NRL-SNT, Siemens and WZL
  - Positive voting for CD version in 2002
  - Ongoing work to be presented for DIS voting in 2003

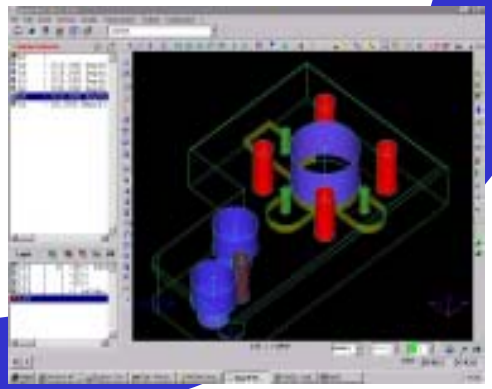
STEP-NC Project (Europe): Milling scenario

Feature Based Design



Feature Based NC-Programming

CATIA V5



Hyper Fact

STEP-NC Control

Siemens

Super Model Project (U.S.A)

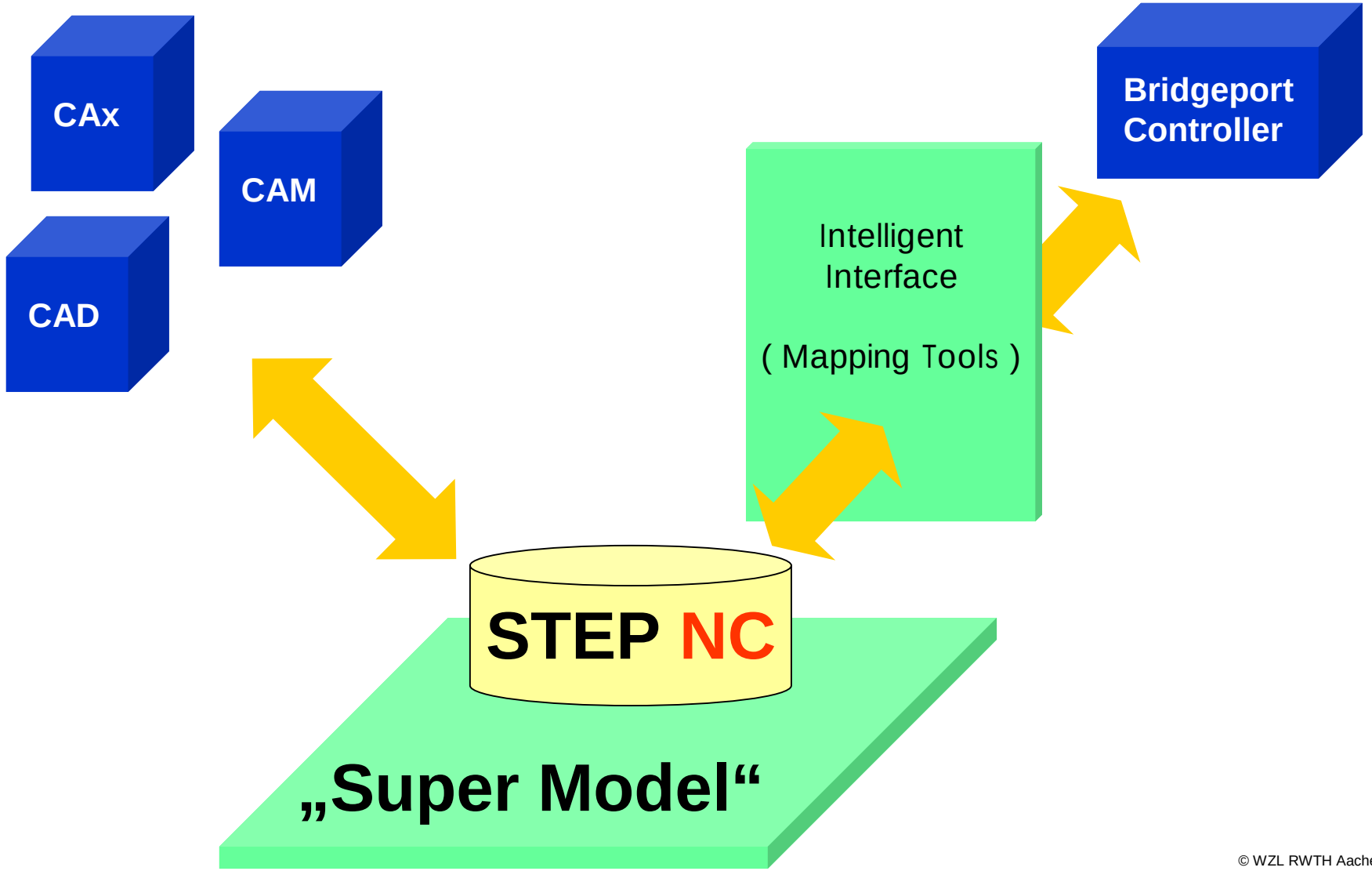
Involved partners and industrial review board

- GE Fanuc
- CNC Data (MASTERCAM)
- CADKEY
- Alibre
- Boeing
- General Electric
- General Motors
- Gibbs and Associates
- Hurco Companies Inc.
- Lockheed Martin
- IBM
- Monarch Machine Tools
- NASA (GSFC)
- NASA (JPL)
- NCMS

STEP NC

- Unigraphics Solutions
- NIST Intelligent Systems
- Lawrence Livermore
- Chrysler
- Watervliet Arsenal (Benet)
- General Dynamics
- The Design Edge
- RMC Associates
- Fala Technologies
- Cambridge Valley Maching
- Allied Signal
- Bridgeport Controls
- Liberty Consulting
- RPI

Super Model Project (USA)



Super Model Project (USA)

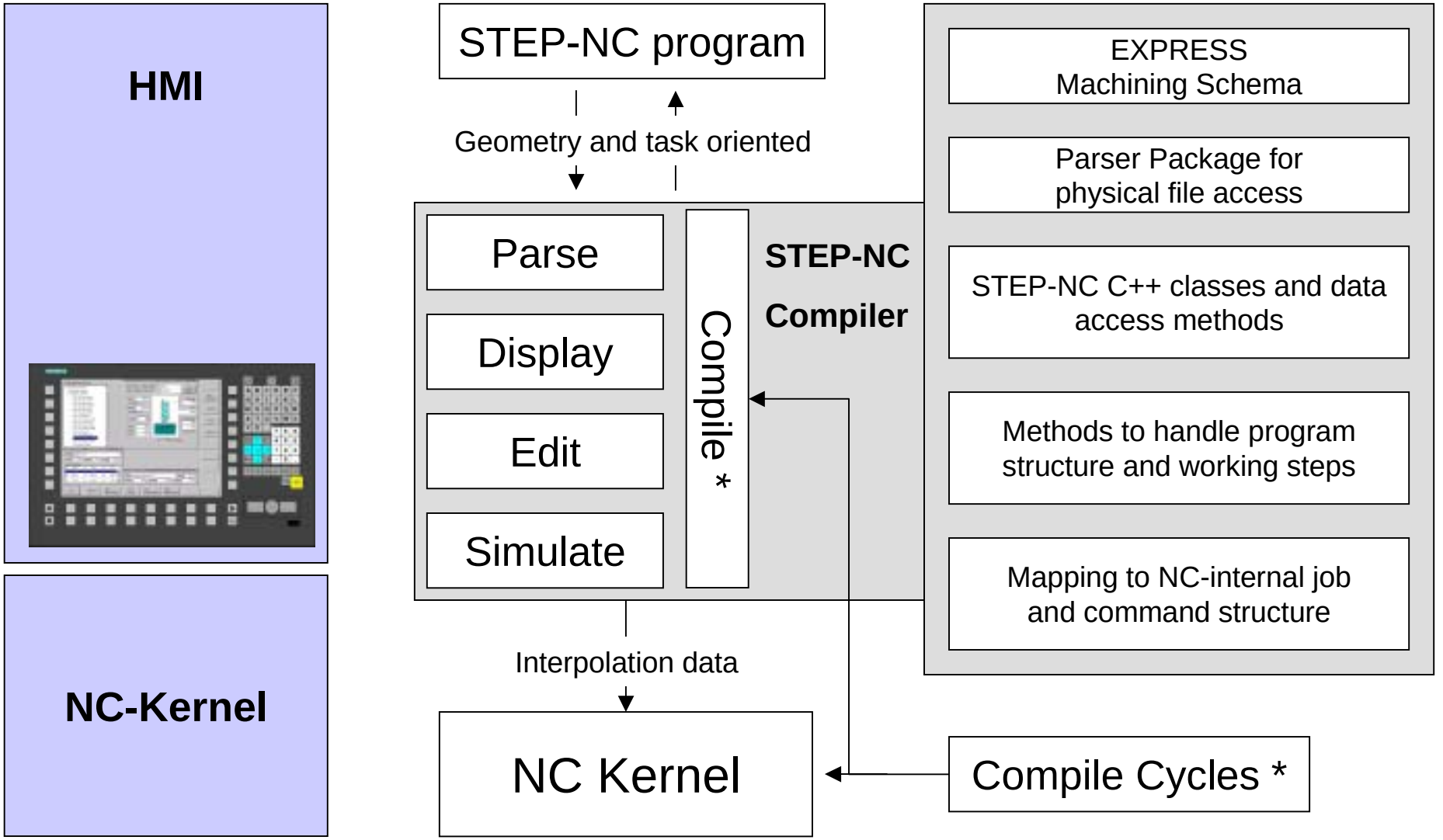
First U.S. Presentation in November 2000, NY

30. November 2000 in the Benet Laboratories in Watervliet, New York

Use of STEP-NC

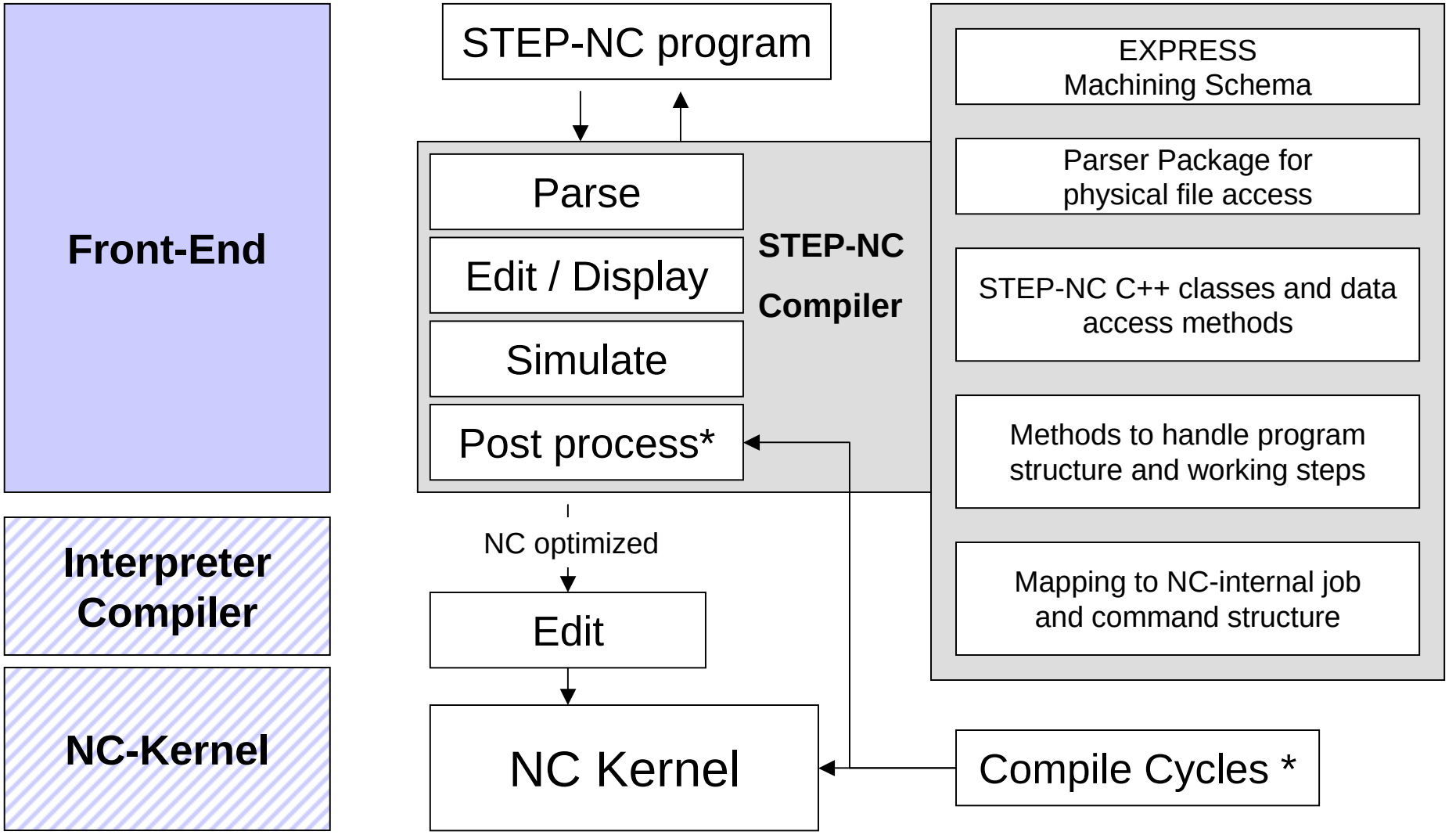
- Scenarios for realisation and use
- Required systems and environment

Execution in numerical controllers



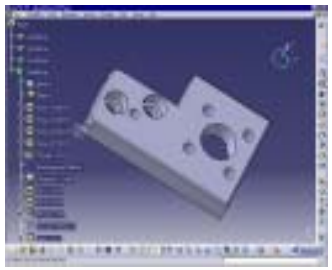
*Tool and NC specific

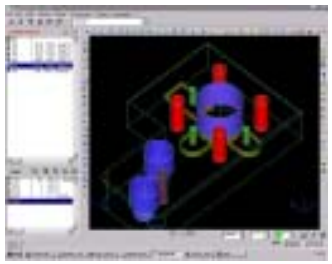
Execution in legacy controllers

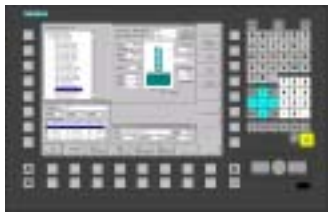


*Tool and NC specific

Requirements for implementation







- **Design (CAD)**
  - Feature definition or feature oriented data; STEP data
  - Raw part definition and material description
  - References and geometry identification for feedback
- **Planning (CAM)**
  - Feature import and export interfaces
  - ’Write’ and ’read’ capability for STEP and STEP-NC data
- **Machining (SFP, HMI, NC)**
  - SFP, HMI: Similar functionality to a CAM system; Feature and workplan based editing and visualisation
  - Logical structure of data: tree view browser
  - NC: Path algorithms to resolve features and strategies
- **Inspection**
  - Task oriented execution of larger units such as features
  - Interpretation of results based on STEP elements

Developments at WZL

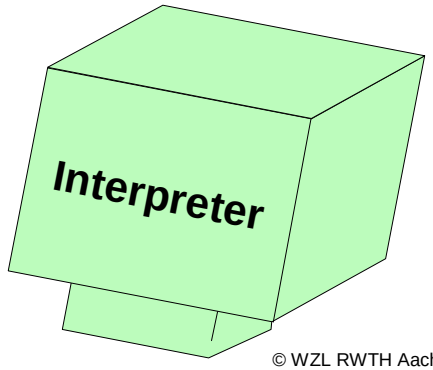
- **WZLNC**
  (OSACA based controller processing ISO 14649.)
- **MATCAM + WZLNC**
  (Solution to process Spline and surface information in the NC.)
- **SFP System**
  (Tools for viewing and editing ISO 14649 data.)
- **Database**
  (Methods to detect changes and store their effects.)

Realization in WZL-NC

- **Completely ISO 14649 based NC-Interpreter**
  - **Object oriented part processing: IF, WHILE, PARALLEL**
  - Interface to provide ISO 14649 based information on current status
  - Semantic checking functionality to ensure a safe process and to provide more informative error-messages for user interaction
  - Algorithms and strategies for more flexible milling of planes and pockets with complex bounding curve

- **Spline based geometric NC-chain**
  - High level data format within all modules of the NC-geometry-chain
  - Generated tool path can be exported for process visualisation

- **EXPRESS based internal data exchange format**
  - All generated and exchanged information can be reported



WZL-NC provides Information

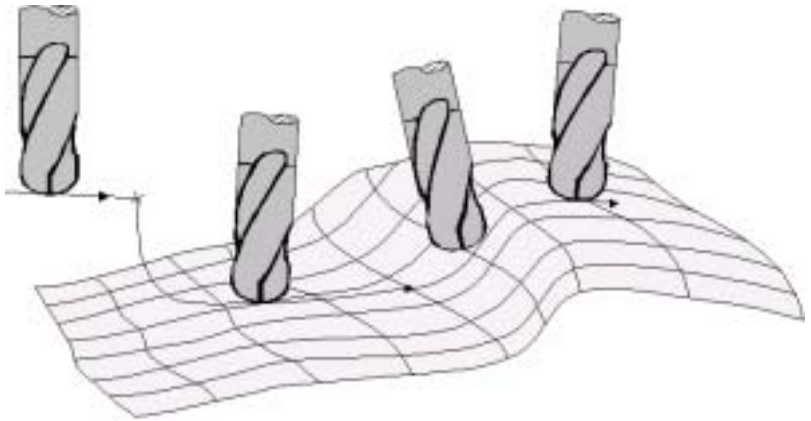
- **For statistical functionalities**
  - Tool Life
  - Time per working step, per geometrical item, per part, …
- **For on-line measurement procedures**
  - geometric shape / item to be measured
  - functionality to store or to write out results (Part 21 conform)
- **Reduced, fast to access information**
  - ID of current working step, tool, feature and technology parameters to be displayed on the WZL-MMI or similar interfaces
  - unique, system generated ID to synchronise visualisation and process

Tool Orientation and technology variation

High speed cutting technology for freeform shapes do require path depend tool orientation and technology. Besides part programming has to remain as simple and easy to understand as possible.

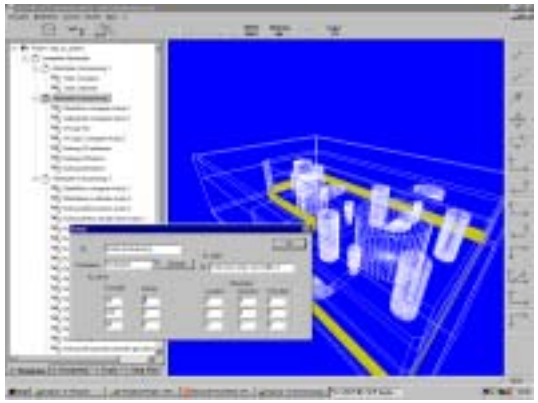
- **2 ½ D milling of prismatic elements**
  - No variation of technological parameters
  - Data sets can generally be reused
  - Settings can easily be defined in dialogs

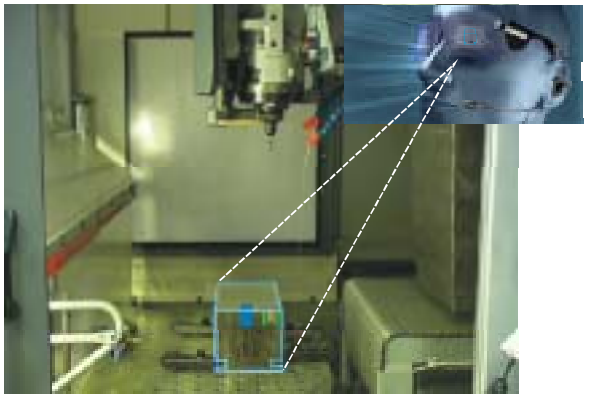
- **Fife axis milling**
  - Predefined technological parameters can be global or attached to single tool paths

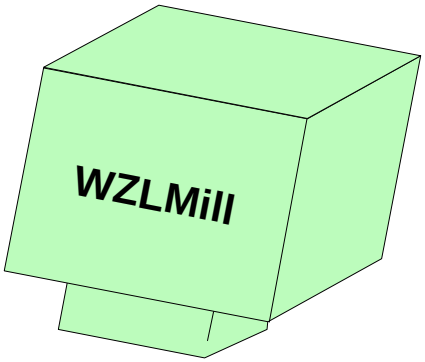


SFP System and On-line Process Visualization

- 2nd Generation of WZL's Shop Floor Oriented Programming System
  - Simple and guided geometry, technology, tool and process definition
  - WZL-NC / OSACA will provide zero positions for part programming
  - OSACA integration will enable visualisation of actual process
  - Exports functionality to read in and visualise part program in other applications: Head Mounted Display (HMD)



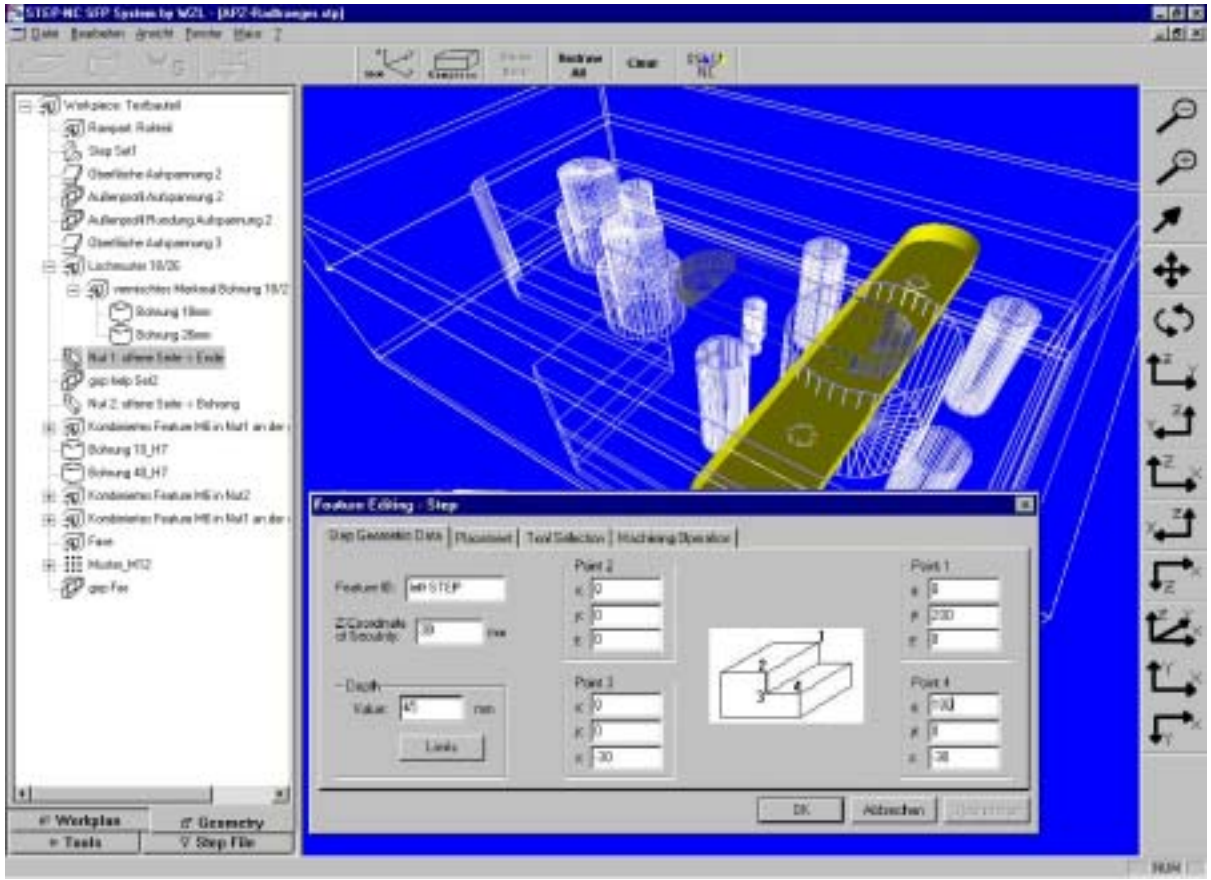




SFP System

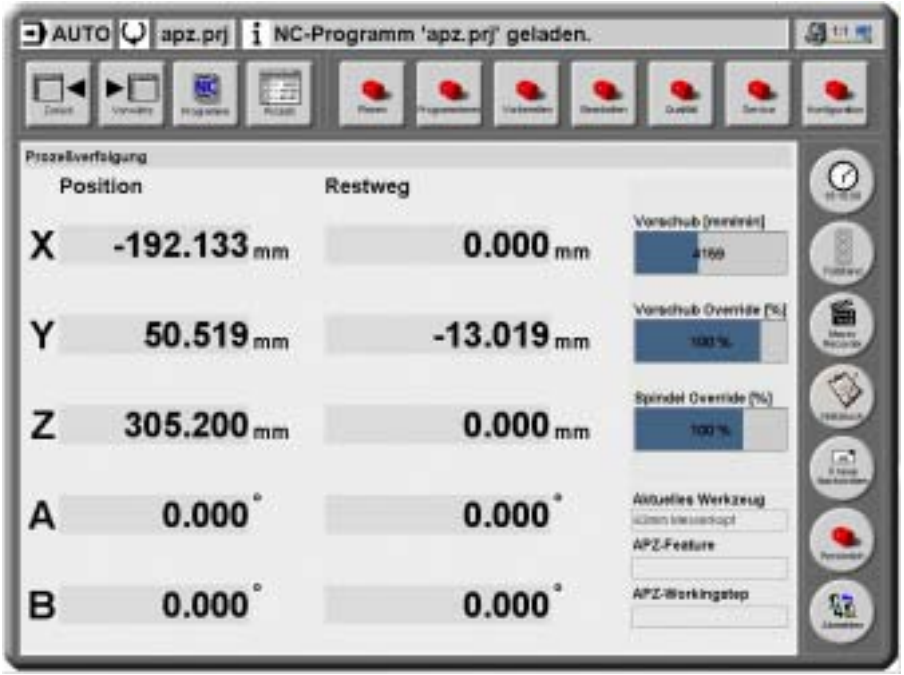
WZLMill is meant for easy part programming and editing in an intuitive way. This is achieved by similar data masks and predefined elements.

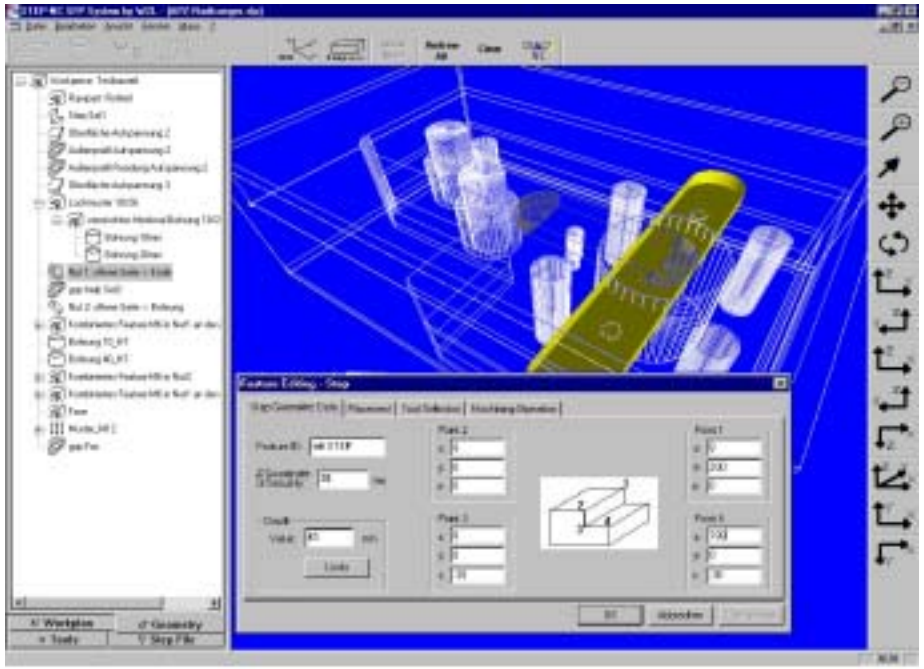
- **All elements prepared for use with touch screen:**
  - **- scalable icons**
  - **- no right mouse click**
  - **- flexible position of views**
- **Tree views for :**
  - **- Working Steps**
  - **- Parts**
  - **- Feature**
- **Predefined data masks:**
  - **- suggestion of predefined and basic shapes**
  - **- checking functionality**



STEP-NC Project (Europe)

Support and Developments at **WZL**





- **WZL** STEP-NC Parser
- **WZL-NC**
- **WZL** WOP-Tool

ISO 14649 offers benefits in manufacturing

- Improvement in the flexibility and autonomy of processing modules in manufacturing systems.
  - **Clear geometry and task description**
  - **Complete information to take decisions**
  - **High-level data for enhanced functionalities**
  - **Scalable realisation depending on technology and functionality**

- Improved exchange of information between manufacturing cell and it's environments
  - **Improvement of work flow in the process chain**
  - **Availability of consistent data**
  - **Structured model to handle geometry as well as technology**
  - **Interface to the growing STEP standard and its applications**

Agenda

#1= Topic(‘Welcome & Introduction to STEP-NC (ISO 14649)‘,(‘Prof. M. Weck ‘,‘J. Wolf‘));
#2= Topic(‘Automotive use of STEP-NC‘,(‘Dr. M. Weyrich‘,‘P.-A. Carlsson‘);
#3= Topic(‘Passing more than simple paths and switching commands to the NC‘,(‘P. Müller`);

#20= Topic(`Coffee Break`,$);

#4= Topic(`Feature based NC programming in CATIA V5 CAM modules`,(` Mr. Scarcelli`));
#5= Topic(`Know-how feedback based on manufacturing features`,(` Mr. Y.T. Hyun`));
#6= Topic(`Build anywhere using STEP-NC`,(` Prof. M. Hardwick`));

#30= Topic(`Lunch`,$);

#7= Topic(`STEP-NC for turning – Data model & implementation`,(`Prof. S.-W. Suh`));
#8= Topic(`Integration of STEP-NC into lathe machine tools`,(`Mr. S. Heusinger`));
#9= Topic(`Opening wire EDM applications through STEP-NC`,(`Dr. Nguyen`));

#40= Topic(`Coffee Break`,$);

#10= Topic(`Overview of STEP-NC in Korea`,(`Prof. W.H. Kwon`));
#11= Topic(`STEP-NC for Milling and RP in Korea‘,(`Mr. W. Lee`));
#50= Topic(`Demonstration‘,$);