TurnSTEP:
Tools to create CNC turning programs

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Part 1: Prologue

State-of-the-art of STEP-NC

- Started for the purpose of replacing G & M codes used for over 50 years
- 1994 Aachen (OPTIMAL), 1999 Europe STEP-NC, 2001 IMS STEP-NC
- Data model formalized as ISO 14649 (ARM by ISO TC184 SC1, AIM by ISO TC184 SC4) available as

  - IS version for Milling, Turning;
  - Lower version for EDM & under progress for Inspection, Combined Machining, Contouring, RP…
- Milling Prototype by Europe (Siemens, Oct 2000), US (STEP Tools, Nov 2000), Korea (POSTECH, May 2001)
- Turning Prototype under progress by POSTECH (1st version presented in Stuttgart, June 2003), (and possibly ISW, Dassault, …???)
- Future prospect;
  - STEP-NC not just as a new CNC language
  - As the fundamental means for realizing for e-Manufacturing, where the *collaborative* manufacturing cycle on the Internet *via standard information* is required
- Impact throughout the whole manufacturing sector including developer, user, R&D institution, government

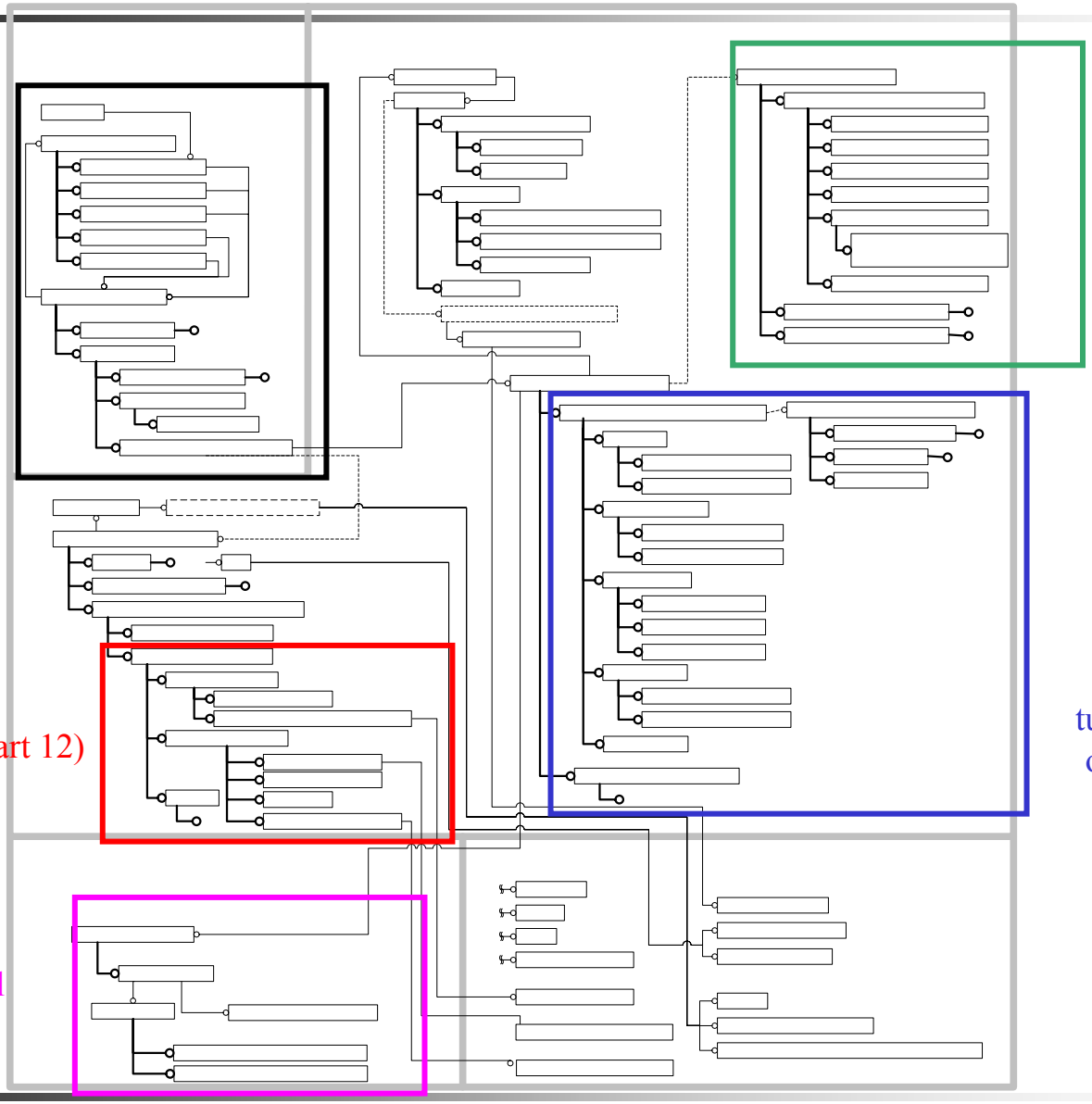
STEP-NC Turning Data Model (ISO 14649-12 & 121)

- Co-worked by two institutions since Feb 2001:
  - NRL-SNT of POSTECH, Korea
  - ISW of University of Stuttgart, Germany
- Version 6 (April 2002) for CD-ballot (May 2002 ~ August 2002)
- Accepted as CD and further revision based on the comments from many countries since ISO TC184 SC1/WG7 Seoul Meeting (Nov 1, 2002), Sandiago, Stuttgart, Paris, …
- Version 14 of Part 12 and Version 9 of Part 121 (March 2004) for DIS-ballot (March 2004 ~ August 2004)
- **Unanimously accepted as DIS/IS** (Zurich, Sept 2004);

"The voting period closed on August 16. and the ISO CS and SC1 reports showed the following results" (copied from Official Minutes of the Convenor Mr. Glantschnig) :

- **Part 12 Turning;** P-Members voting: 15 in favour out of 15 = 100% (requirement >= 66.66%)
- **Part 121 Tools for Turning;** P-Members voting: 15 in favour out of 15 = 100% (requirement >= 66.66%)
- With this result, ISO 14649-12 and 121 will become directly the status of IS International standard. The minor comments of Japan and UK will be taken care in a technical corrigenda.

Overall structure of ISO 14649 (Part 12 and 121)



A. Task de

project

program_structu

workplan

parallel

if_stateme

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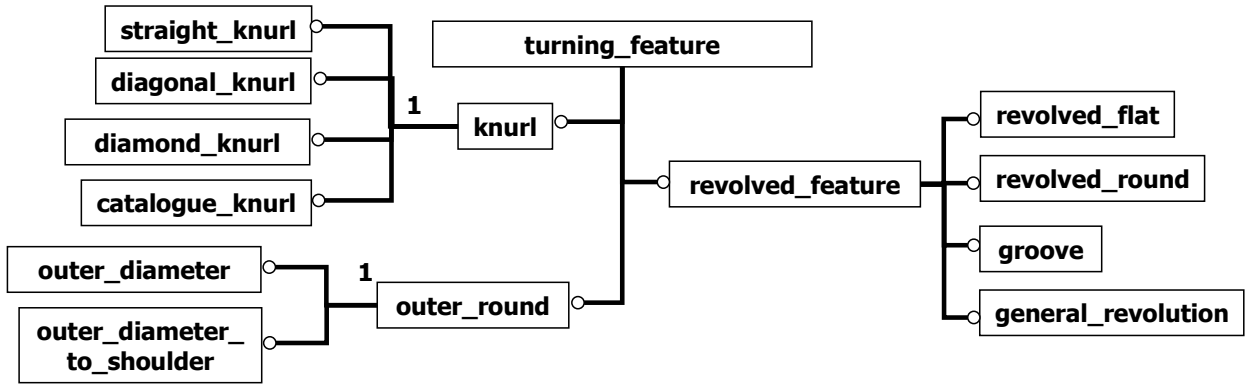
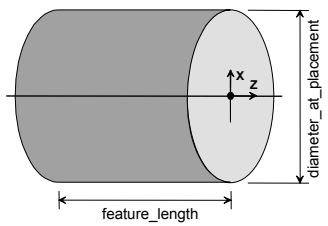
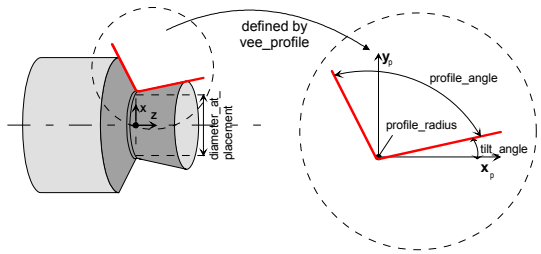
assignmer

Turning features

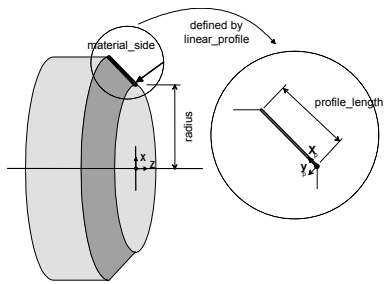




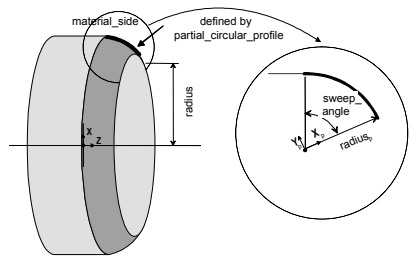
outer_diameter



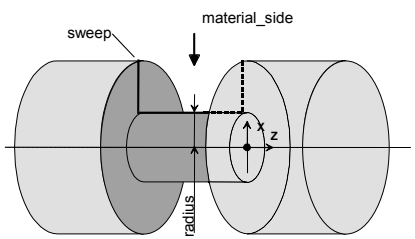
outer_diameter_to_shoulder



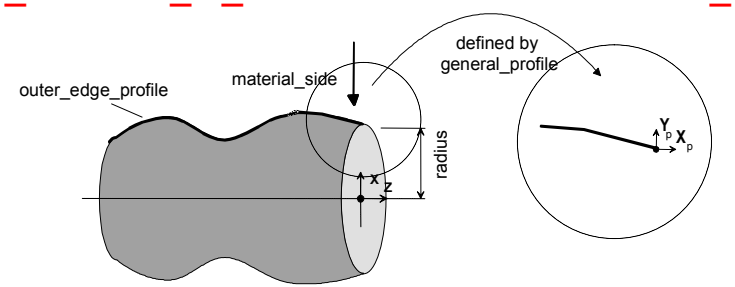
revolved_flat



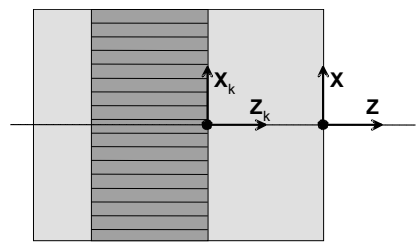
revolved_round



groove

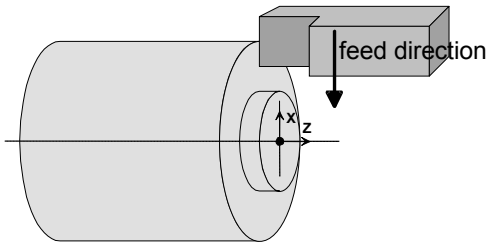


general_revolution

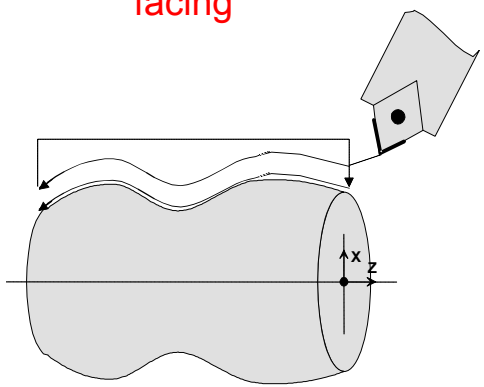


knurl

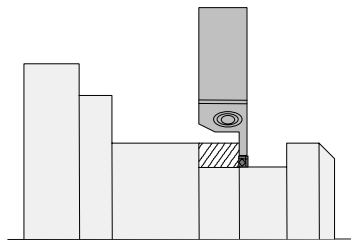
Turning operations



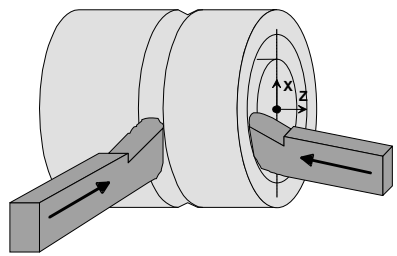
facing



contouring

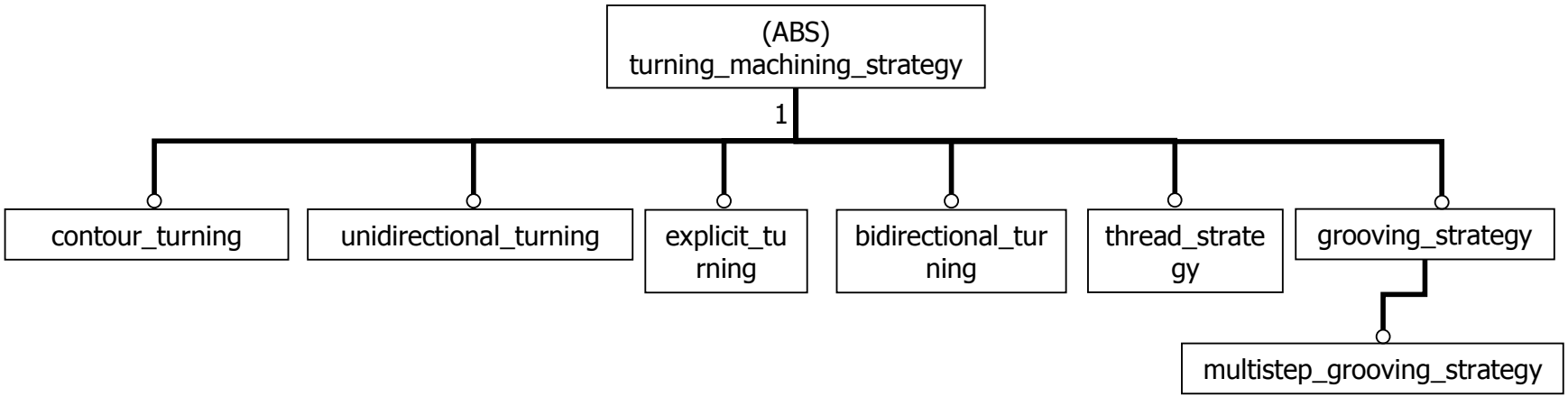


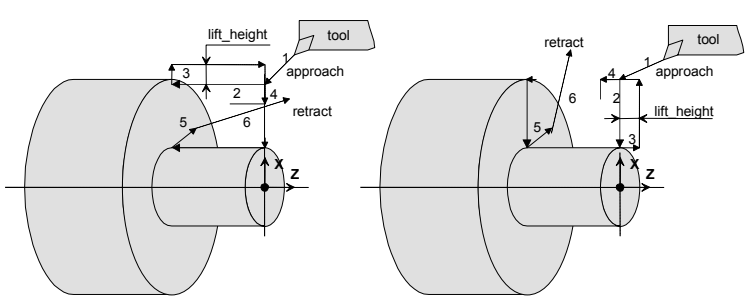
grooving



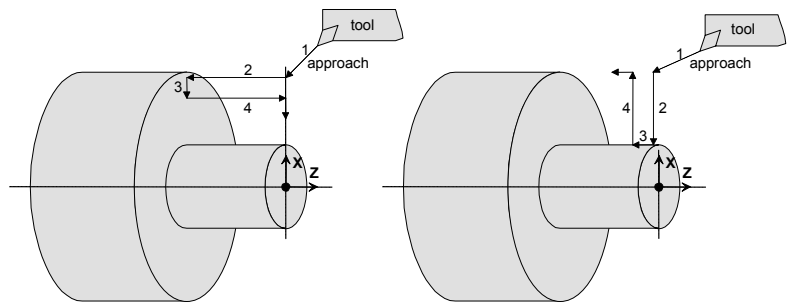
cutting in

Turning machining strategies

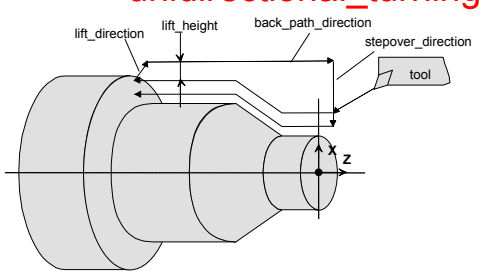




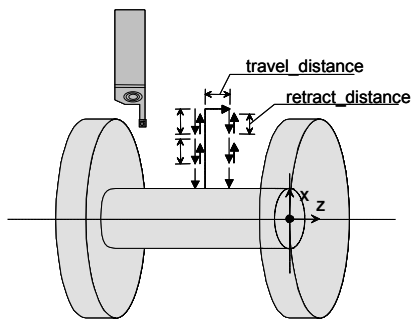
unidirectional_turning



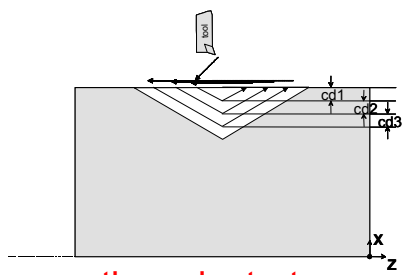
bidirectional_turning



contour_turning

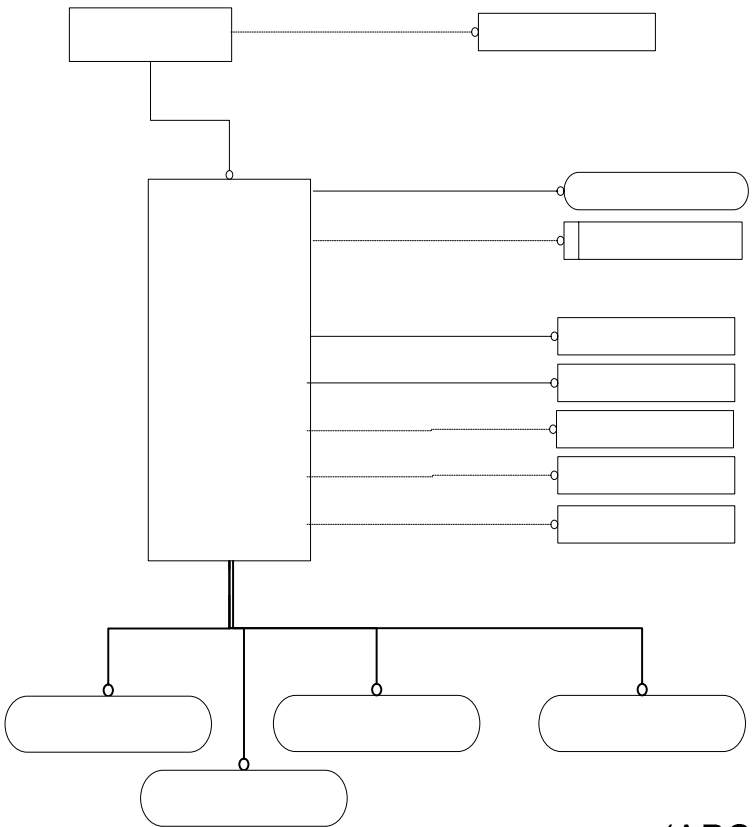


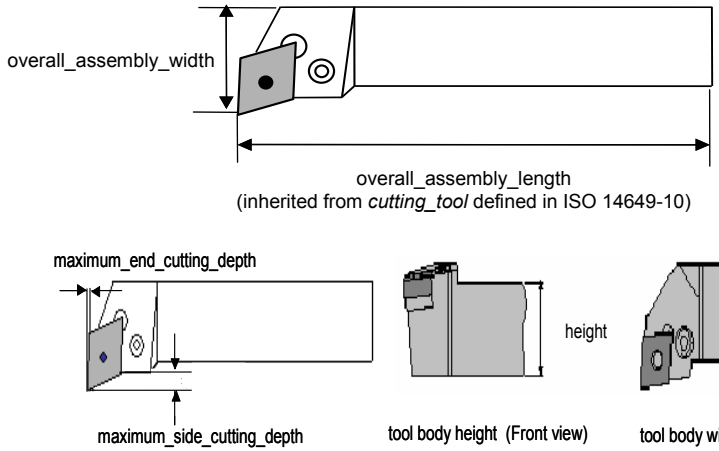
grooving/multi_step_grooving



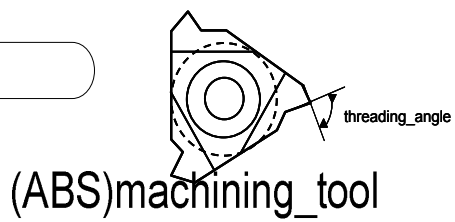
thread_strategy

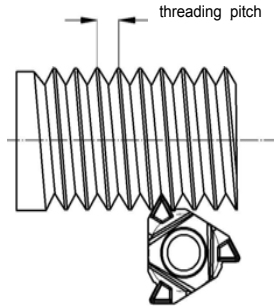
Turning cutting tools



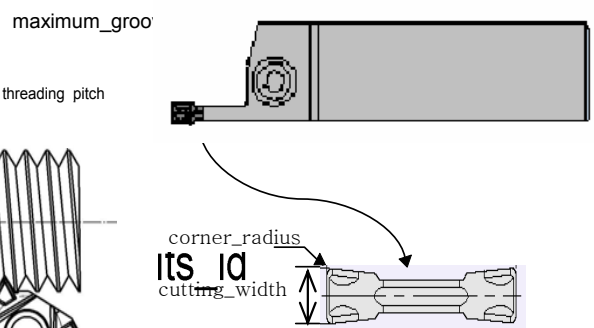


Attribute of turning_machine_cutting_tool





Threading tool



Grooving tool

Design philosophy of TurnSTEP

- Fully supporting ISO 14649 Part 12 and Part 121 → Means for verifying the data models
- Distributed architecture for e-Manufacturing;

  - CGS (Code Generation System) for generating Neutral (Hardware independent) STEP-NC code based on ISO 14649

  - CES (Code Editing System, installed on CNC) for editing/customizing for machine tool to be used for execution of STEP-NC code
- Extension for the Intelligent/Autonomous execution of the machining by fully utilizing the *rich* (compared with G-code) STEP-NC information → via ACS (Autonomous Control System)
- Providing a variety of data interface for e-Manufacturing;

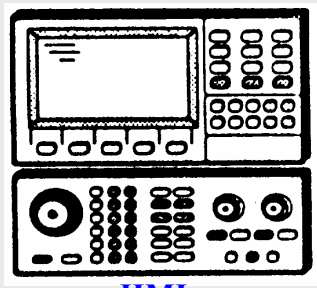
  - Physical file/XML translation capability

  - Local DB/global (Internet) DB
- Optimization of the machining sequences for the CNC controller → by nonlinear process planning available in the STEP-NC data model
- Automated + Interactive generation capability (e.g., feature recognition, alternative generation, process sequence, cutting conditions, etc)

Three sub-systems of TurnSTEP

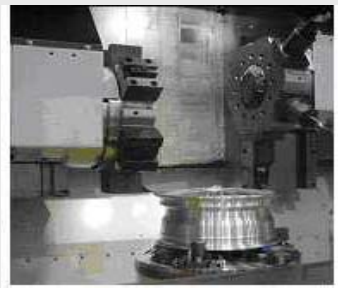
STEP/STEP-NC on the Internet

STEP AP(CAD) files | **ISO 14649 part program** | **ISO 14649 part program**

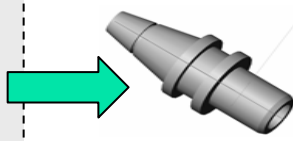


HMI

EPSG



NCK/PLC



CGS (Code Generation System)

- Input : STEP AP (CAD) files
- Output : ISO 14649 part program
- Functions
  - Part visualization
  - Machining feature recognition
  - Generation of hardware-independent Neutral Process Sequence Graph (NPSG)
  - Generation of ISO 14649 part pro'g
  - Interpretation/Edit of ISO 14649 part program

CES (Code Edit System)

- Input : ISO 14649 part program
- Output : HPSG, EPSG
- Functions
  - Interpretation of part pro'g
  - Verification of logical contents
  - Generation of Hardware-dependent Process Sequence Graph (HPSG)
  - Generation of tool path
  - Generation of Executable Process Sequence Graph (EPSG)

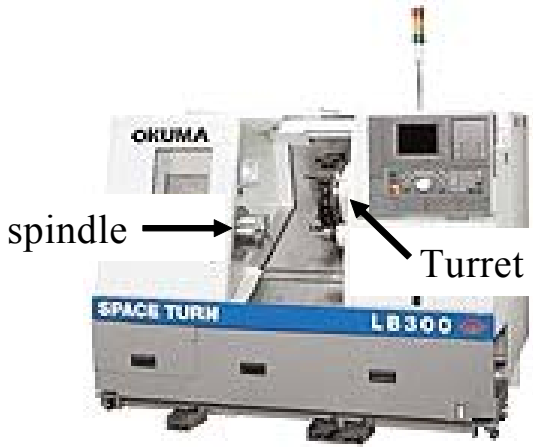
ACS (Autonomous Control System)

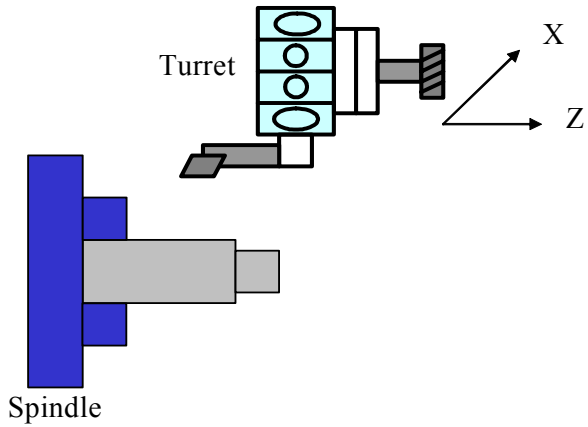
- Input : EPSG (and HPSG)
- Output : Machined part
- Modules:
  - Setup Manager
  - Intelligent Scheduler
  - Adaptive TPG
  - OMM & Quality Report
  - Remachining
  - Emergency handling
  - Monitoring / Adaptive Control

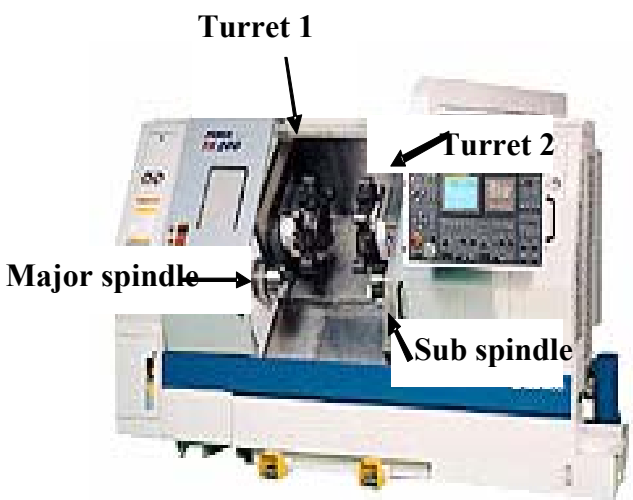
Capability of TurnSTEP system (Informative)

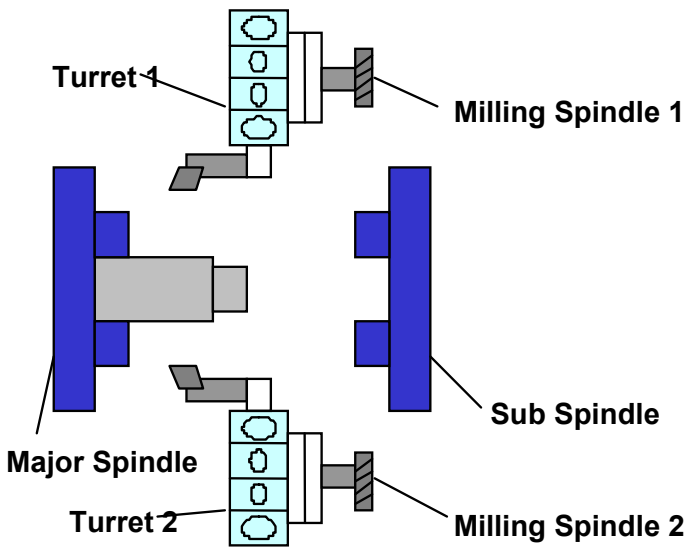
- Capable of Delta volume decomposition
- Capable of Automatic/Interactive/ Alternative Feature recognition for ISO 14649 part 12 turning features
- Capable of Non-linear process planning
- Capable of Automatic generation of ISO 14649 part program
- Capable of Interpretation of ISO 14649 code
- Capable of Data interchanging between XML and STEP-NC part program
- Capable of Hardware dependent process planning
- Capable of Generation of optimal process planning
- Capable of Generation of tool path for simultaneous machining and parallel machining for 2 turret 2 spindle machine
- Capable of Autonomous/Intelligent control

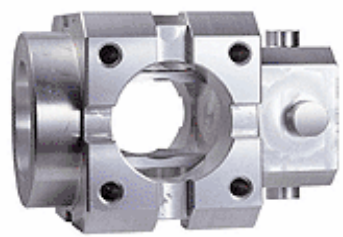
Various hardware configuration



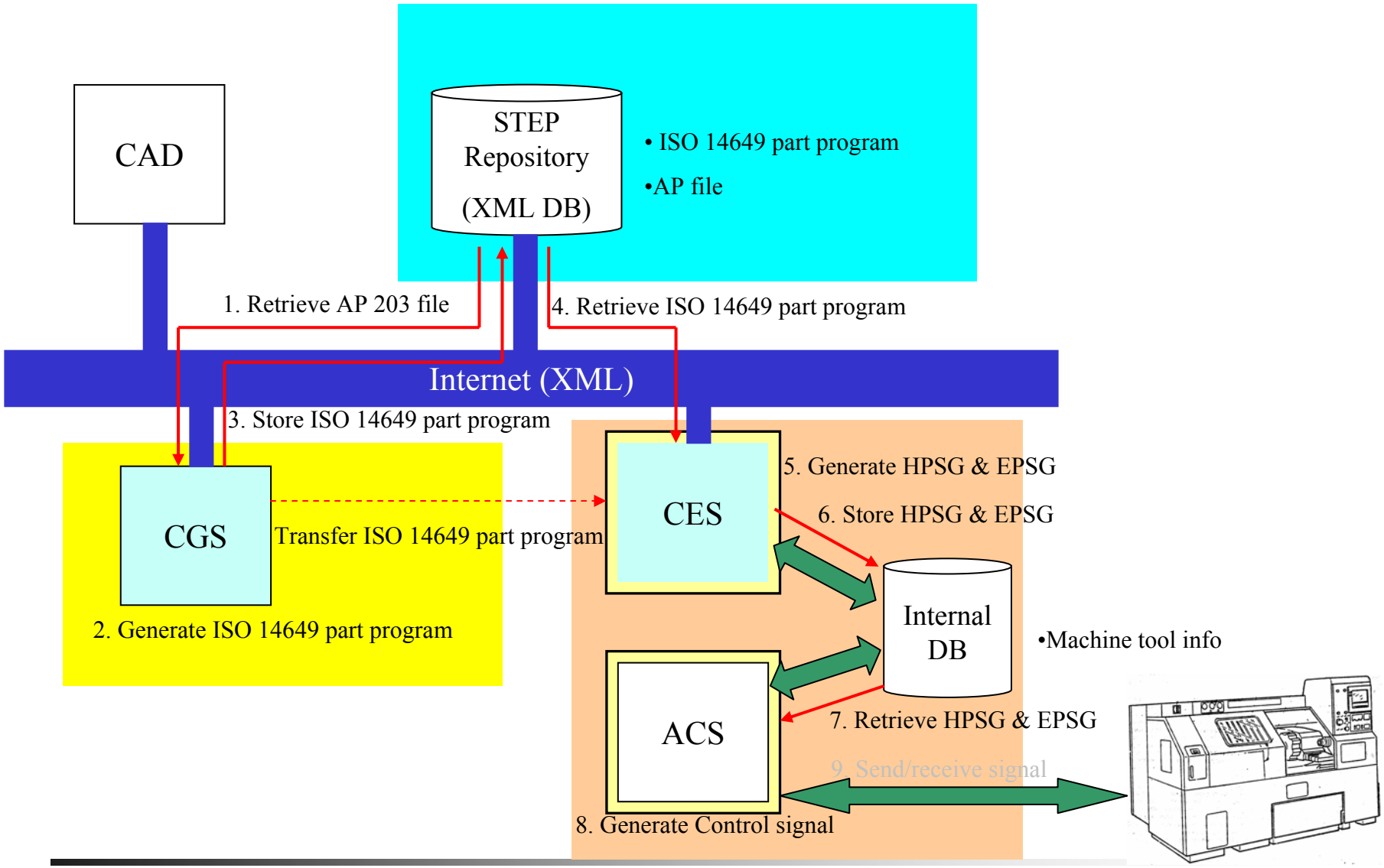








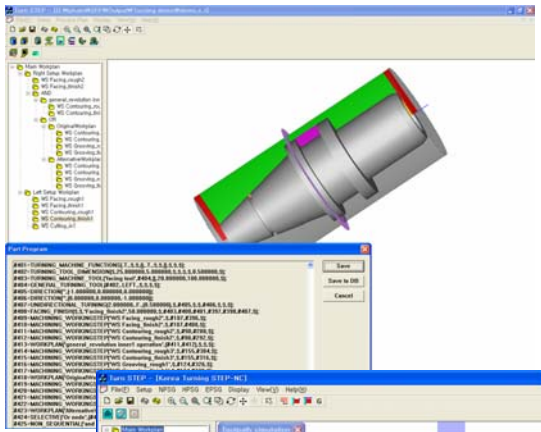
Usage scenario

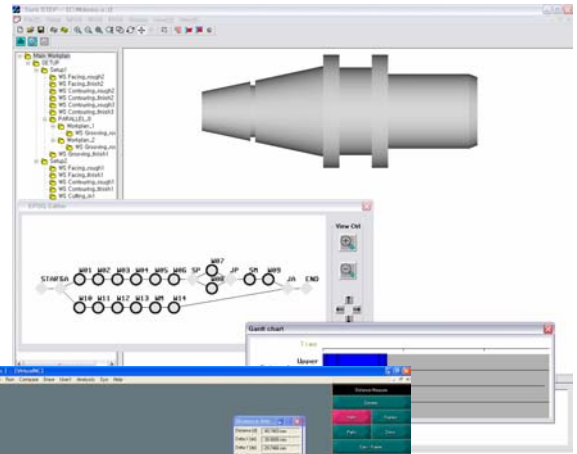


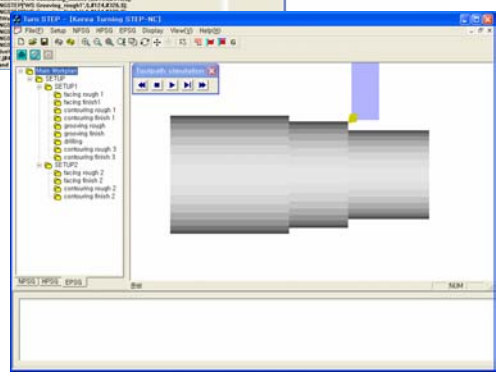
TurnSTEP System
(ISO 14649 based intelligent turning STEP-NC system)

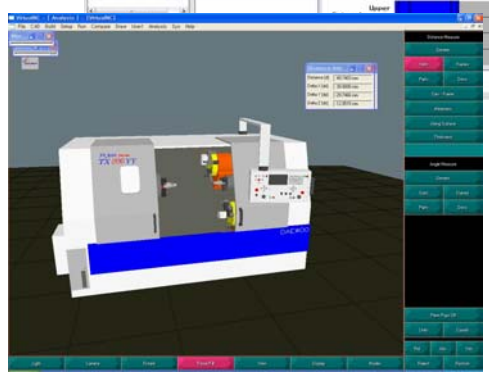
Introduction

- TurnSTEP system is a first turning STEP-NC system based on ISO 14649
- TurnSTEP system is composed of three sub-systems: CGS, CES, ACS
- CGS system is for generatingan ISO 14649 code generation system
- CES system is a code edit system based on the machine configuration
- ACS system is an autonomous control system based on the ISO 14649 and machine configuration info.



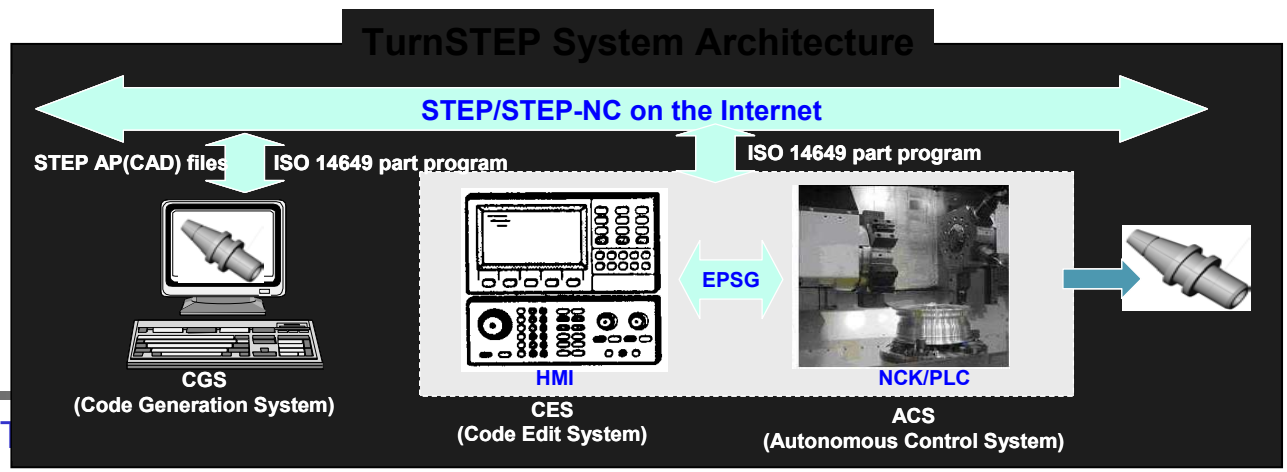






Capabilities

- Delta volume decomposition
- Automatic/Interactive/ Alternative Feature recognition for ISO 14649 part 12 turning features
- Automatic generation of ISO 14649 part program
- Interpretation of ISO 14649 code
- Non-linear process planning
- Hardware dependent process planning
- Data interchanging between XML and STEP-NC part program

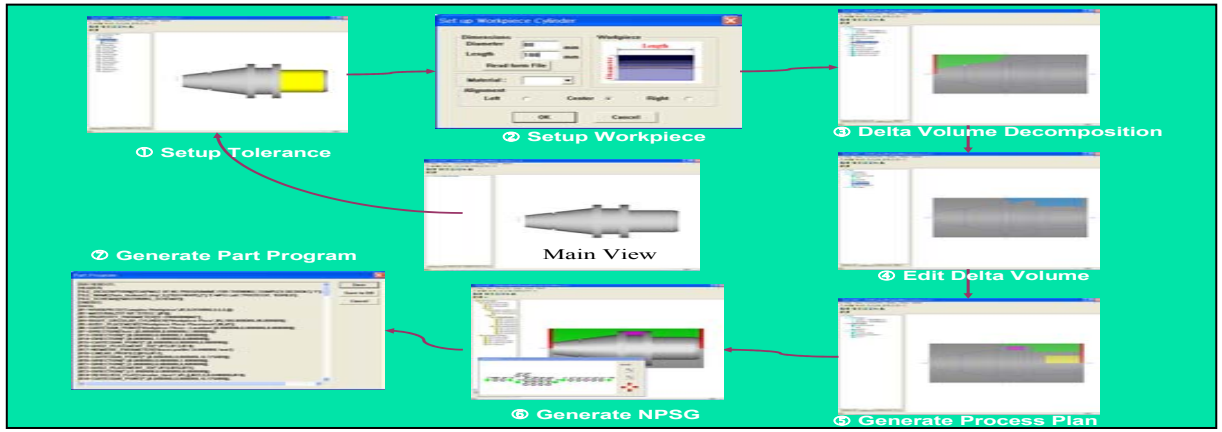


TurnSTEP System

(ISO 14649 based turning STEP-NC system)

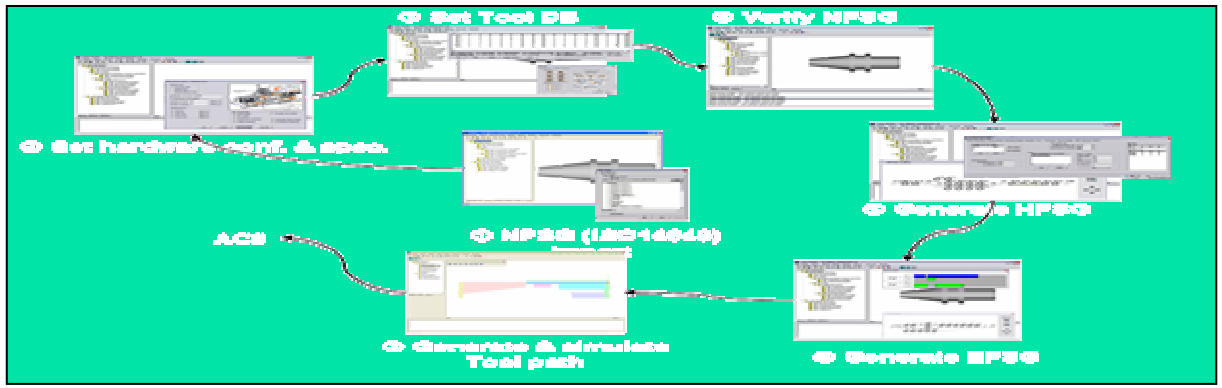
CGS

- Input : STEP AP (CAD) files
- Output : ISO 14649 part program
- Functions
  - Part visualization
  - Machining feature recognition
  - Generation of hardware-independent Neutral Process Sequence Graph (NPSG)
  - Generation of ISO 14649 part pro'g
  - Interpretation/Edit of ISO 14649 part program



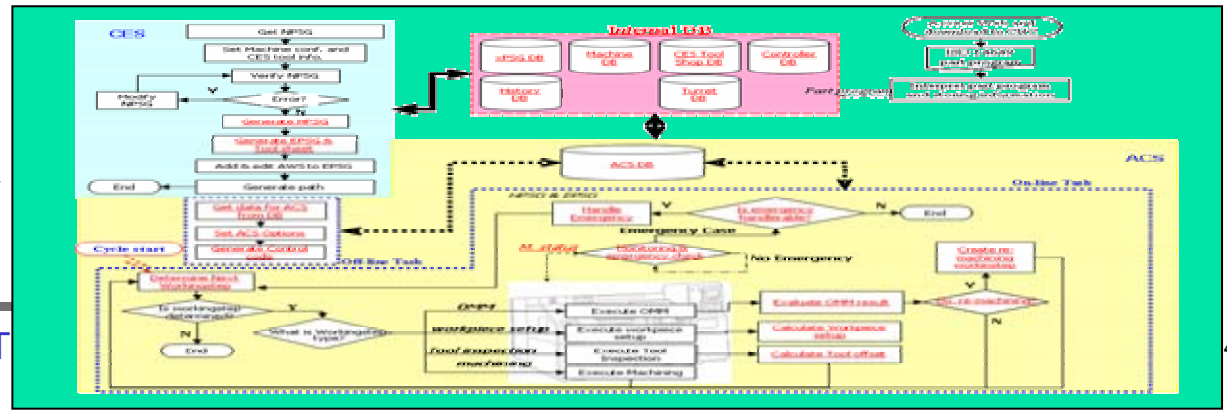
CES

- Input : ISO 14649 part program
- Output : HPSG, EPSG
- Functions
  - Interpretation of part pro'g
  - Verification of logical contents
  - Generation of Hardware-dependent Process Sequence Graph (HPSG)
  - Generation of tool path
  - Generation of Executable Process Sequence Graph (EPSG)



ACS

- Input : EPSG (and HPSG)
- Output : Machined part
- Modules:
  - Setup Manager
  - Intelligent Scheduler
  - Adaptive TPG
  - OMM & Quality Report
  - Remachining
  - Emergency handling
  - Monitoring / Adaptive Control




STEP
NC
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POHANG UNIVERSITY OF SCIENCE AND TECHNOLOGY
포항공대
1986

Thank you