Projeto STEP-NC Embraer

Processos de Manufatura Avançada Baseada no Padrão STEP e STEP-NC

Projeto Finep TECSA 1/2010

Embraer-UnB-UFSC

Coordenador: Prof. Alberto J. Álvares

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31/08/2010

Objetivos

- Propor projeto conjunto UnB-Embraer para FINEP
- Participação Embraer como Interveniente ou Colaboradora Sem Aporte Financeiro
- Processos de Manufatura Avançado Baseado no Padrão STEP-NC – AP238
- Discussão sobre necessidades Embraer em Manufatura Avançada associada Processos de Usinagem com Máquina CNC
- Atender interesses específicos Embraer:
  - Implantação MES;
  - Traceability (Rastreabilidade de dados gerados no Processo);
  - Gerenciamento Ferramentas;
  - Estratégias de otimização de usinagem;
  - Manufatura em Malha Fechada;
  - Integração com Inspeção;
- Adoção no futuro do Padrão STEP-NC e AP238

Edital: Datas e Contrapartida

Lançamento da Chamada pública	09/07/2010
Disponibilização do Formulário - FAP	23/07/2010
Data final para envio eletrônico da proposta	08/09/2010
Data final para o envio das cópias impressas	09/09/2010
Divulgação Resultados	A partir de 5/11/2010

PORTE EMPRESA	FATURAMENTO ANUAL	APORTE MÍNIMO
Micro e pequeno porte	Até R$ 2.400.000,00	5%
Pequena	De R$ 2.400.000,01 a R$ 16.000.000,00	10%
Média	De R$16.000.000,01 a R$ 90.000.000,00	50%
Média-grande e Grande	Maior de R$ 90.000.000,00	100%

Edital: Critérios Avaliação

CRITÉRIOS	Δ NOTAS	PESO
Aderência da proposta aos objetivos, adequação da metodologia e sua compatibilidade com o cronograma físico.	1 - 5	3
Qualificação técnica da equipe executora da ICT e sua adequação às necessidades da proposta.	1 - 5	4
Capacitação técnica da equipe da Instituição Interveniente Cofinanciadora.	1 - 5	4
Adequação do orçamento e cronograma de desembolso aos objetivos da proposta.	1 - 5	3
Aporte de recursos financeiros da Instituição Interveniente Cofinanciadora, em relação aos recursos globais do projeto.	1 - 5	5
Adequação da infraestrutura das instituições executora e cofinanciadoras para o desenvolvimento do projeto.	1 - 5	5
Incorporação dos resultados esperados do projeto proposto para os setores produtivos considerando o impacto do produto ou sistema no mercado e sua importância estratégica para a sociedade.	1 - 5	5

Edital: Valores

- apresentar valor total solicitado ao FNDCT de no mínimo R$ 1.000.000,00 (um milhão de reais);
- solicitar ao FNDCT no máximo R$ 4.000.000,00 (quatro milhões de reais), incluindo o valor das bolsas.

4. RECURSOS FINANCEIROS A SEREM CONCEDIDOS

No âmbito desta Chamada Pública, serão comprometidos recursos não-reembolsáveis no valor de R$ 23.000.000,00 (vinte e três milhões de reais) originários do FNDCT/CT – AERO.

Dos recursos financeiros a serem concedidos ao proponente, 30% deverão ser aplicados nas regiões Norte (N), Nordeste (NE) e Centro-Oeste (CO). Caso o valor total das propostas selecionadas, oriundas dessas regiões, seja inferior a este percentual, os recursos não aplicados serão automaticamente transferidos às propostas com melhor classificação de outras regiões.

STEP-NC
Closed Loop Machining

Martin Hardwick
David Loffredo
info@steptools.com

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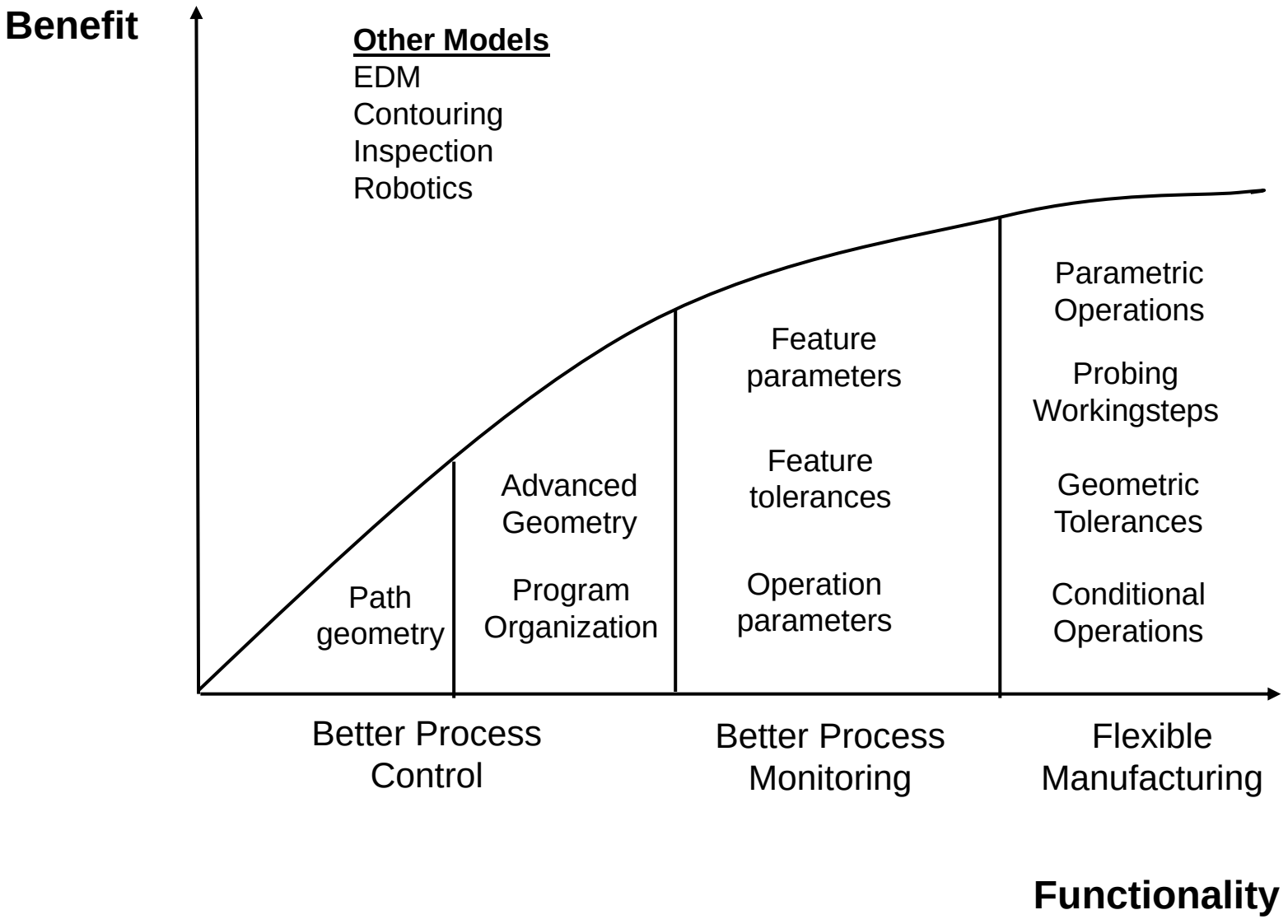
Watervliet Arsenal, Building 20
Metal Processing Manufacturing Division
Watervliet, New York 12189
(518) 687-2848 / (518) 687-4420 fax
http://www.steptools.com

STEP-NC AP-238

- **What is AP-238?**
  - An ISO Standard for CNC data
  - Interfaces with CAD, CAM, CNC and PLM systems
- **How does it operate?**
  - Defines an object model for:
    - » Workingsteps – e.g. WS 1, WS2 etc
    - » Operations – e.g WS1 is Rough milling
    - » Features and tolerances – e.g. Pocket being rough milled
    - » Tooling – e.g. Required attributes for rough pocket milling
    - » Toolpath – e.g. Path, speeds and feeds to mill the pocket

STEP-NC Functionality



Applications

- **Smart Process Control**
  - Operator needs to change a speed for all pocketing operations
  - CNC identifies all pocketing workingsteps that use this feed.
- **Smart Process Monitoring**
  - Motion control records maximum Z tool tip position for Hole 1
  - Customer checks hole feature has required depth.
- **Smart Manufacturing**
  - CNC measures in-process part
  - CAM generates modified tool paths

Production testing

STEP NC

“4 CAM’s – 2 Controls – 0 Postprocessors”

UGS The PLM Company

CATIA

Mastercam CAD/CAM Systems

DibuCAM

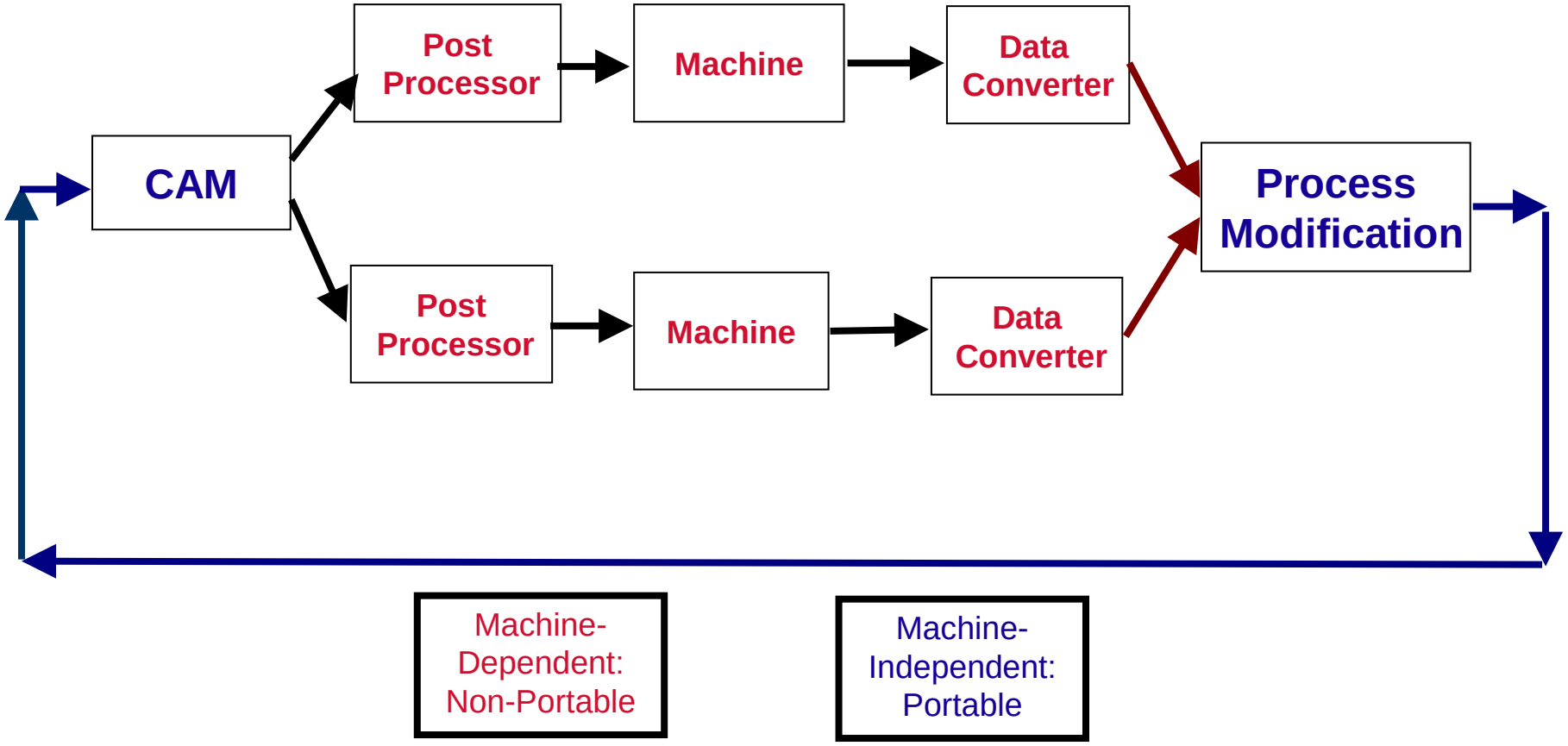
STEP-NC

AB Tool Tilt

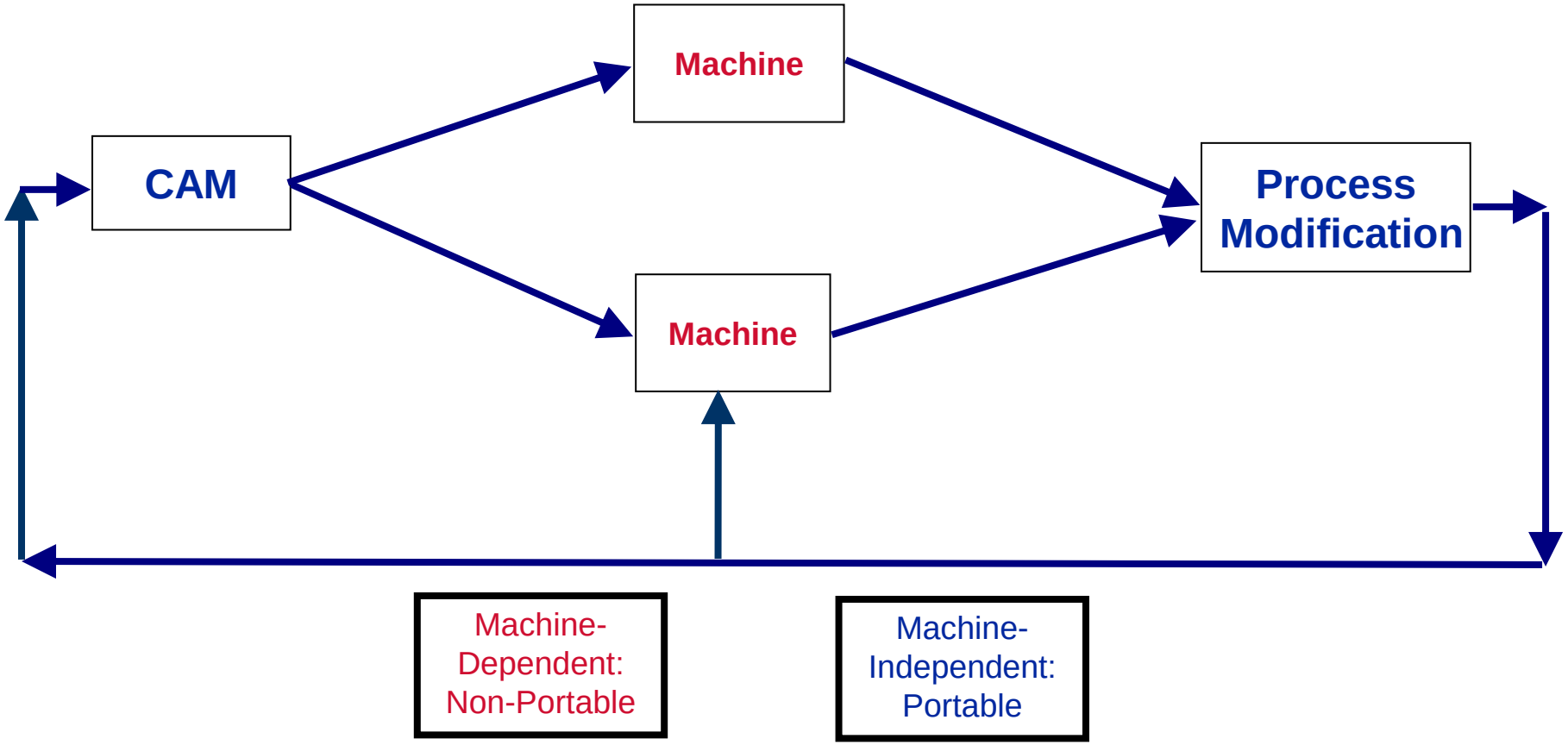
BC Table Tilt

Boeing
NIST
GDLS
P&W
Caterpillar
GM
Lockheed
Army

“Traditional CNC” Closed-Loop Machining



“Smart CNC” Closed-Loop Machining



Current Status

- **Can machine any part**
  - CDS NAS 979 part with a five axis cone
  - Path geometry, machining functions, technology parameters
- **Software Dll's ready for production testing**
  - Stage 1 – replace RS274D but keep same procedures
  - Stage 2 – optimize procedures using new intelligent data
- **Implement by**
  - Add STEP-NC export to the CAM
  - Add STEP-NC converter to control

Conclusion

- **STEP-NC delivers rich data to the control**
- **The benefits are well known**
  - More accurate machining
  - Design anywhere, build anywhere
  - Fewer operational errors
  - Faster set-up and more flexible manufacturing
- **The Post was in the way**
  - STEP-NC eliminates the post
  - Rich data from the CAM into the control and back again
  - Enabling closed loop machining

Early AP-238 Implementation at Boeing

David Odendahl
Sid Venkatesh
ISA Expo 2005
10/27/2005

PTQ VIDEO

- 777 ER VIDEO

Part 1:

Background

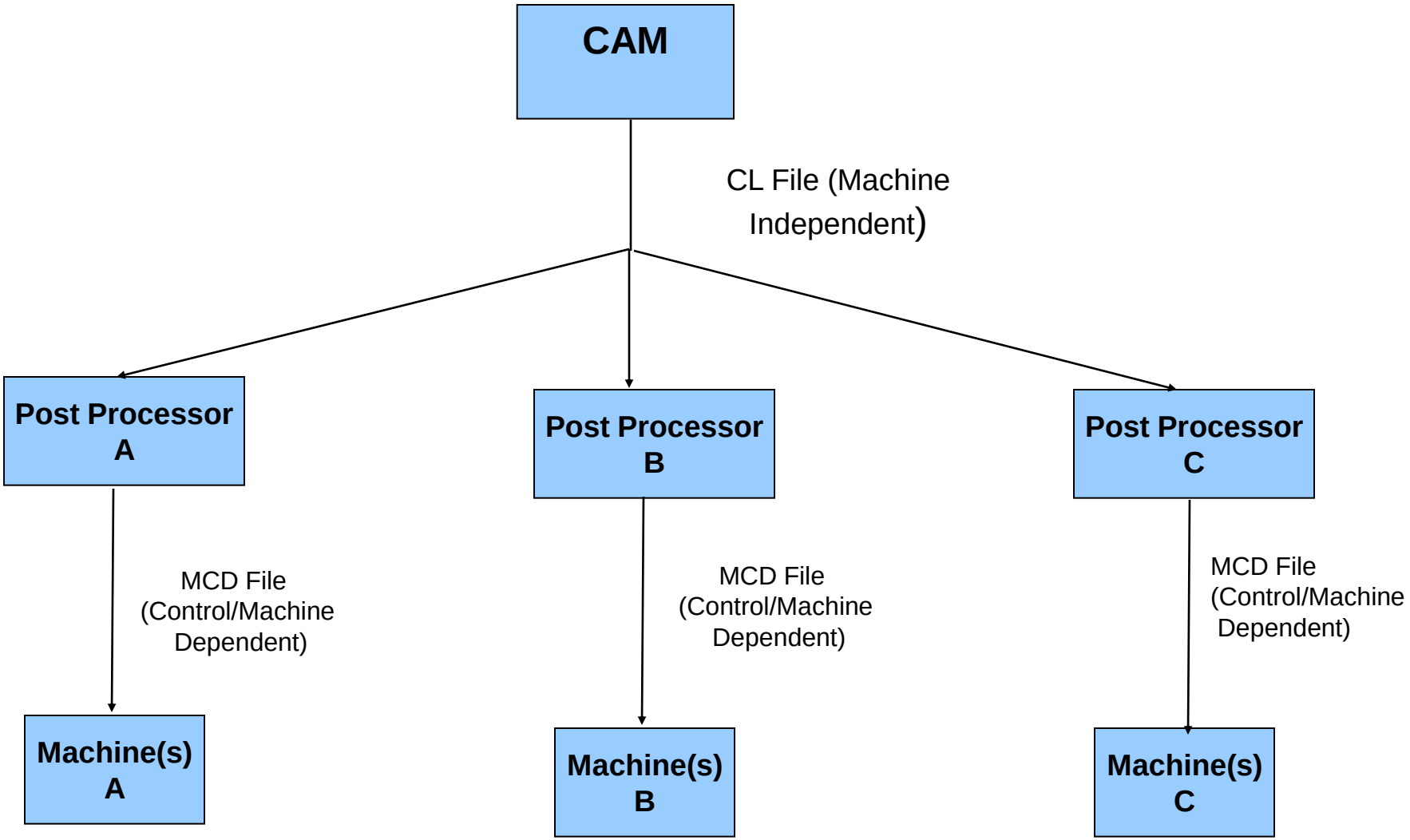
Present Situation - “Dumb CNC”

- **Presently, CNC machines receive data defining the axis movement required in order to manufacture a part. This is referred to as MCD or machine control data.**
- **MCD is a very low level of instruction. Traditionally, CNC machines do not have access to higher-level information about the tasks they are executing or the part they are trying to manufacture.**
- **High-level intelligence is only utilized at the CAD and CAM stages of the manufacturing process.**
- **Why???**

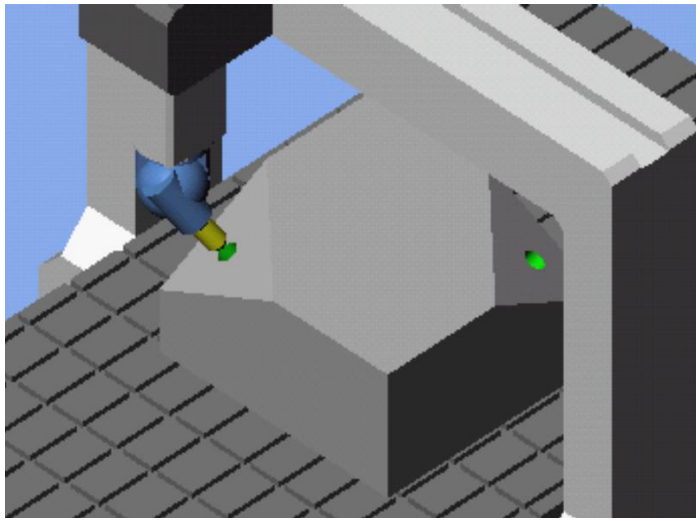
“Dumb CNC” Problems

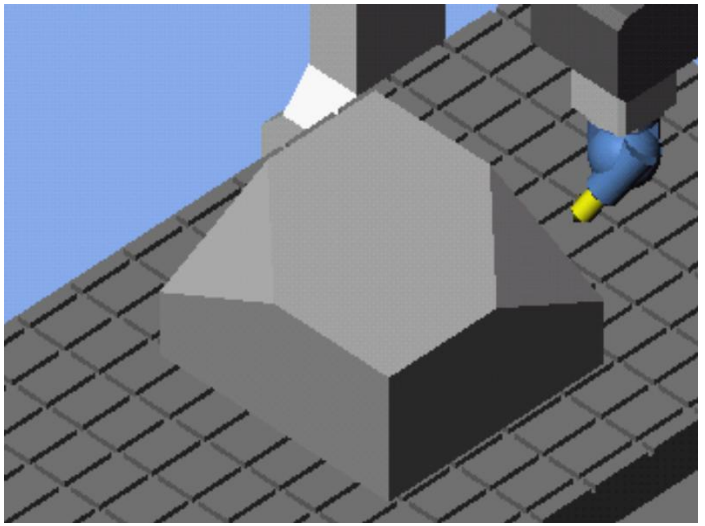
- Not Portable
  - **Unique data must be generated for each machine control combination on which the part is to be run**
- Not Adaptable
  - **No information is provided to the machine to help it adapt to real-time changes in machining dynamics and machine tool alignment.**
- Existing standards are weak
  - **Data format inconsistencies**

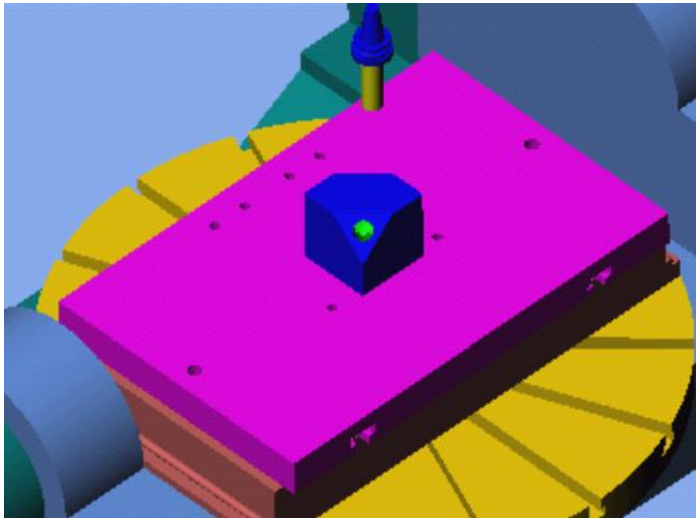
“Dumb CNC” Data Flow

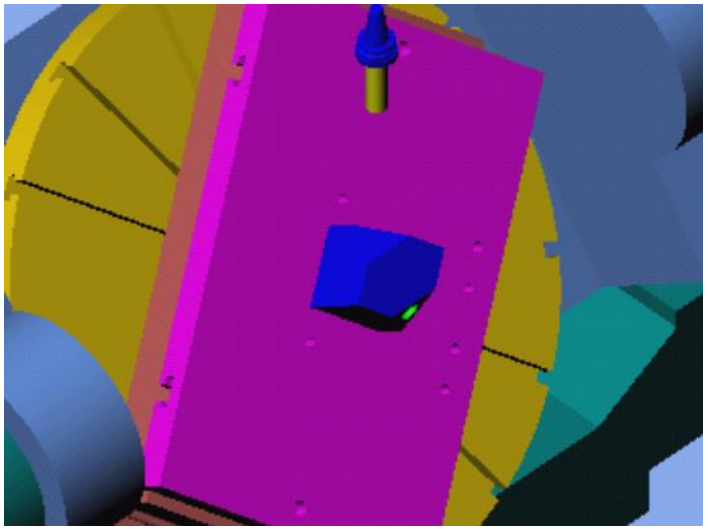


Axis Motion vs. Cutter Motion









Target - “Smart CNC”

- **Cutter movement data, instead of axis movement data, is sent to the CNC. Sophisticated CNCs have the capability of converting cutter movement data to axis movement data.**
- **High level information about the part features, materials, cutters, and dimensional tolerances can also be sent to the CNC.**
- **This information should be sent using a data standard such as: AP238 “STEP-NC”.**

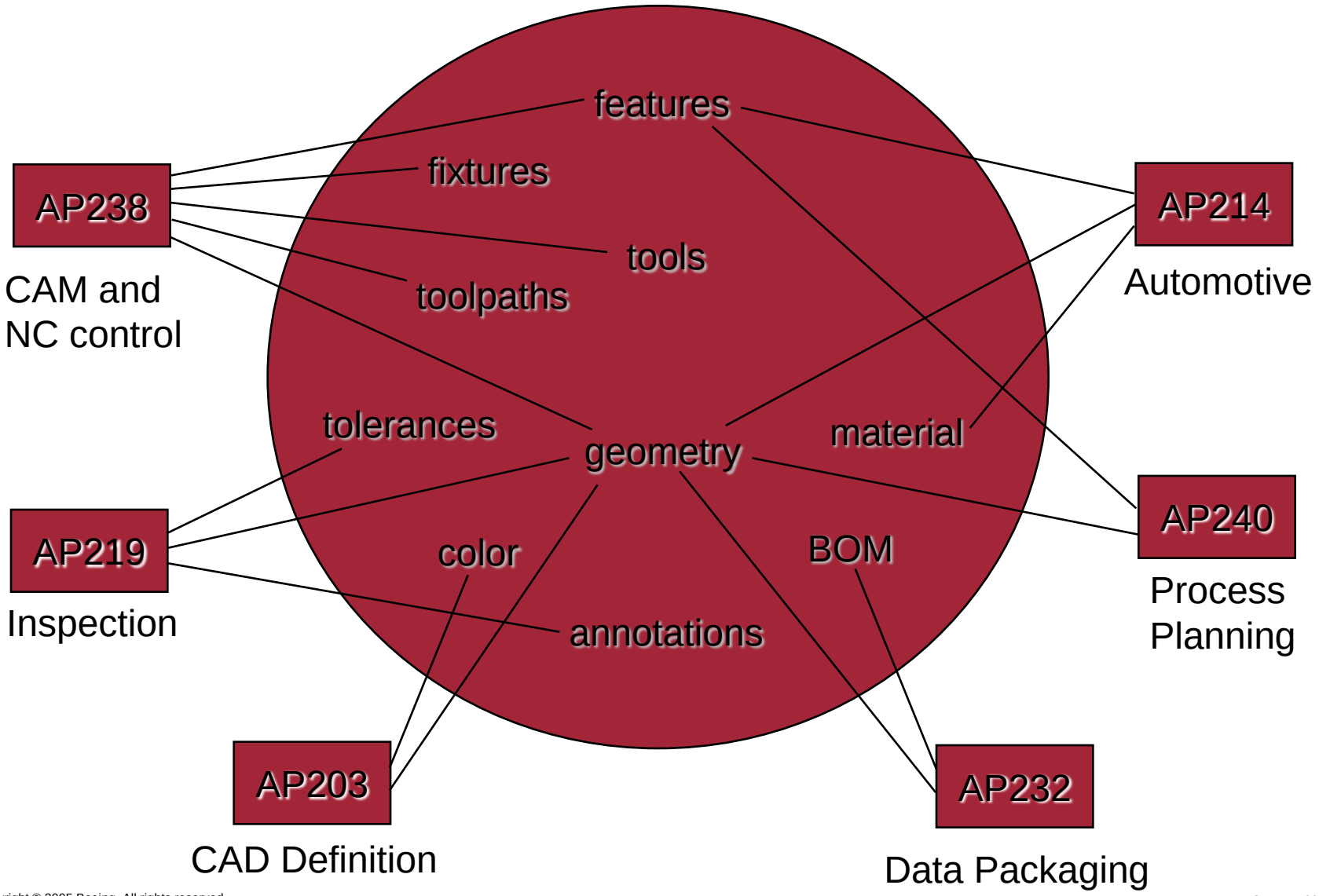
Benefits

- Portable
  - **Cutter motion data is “machine neutral” and may be used directly by machines with different geometries**
- Adaptable
  - **High level data can be used by the CNC to adapt to changing machining conditions between similar machines**
- Expandable
  - **A route is established to transfer other data/ information to and from the CNC, such as As-built measurement data, machine health, etc.**
- Defined
  - **As a part of the ISO STEP standard, the data format and CNC response to the data is clearly defined**

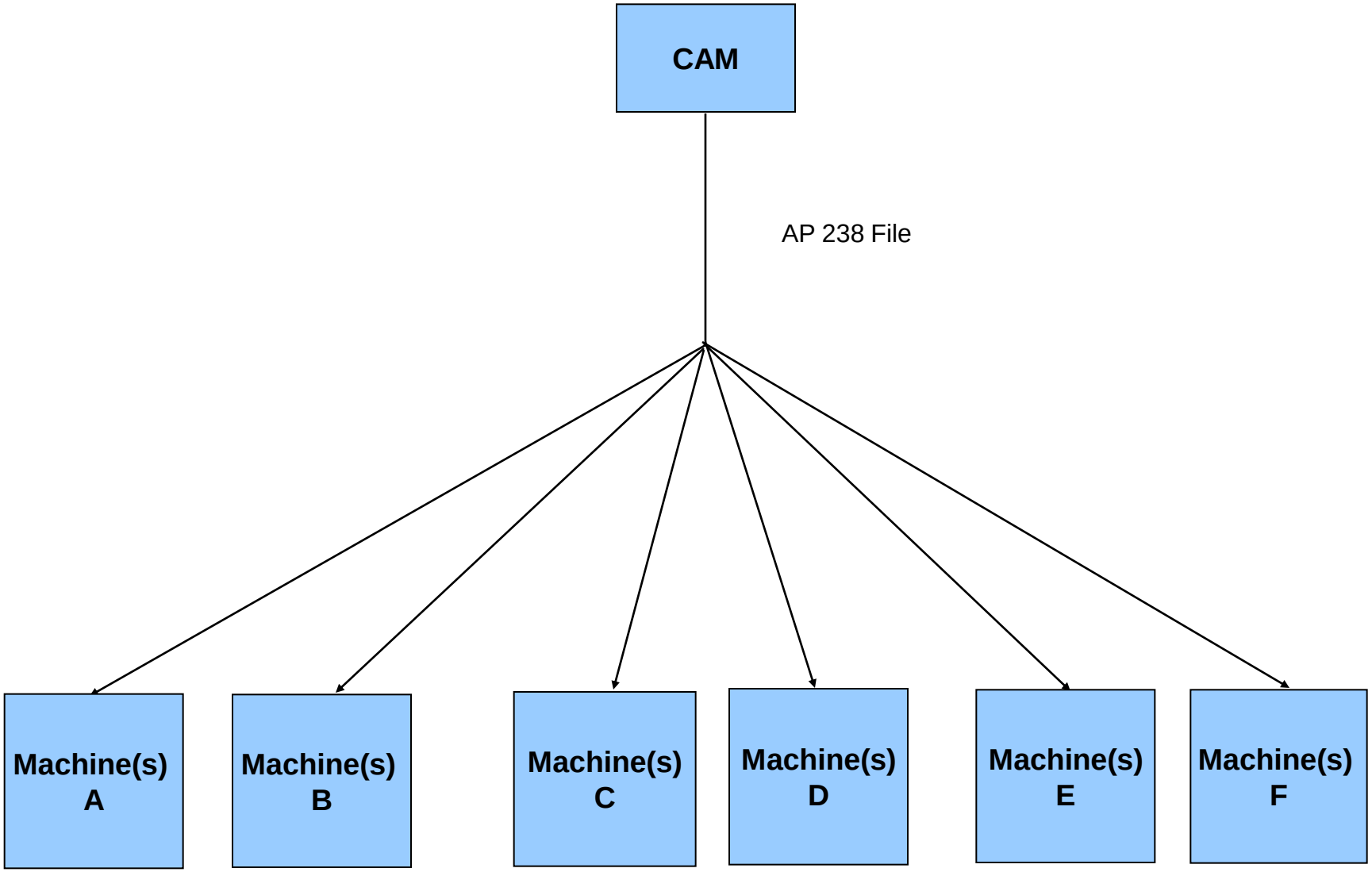
AP238 or “STEP-NC” is:

- A part of the ISO suite of STEP product standards
- A standard way of transmitting **process and part** information to/from CNCs and CAM systems

STEP: Standard for the Exchange of Product Data



AP238 Data Flow



Capabilities of AP238 Data

- Cutter movement data, in addition to axis movement data can be sent to the CNC.
  - Sophisticated CNCs have the capability of converting cutter movement data to axis movement data.
- High level information about the part geometry, materials, cutters, and dimensional tolerances can also be sent to the CNC.
- Higher level tool path descriptions directly supported
- As a part of the ISO STEP standard, the data format and CNC response to the data is clearly defined

Part 2:

The State of AP238

A New way of Looking at AP238

- **AP238 supports both part and process data**
  - Previously, transfer of part data was emphasized
    - Technology not mature
  - Transfer of process information is now emphasized
    - Much easier to implement
  - Part information will be phased in as adoption/technology permits

The ISO STEP Process

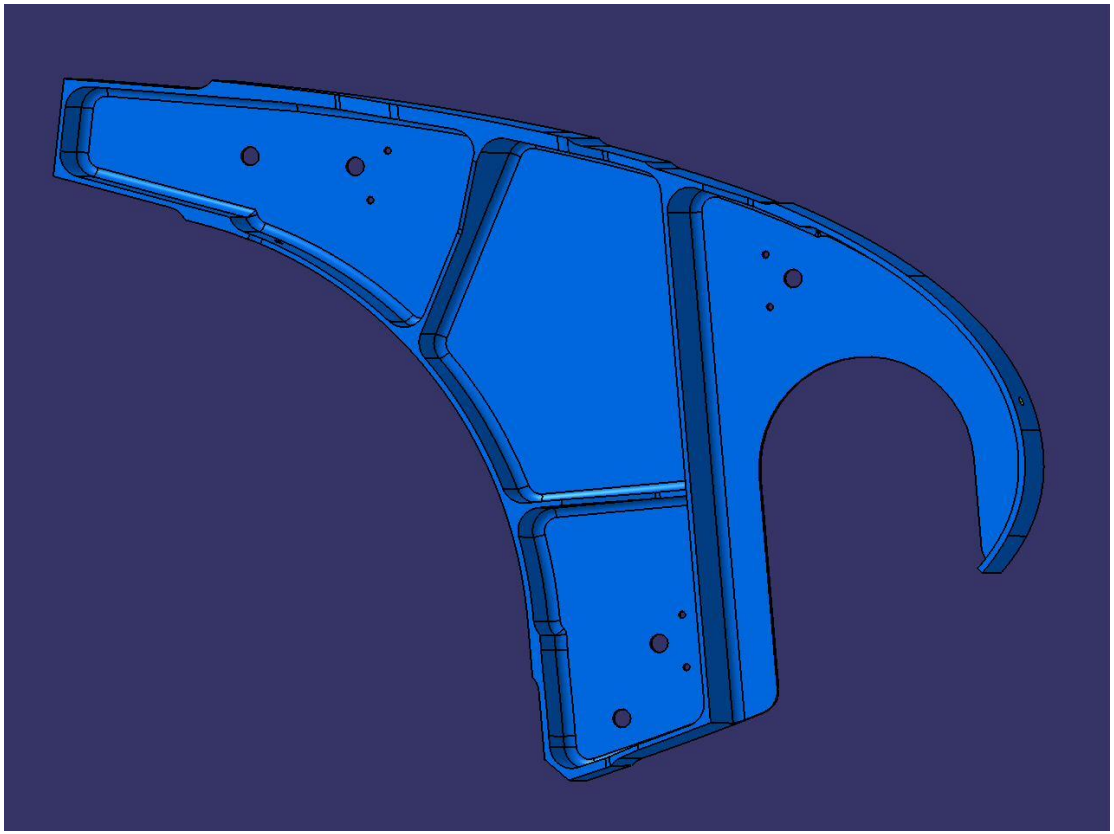
1. Proposal: **Anybody interested?**
2. Preparatory: **Working drafts**
3. Committee: **Finalize submission (DIS)**
4. Enquiry: **2/3 vote for final draft (FDIS)**
5. Approval: **2/3 vote includes comments**
6. Publication: **Becomes ISO standard**
7. Review: **At least every 5 years**

Boeing 2004 Testing

- **Is AP238 practical?**
  - **Are file sizes reasonable?**
  - **Is processing time reasonable?**
  - **Can we make a “real” part with this?**

Test Part

5-axis Aerospace Part



5-Axis Aerospace Part

- **CATIA CL file size: 2077 KB**
- **AP238 Part 21 file size: 2305 KB**
- **NC file size: 560 KB to 1304 KB**
- **Total processing time: 20 seconds**

  (1 GHZ Pentium)

2004/2005 Demonstrations

• 5-axis NAS979 test part machined	8/04
• 5-axis NAS979 portability	8/04 – 12/04
• 5-axis aerospace part machined	12/04
• CAM to CNC portability	2/05
• Closed Loop Machining	4/05
• Visualization	?/05

Vendor Commitments

- Dassault
- UniGraphics
- Siemens
- Fanuc
- Others

Part 3:

The Future

Summary

- **An alternative exists for the 50-year old data model used for CNC machine tools**
- **After missteps, AP238 is gaining momentum**
- **Cultural issues abound**
- **We need to get together more often**

Part 4:

Questions and Discussion

Boeing's AP238 (STEP-NC) Early Implementation Study

TEAM Members

BCA Tulsa Division

- David Odendahl
- Paul Pennekamp
- Mick Fine

BCA Wichita

- Ming Liu
- Waris Jaffery
- Joe Page

787 Factory Controls

- Al Glasscock – project manager
- Ted Schultz – project architect
- Mauro Costa
- Steve Dostert

Material & Process Tech.

- Sid Venkatesh
- Rich Morihara

BCA Fabrication Division

- Keith Mackay

Special Thanks To

STEP Tools

- Martin Hardwick
- Dave Loffredo

NIST

- John Michaloski
- Fred Proctor
- Xun Xu

Boeing is presently examining AP238 to see if the standard's toolpath description capabilities can be used to streamline the data flow between existing CAD/CAM systems and CNC machine tools.

Why???

Present Situation - “Dumb CNC”

- Presently, CNC machines receive data defining the axis movement required in order to manufacture a part. This is referred to as MCD or machine control data.
- MCD is a very low level of instruction. Traditionally, CNC machines do not have access to higher-level information about the tasks they are executing or the part they are trying to manufacture.
- High-level intelligence is only utilized at the CAD and CAM stages of the manufacturing process.

“Dumb CNC” Problems

- **Not Portable**
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Target - “Smart CNC”

- Cutter movement data, instead of axis movement data is sent to the CNC. Sophisticated CNCs have the capability of converting cutter movement data to axis movement data.
- High level information about the part features, materials, cutters, and dimensional tolerances can also be sent to the CNC.
- This information should be sent using a data standard such as: AP238 “STEP-NC”.

Dumb vs. Smart

Dumb:
Axis Motion
Spindle Speeds
Auxiliary Functions

Smart
Tool Motion
Toolpath Tolerances
Spindle Speeds
Auxiliary Functions
Material Characteristics
Fixturing
End Result
Part Tolerances
Cutter information

Smart CNC Benefits: Portability

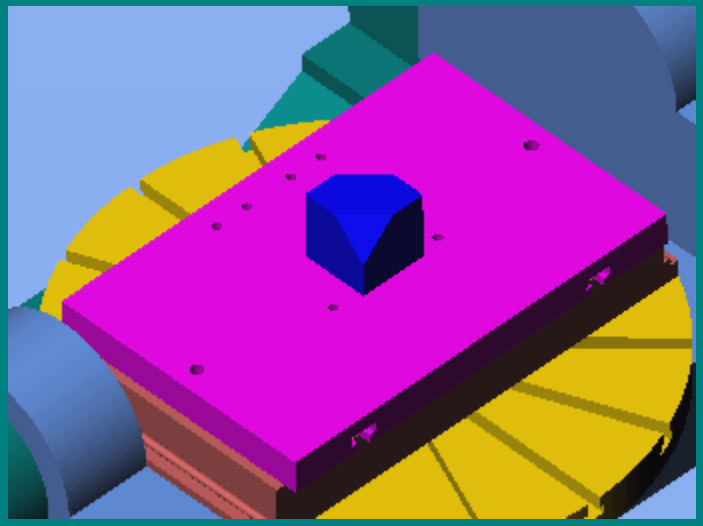
- **Portable**
  - Cutter motion data is “machine neutral” and may be used directly by machines with different geometries
  - Separate post-processors are not required for each unique control/machine combination
  - Direct portability between machine tools/controls is possible (within reason)

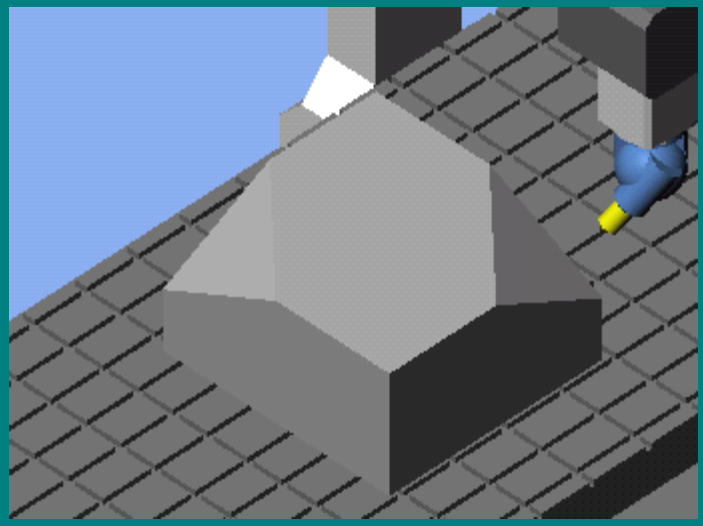
Portability Issues

- Data that is presently sent to a CNC is not portable for two main reasons:
  - No standard format followed (a bad reason)
  - Machine geometries vary (used to be a good reason)
  - Machine auxiliary functions are not implemented in a consistent, standard manner

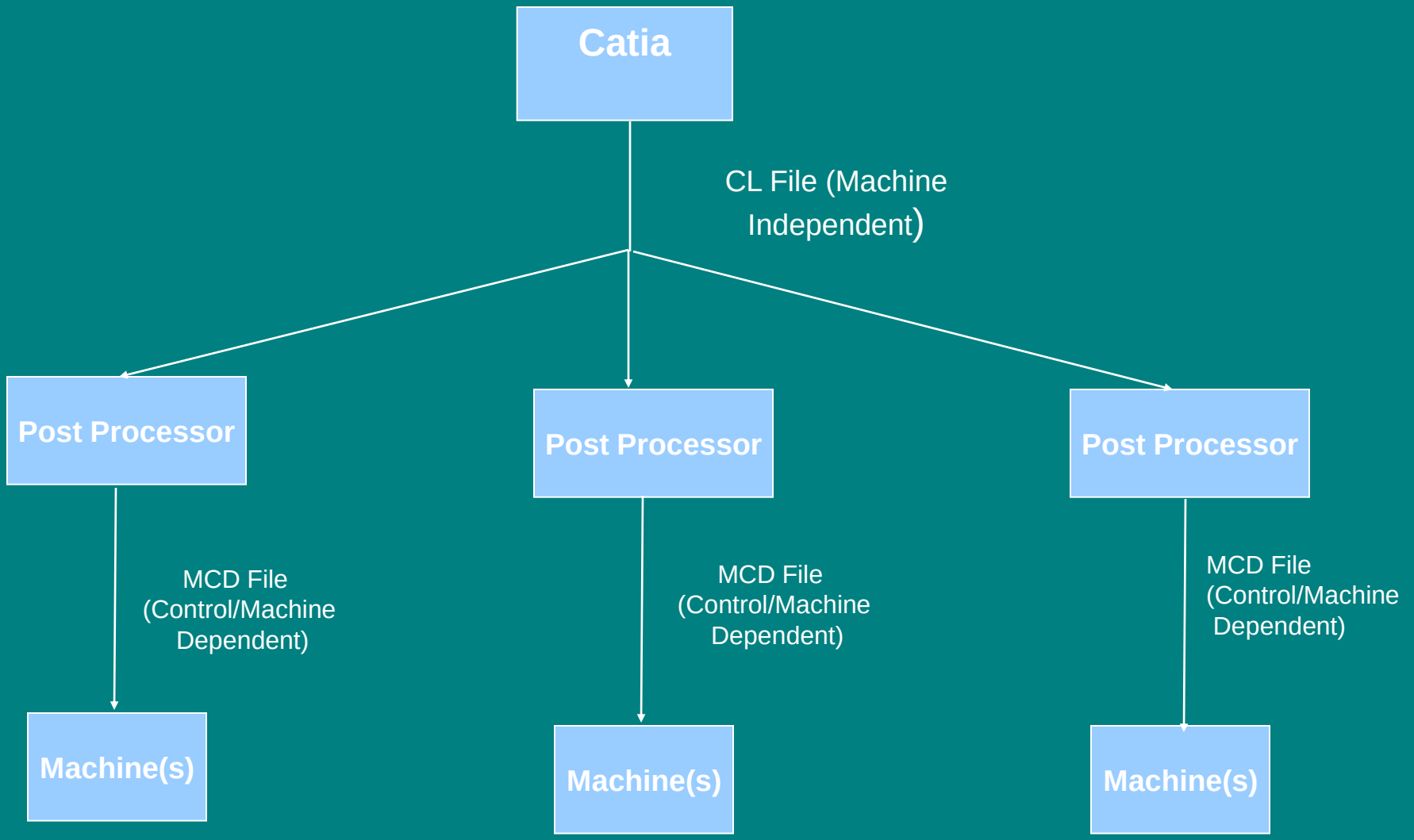
Tool Motion Vs. Axis Motion

On machines with different geometries, different axis motions are required to achieve the same cutter motion relative to the part

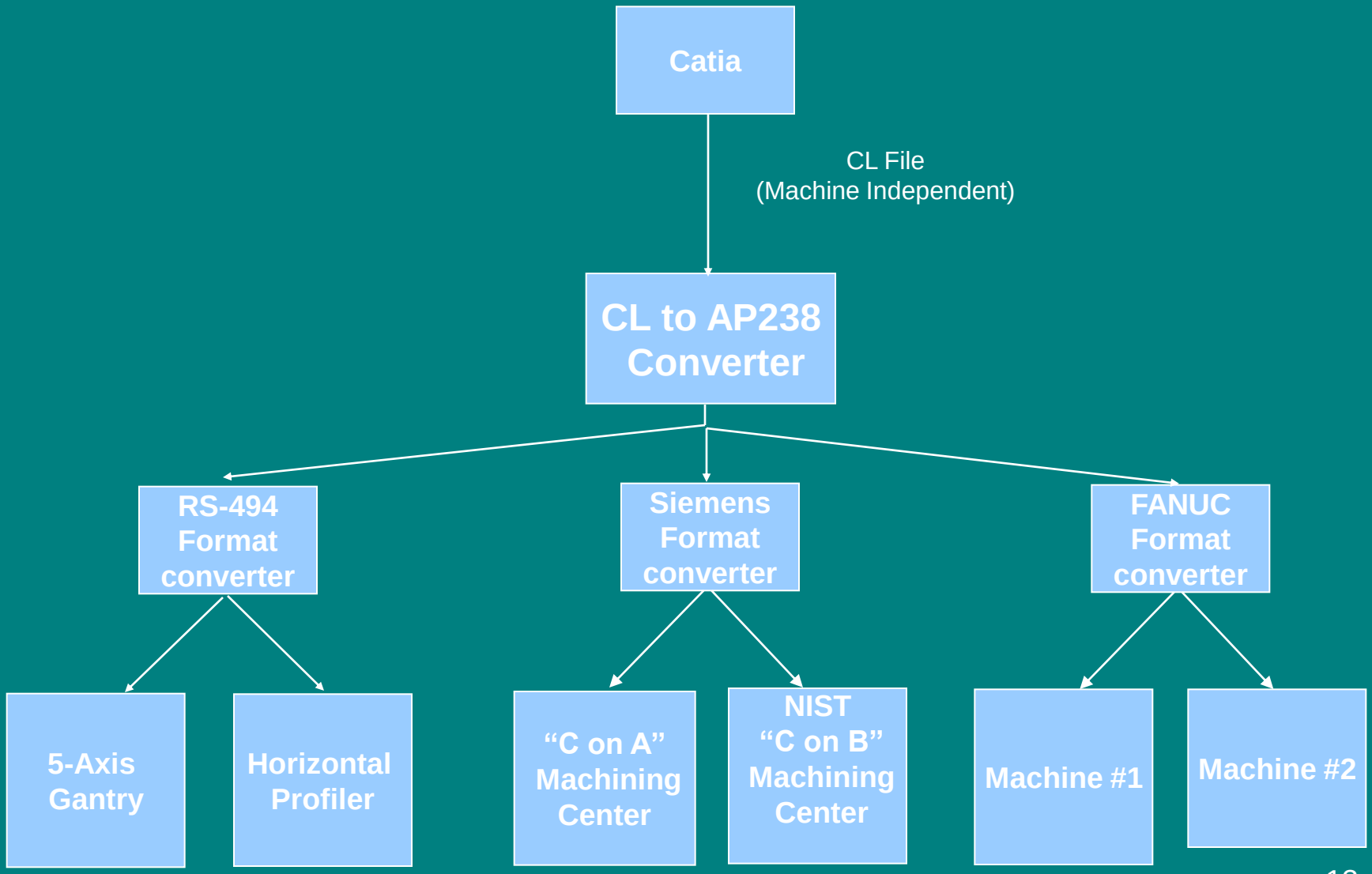




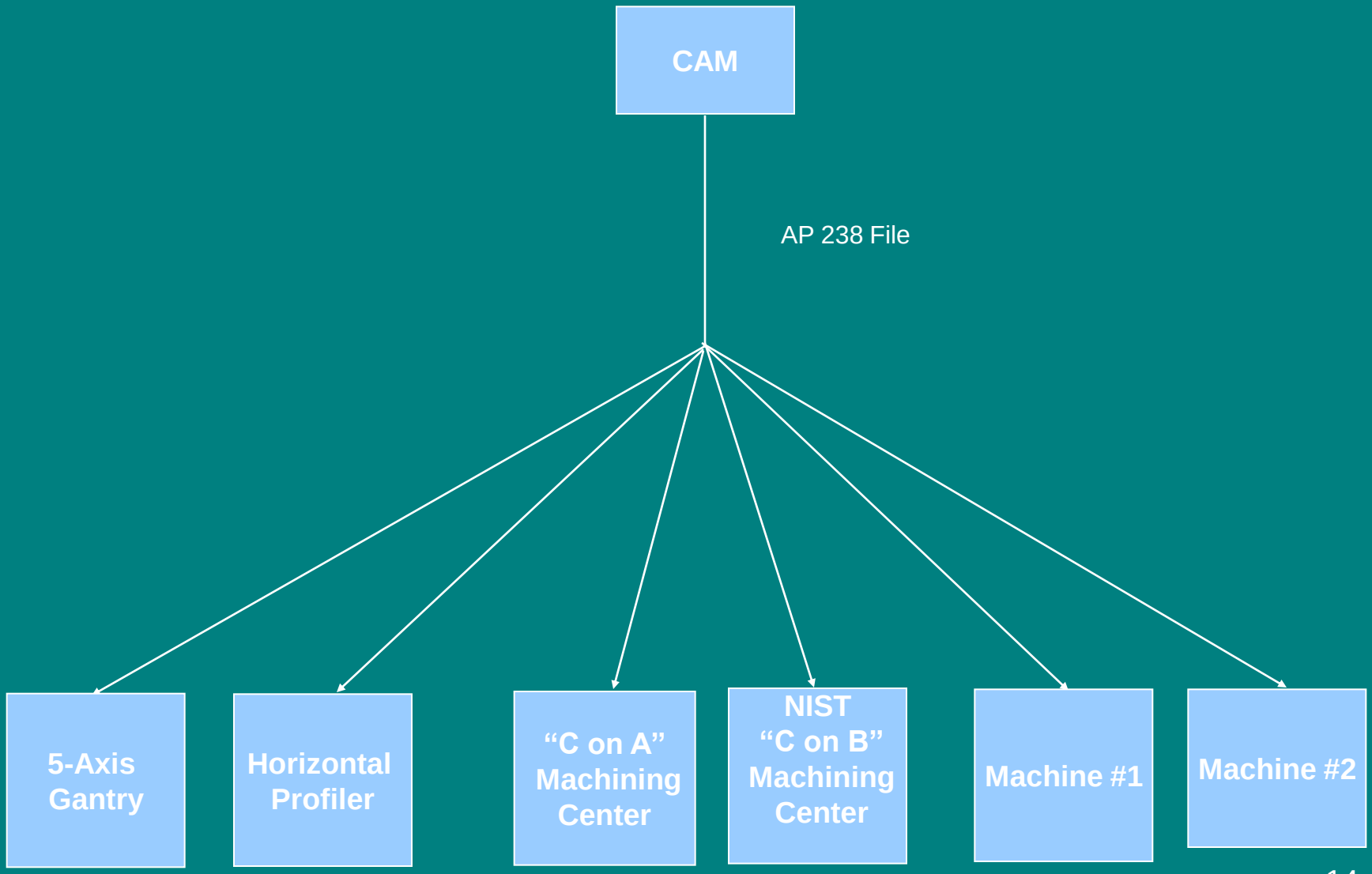
“Dumb CNC” Data Flow



Smart CNC Data Flow: Transitional

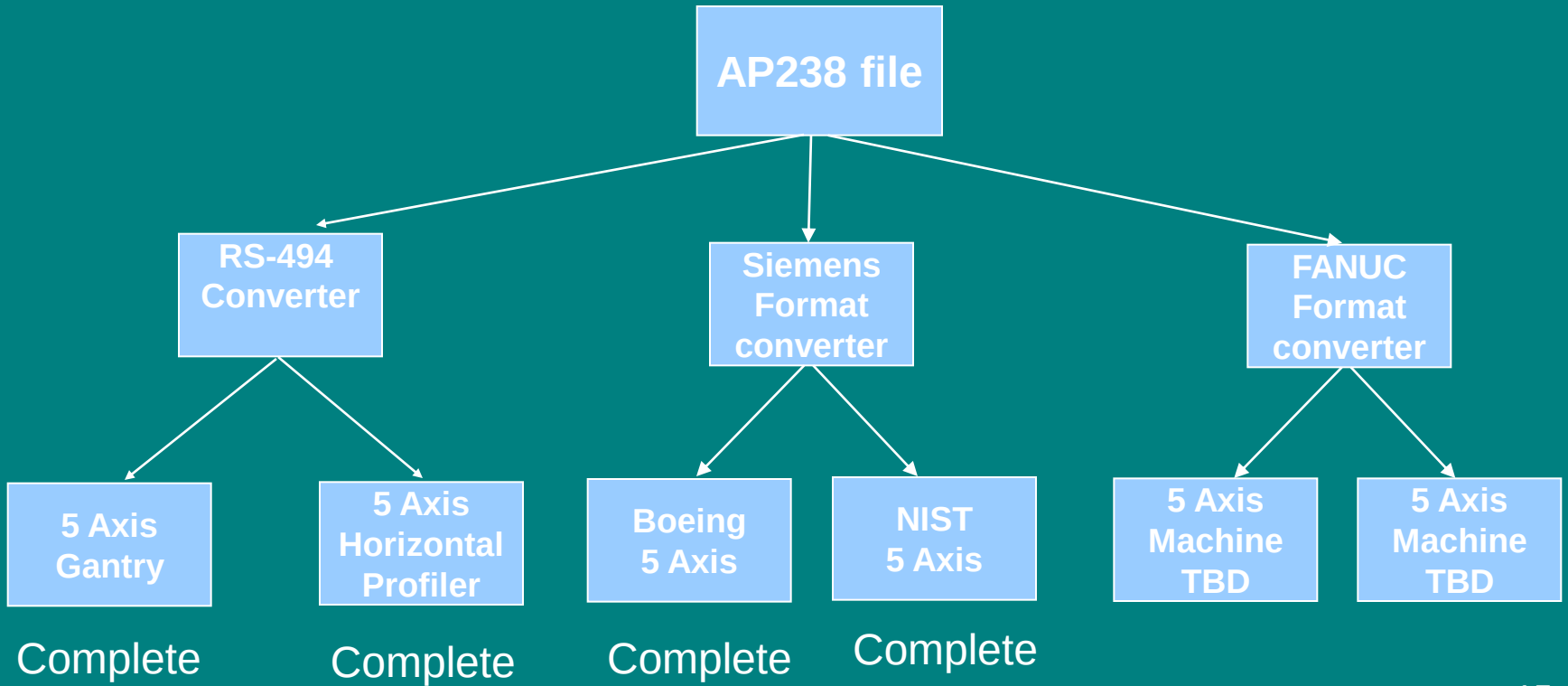


Smart CNC Data Flow: Final



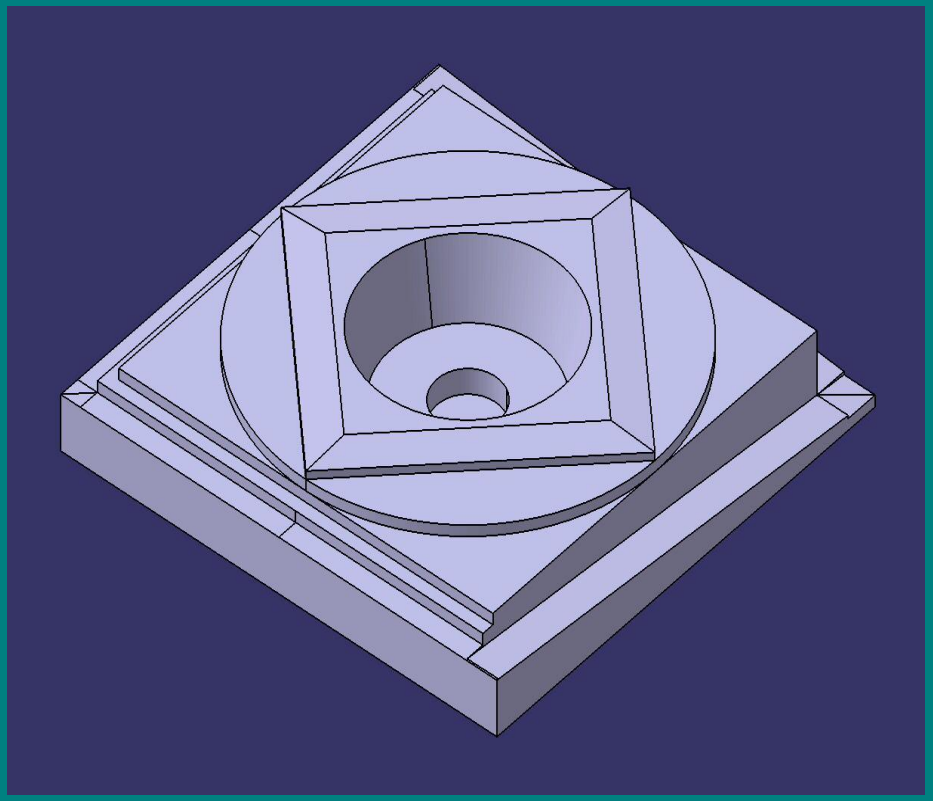
Demonstration A: Portability

- Plan – demonstrate portability
- Result – six identical parts from one file



Test Part for Demonstration A

NAS 979
Circle-Diamond-Square
combined with a
NAS 979 cone test.



Dumb CNC Scenario #1

- Due to increases in rate, an existing machine is no longer able to support required workload.
- The machine is no longer manufactured, or it is desired to purchase a similar machine from a different manufacturer or with a different control.
- Because the MCD data sent to the machines is non-portable, a separate set of MCD data must be kept and supported for the new machine

Smart CNC Scenario #1

- Due to increases in rate, a machine is no longer able to support the workload.
- The machine is no longer manufactured, or it is desired to purchase a similar machine from a different manufacturer or with a different control.
- Because the MCD data sent to the machines is portable, the existing MCD data could be used directly on the new, similar machine.

A Wide Data Path

- Other information about the part can be transmitted using AP238
  - Fixtures
  - Material
  - Cutters
  - Tolerances
  - Part Geometry
  - NC Data

Dumb CNC Scenario #2

- Three machines all have different mechanical characteristics. Machine #1, the strongest machine, can handle a cutter load 20% greater than the weakest machine, #3.
- Program for the weakest machine, otherwise separate NC programs for each machine would have to be maintained

Smart CNC Scenario #2

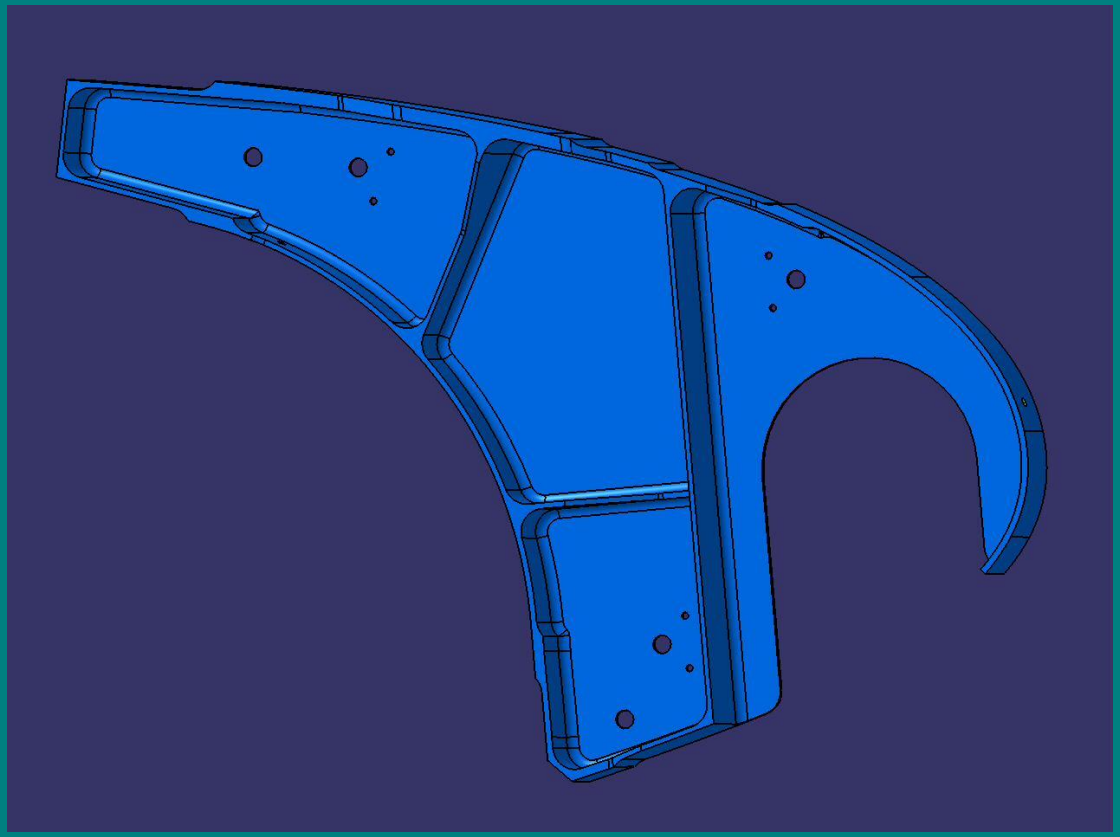
- Three machines all have different mechanical characteristics. Machine #1, the strongest machine, can handle a cutter load 20% greater than the weakest machine, #3.
- Because, through the AP238 file, the CNC is aware of the tolerances for the final part, the cutter type, and the material to be machined, the CNC can automatically adjust feed and spindle rates to optimize the program for each individual machine.

Demonstration B: "Real World" Practicality

- The practicality of using AP238 to define and produce a complex, 5-axis, "real-world" part was unproven
  - Are file sizes reasonable?
  - Is processing time reasonable?
  - Can the required software be produced?
  - What other problems will be encountered?

Test Part for Demonstration B

5-axis
Aerospace Part



Progress to Date

- Today's demonstration Prototype converters for transferring AP238 Part 21 files to Fanuc, Siemens, and BCL formats written.
- NAS 979 CDS/Cone test part machined
- 5-axis demonstration part machined

NAS 979 CDS/Cone Test Part

- CATIA CL file size: 201 KB
- AP238 Part 21 file size: 114 KB
- NC file size: 45 KB to 104KB
- Total processing time: 5 seconds

  (1 GHZ Pentium)

5-Axis Aerospace part

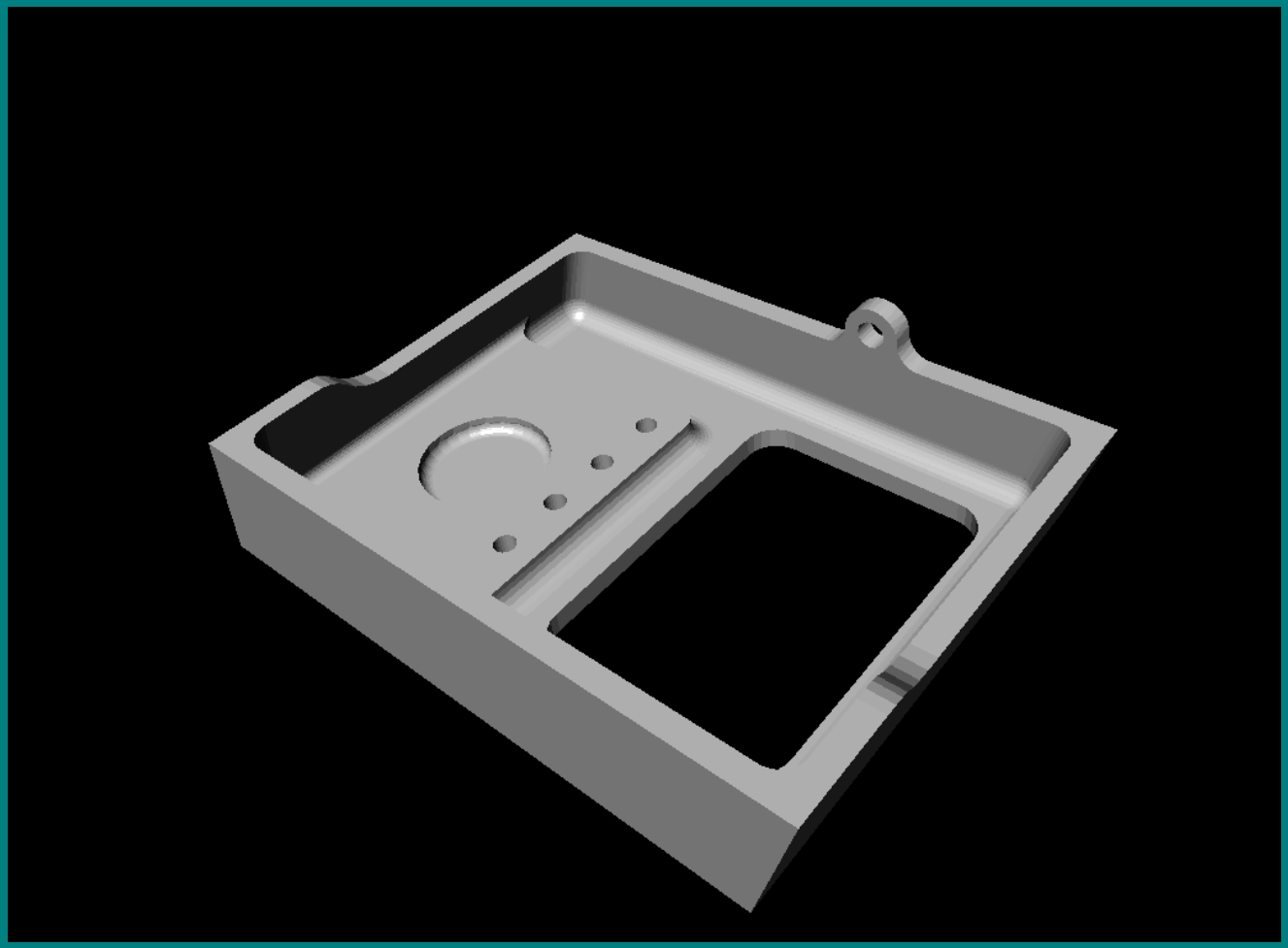
- CATIA CL file size: 2077 KB
- AP238 Part 21 file size: 2305 KB
- NC file size: 560 KB to 1304 KB
- Total processing time: 20 seconds

  (1 GHZ Pentium)

Wichita AP238 Efforts

- Wichita test part generated
- NC programming to begin soon
- Part will be machined on two different machines in Wichita
- Part will also be machined in Tulsa

Wichita STEP-NC Part



Caveat

AP238 allows DATA portability. It does not guarantee PROCESS portability.

- Machine work envelope
- Spindle capability
- Machining philosophy
- Cultural Issues

However, much benefit can be shown using AP238 to describe SIMILAR processes

Questions?

Parameterization of the Cross-Sectional Area in Milling Operations (Draft, Rev 1)

Leon Xu

The Boeing Company

November 10, 2007

Example of Digitized Cross-Sectional Area

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
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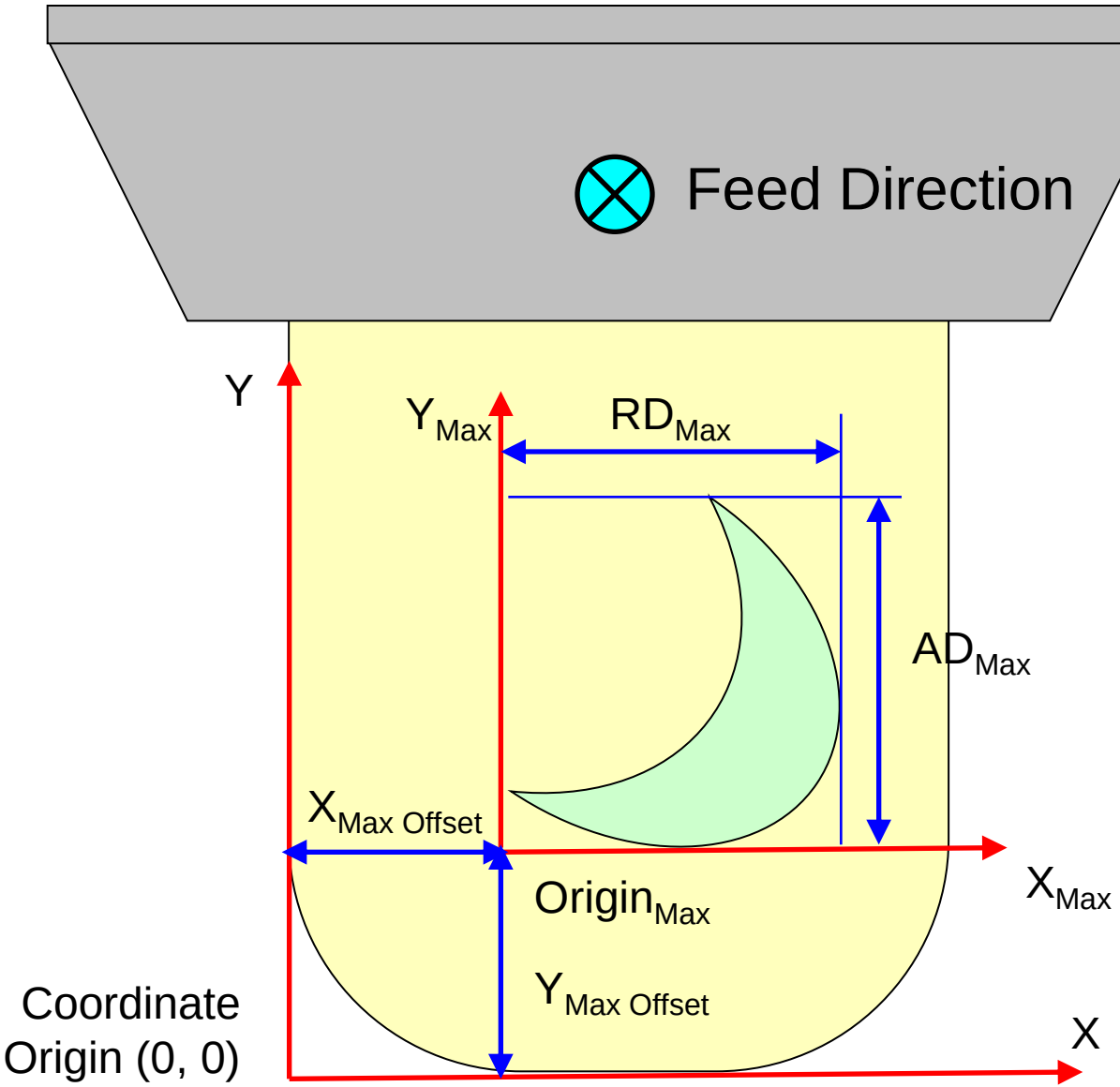
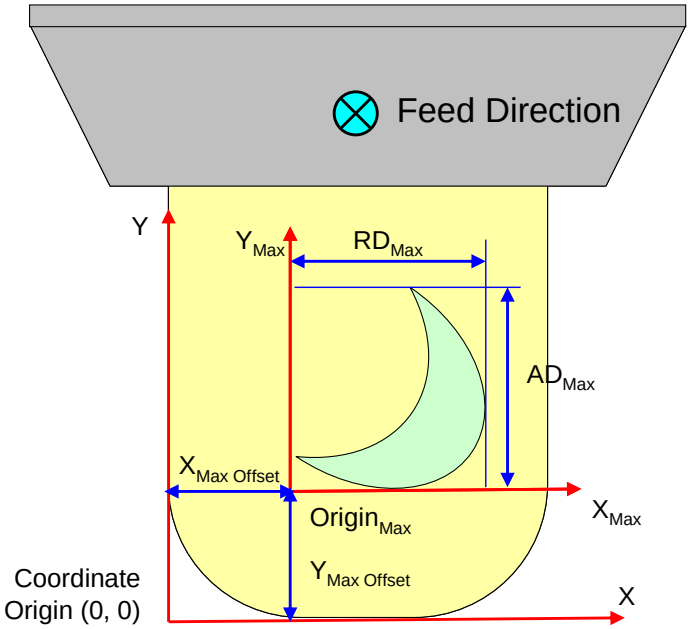
Proposed Parameters for Cross-Sectional Area in Milling Operations

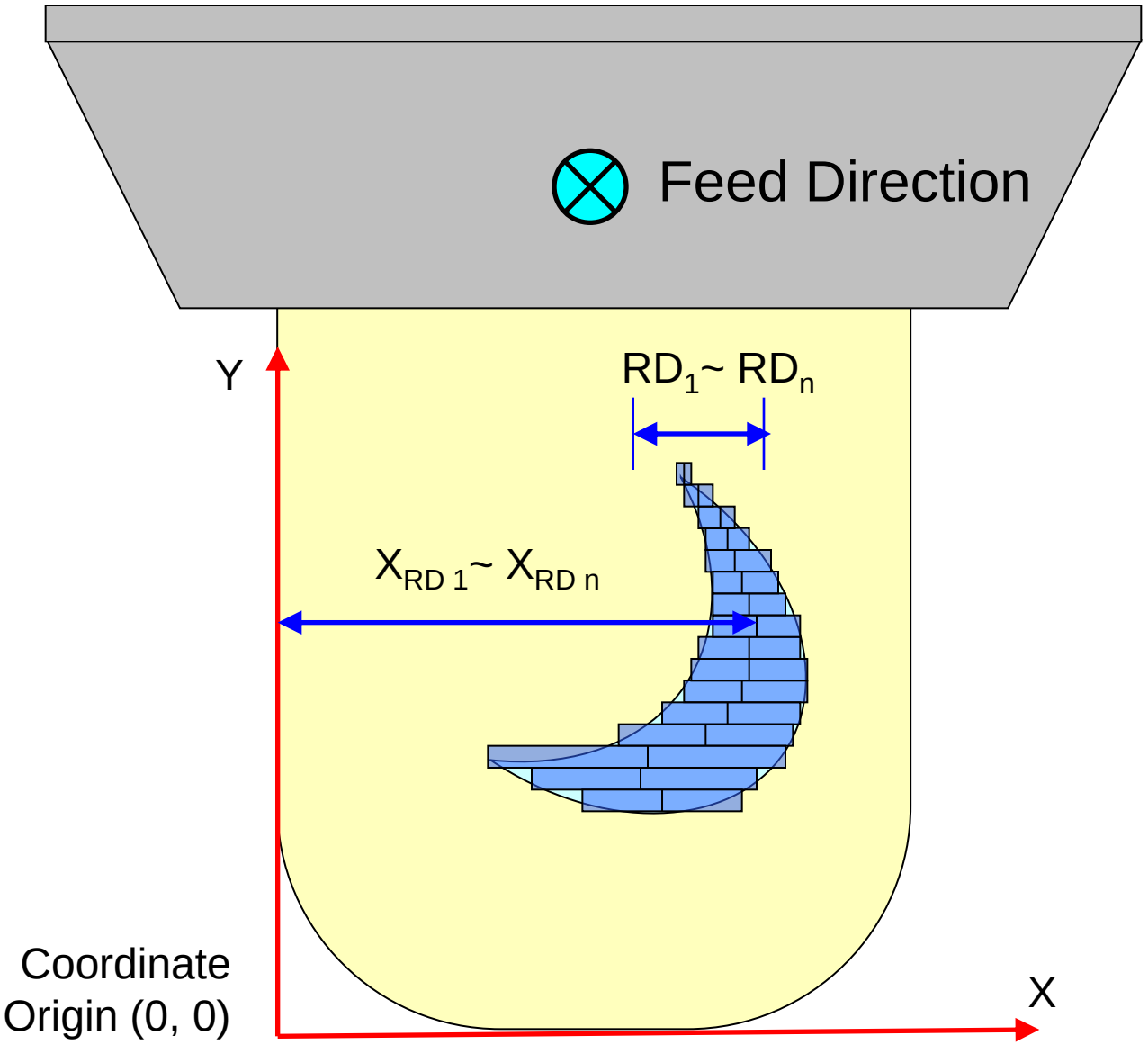
- AD_{Max} : Maximum Axial Depth
- RD_{Max} : Maximum Radial Depth
- $X_{Max\ Offset}$: X Offset of Maximum AD/RD Origin
- $Y_{Max\ Offset}$: Y Offset of Maximum AD/RD Origin
- RD_{avg} : Average Radial Depth
- $X_{RD\ avg}$: X Offset of Average Radial Depth

Maximum Radial and Axial Depths

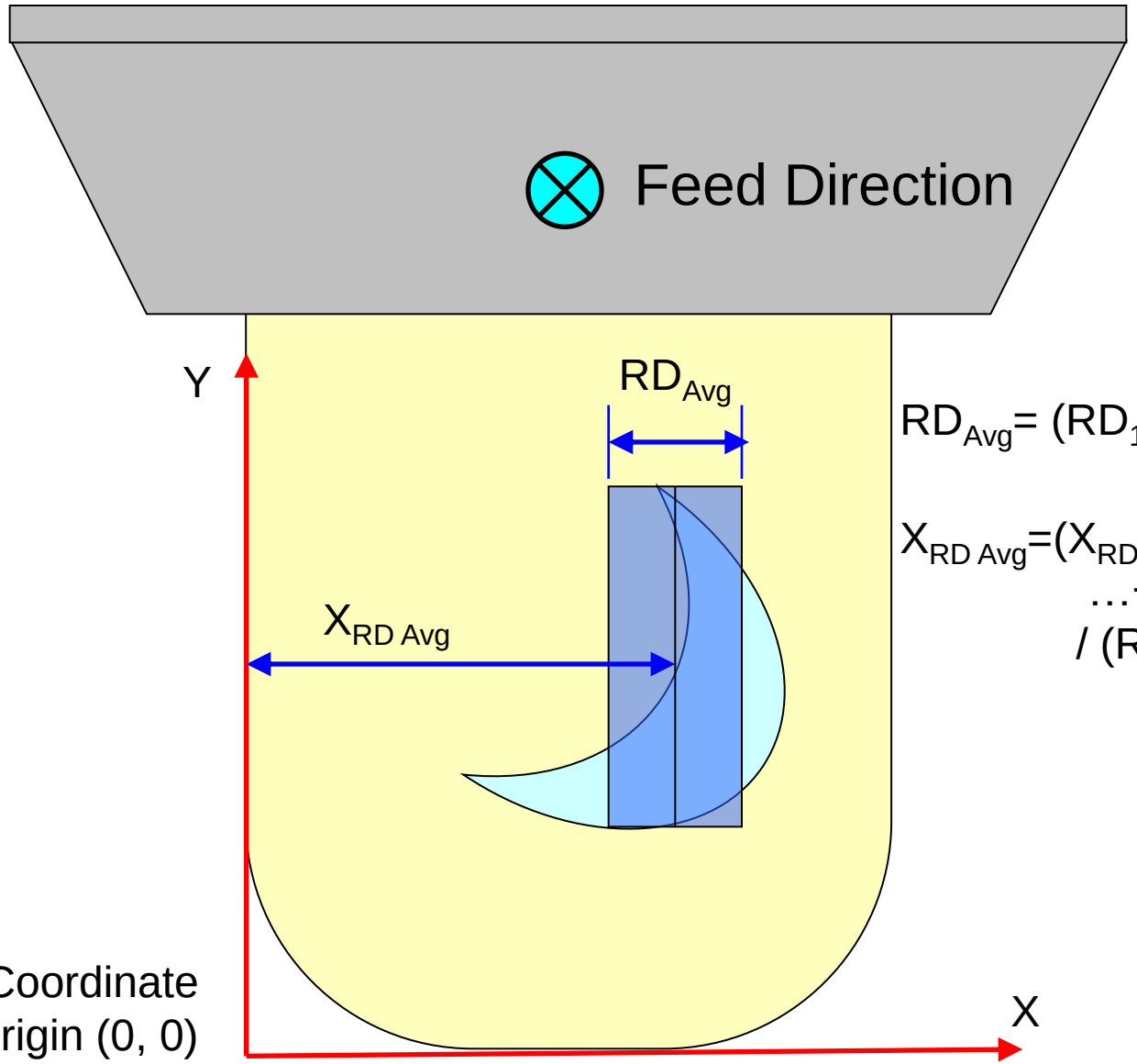



Feed Direction
Y
Y_{Max}
RD_{Max}
AD_{Max}
$X_{Max\ Offset}$
$Origin_{Max}$
X_{Max}
$Y_{Max\ Offset}$
Coordinate
Origin (0, 0)
X

Discrete Radial Depths and Midpoints



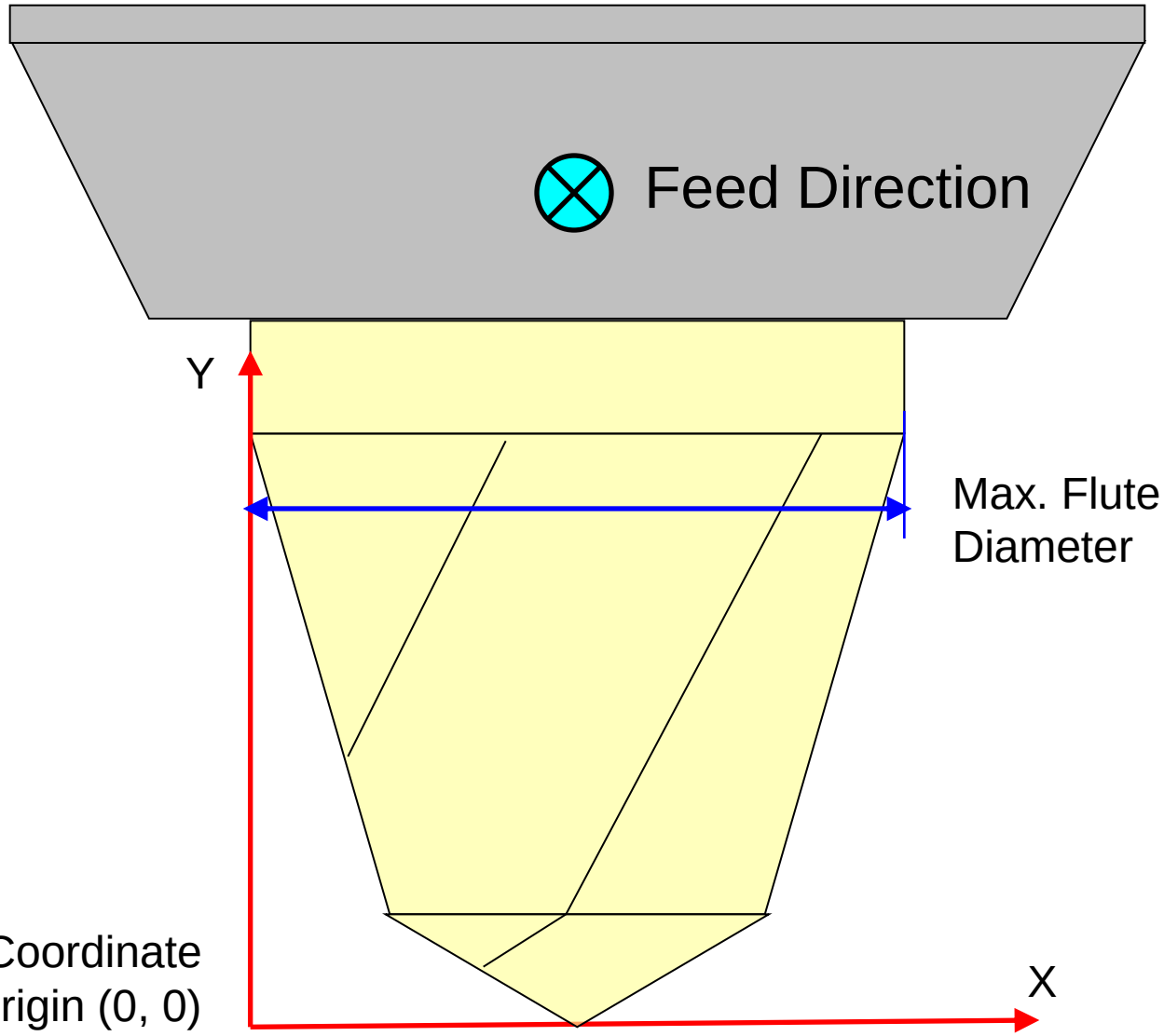
Average Radial Depth and Midpoint



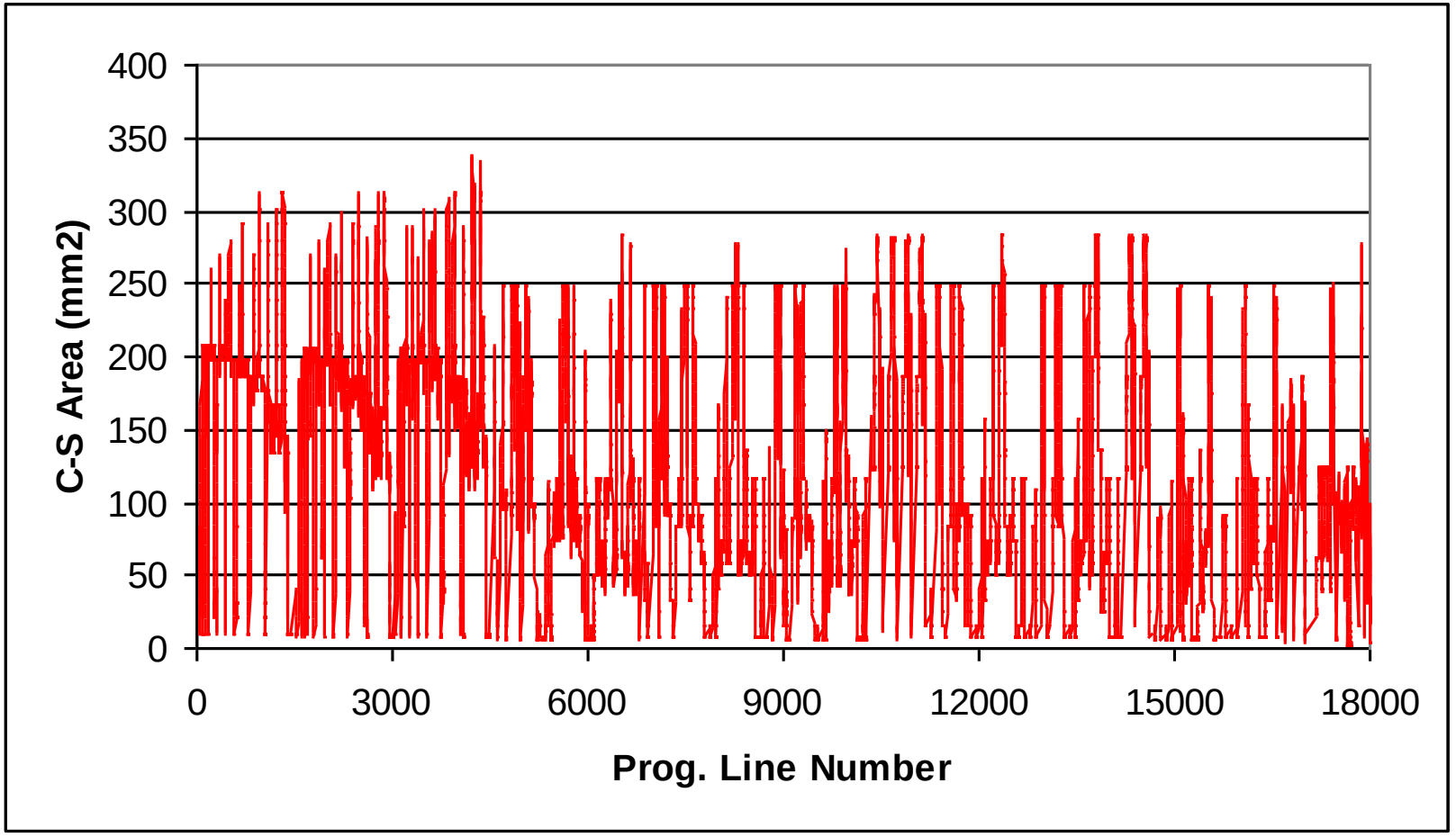
$$RD_{Avg} = (RD_1 + RD_2 + \ldots + RD_n) / n$$

$$X_{RD\ Avg} = (X_{RD\ 1} * RD_1 + X_{RD\ 2} * RD_2 \ldots + X_{RD\ n} * RD_n) / (RD_1 + RD_2 + \ldots + RD_n)$$

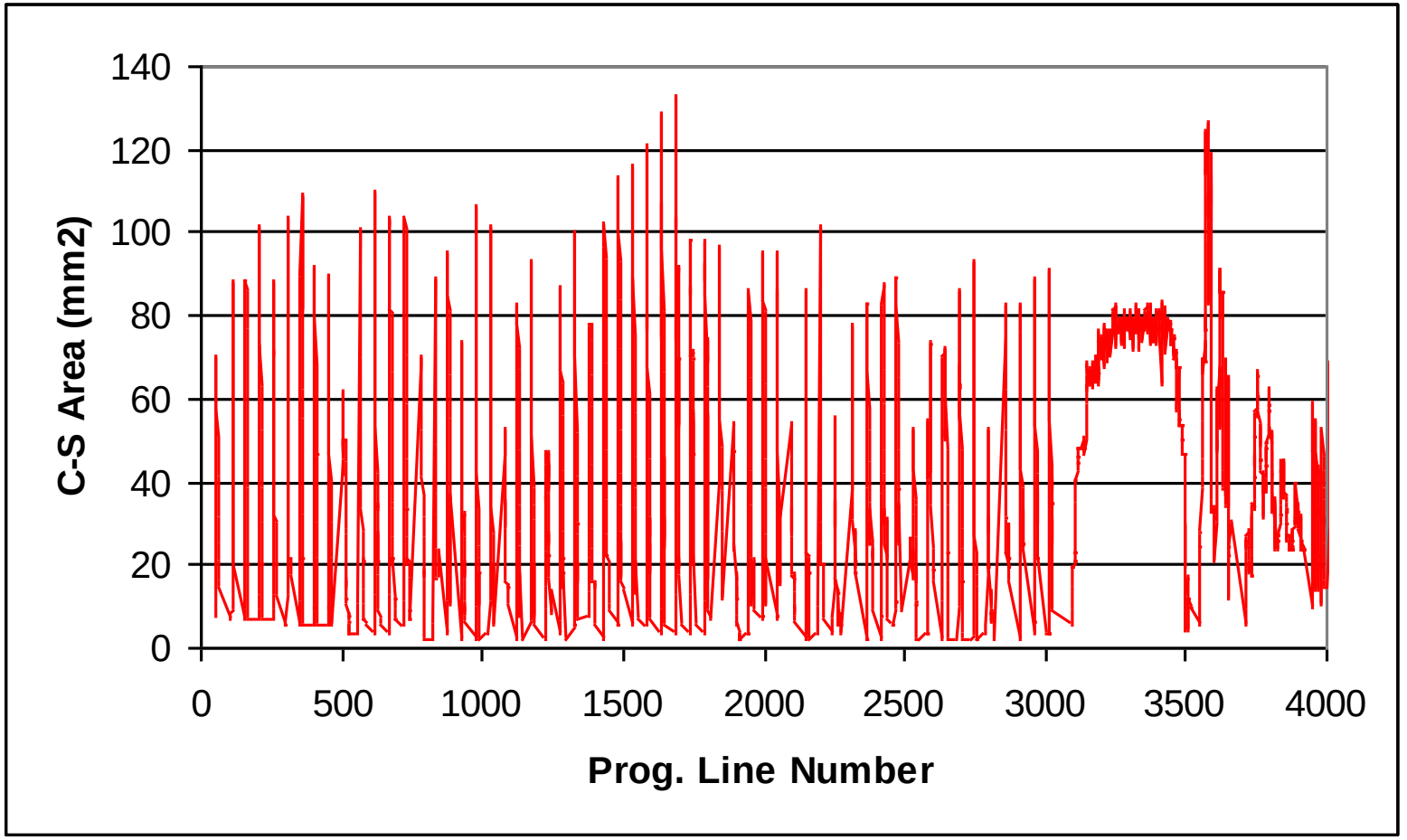
Coordinate Origin of Non-Cylindrical Cutters



Cross-Sectional Area of Fish Head (Tool #10)

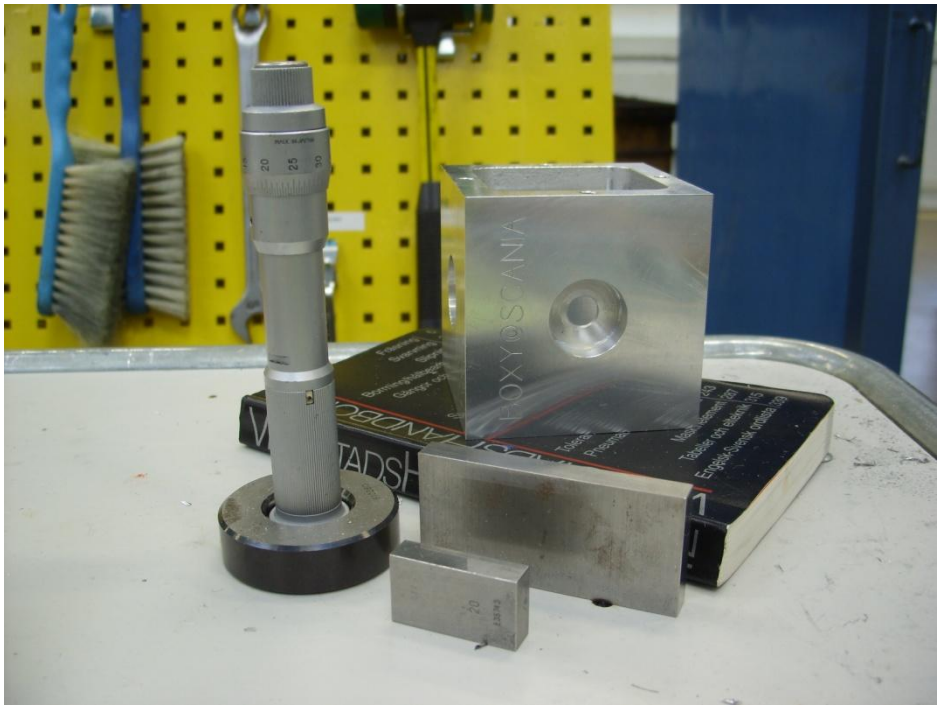


Cross-Sectional Area of Fish Head (Tool #11)



Boxy

or…



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I wouldn´t done it that way

KTH Industrial Engineering and Management

Magnus Lundgren

magnus.lundgren@iip.kth.se

B.Sc., Ph.D Student

KTH, Royal Institute of Technology

Computer System for Design and Manufacturing

Machinist background

Has worked as CNC-operator and manufacturing engineer for about 10 years before entering studies at KTH. Graduated for B.Sc. in 2001 and after that working with education at KTH in the area of manufacturing engineering.

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Parksville, May 2009

Multiple setups

Multiple CAM systems

Metric part and tooling

Machining tests from 2009-07-15 to 2009-09-15

- KTH (Tricept & Mazak VQC)
- Scania (Hardinge VMC 600 II)
- Boeing (Okuma, Northwood)
- University of Bath (DMG?)

So what is Boxy?

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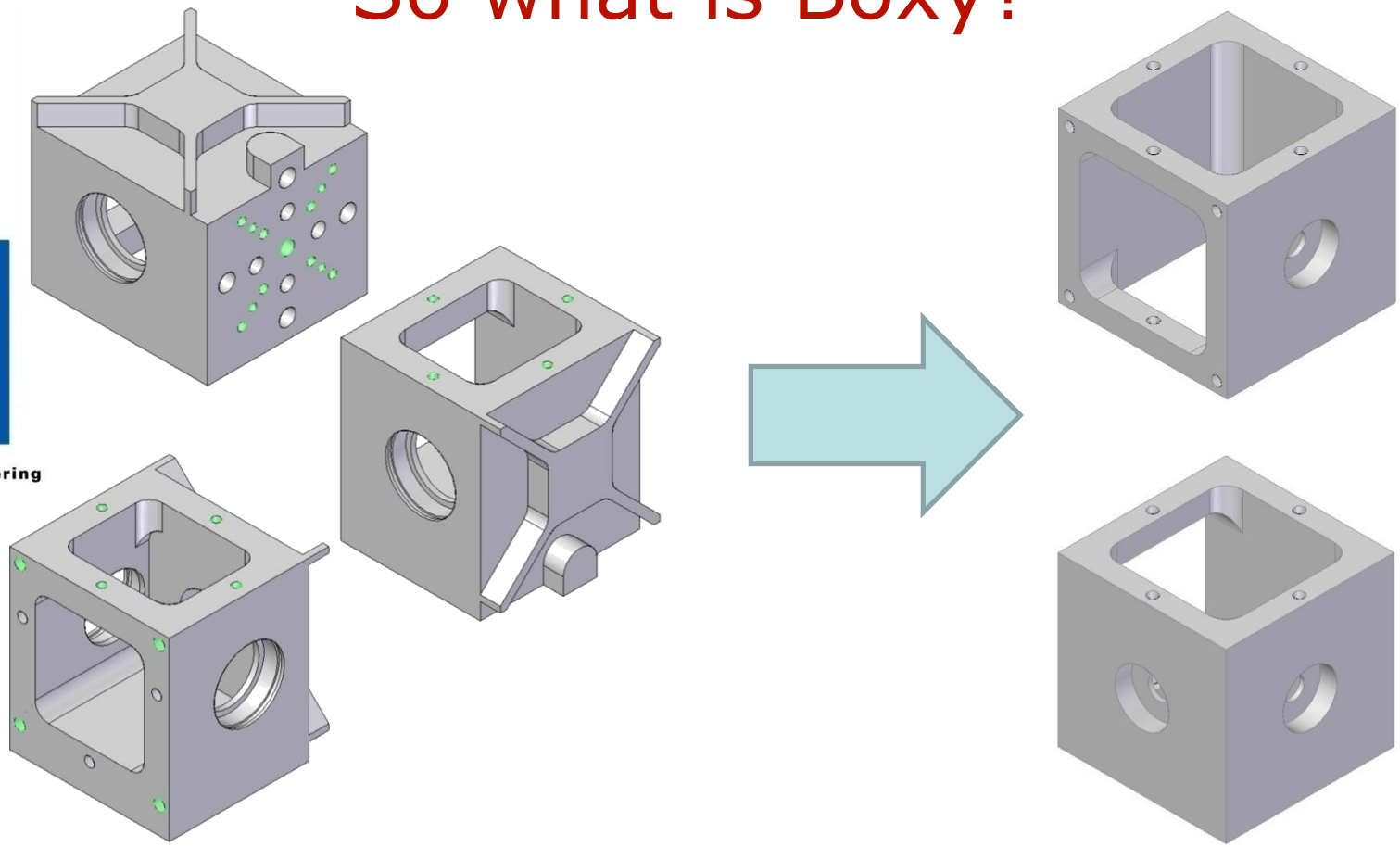
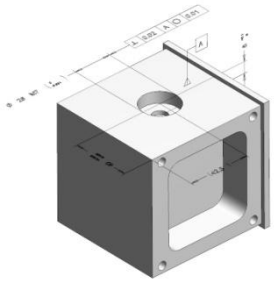
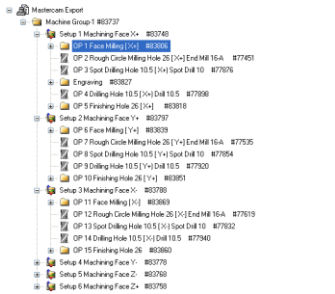
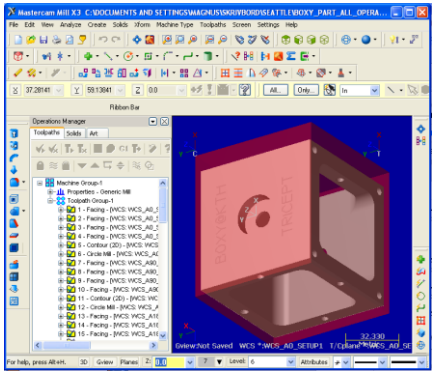




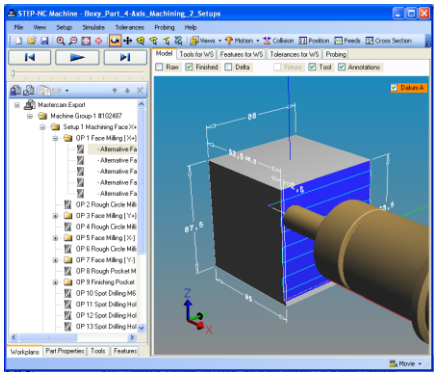
AP203e2

3-axis / 6 setups

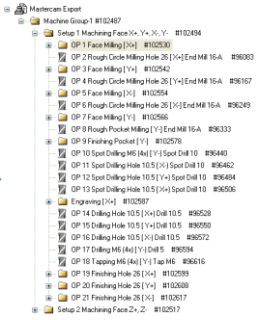




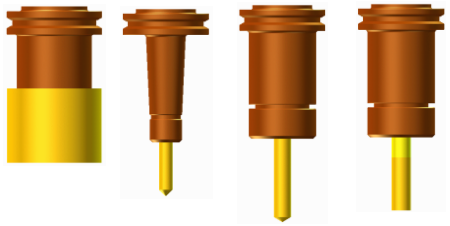
AP238



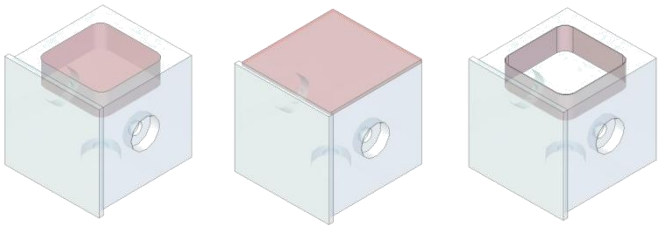
4-axis / 2 setups



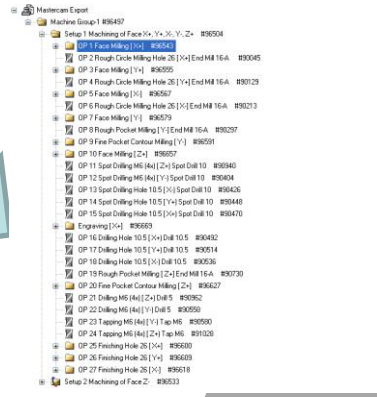
AP203



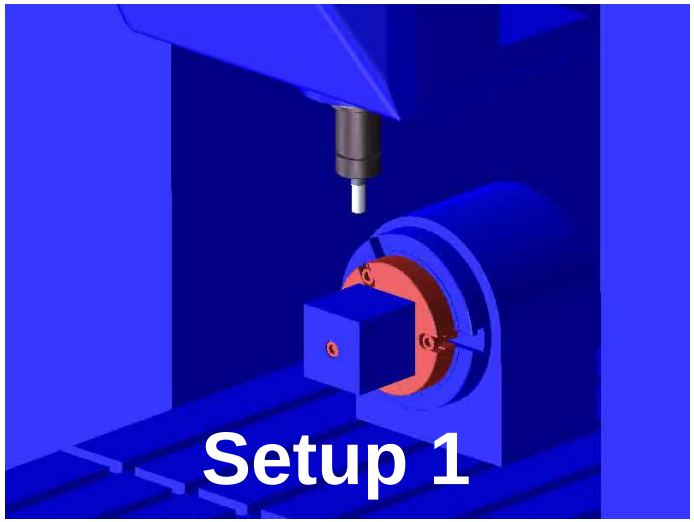
AP203

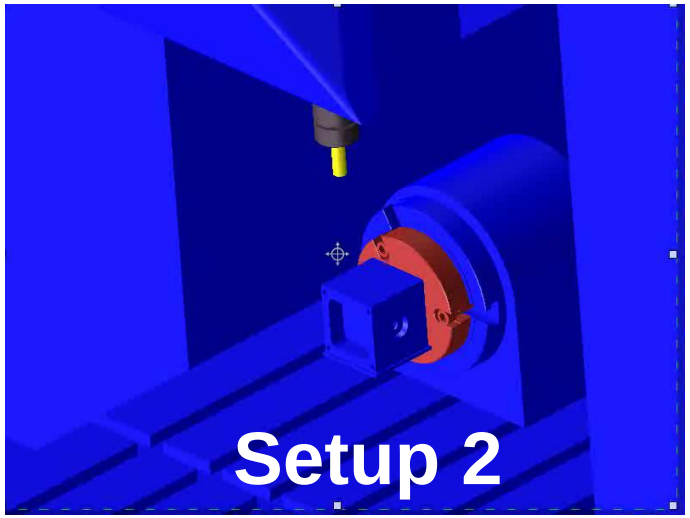


5-axis / 2 setups



4-Axis / 2 setups





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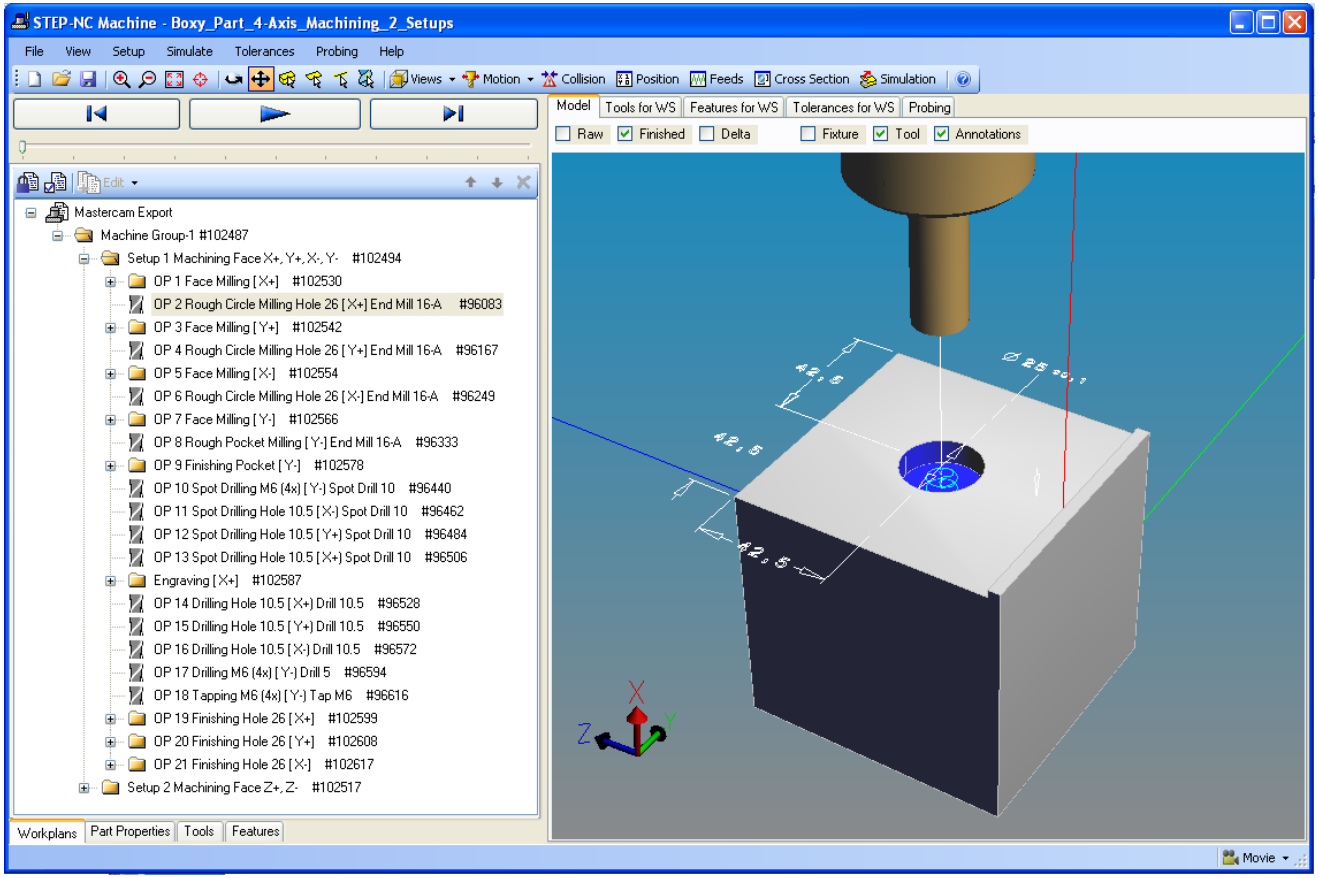
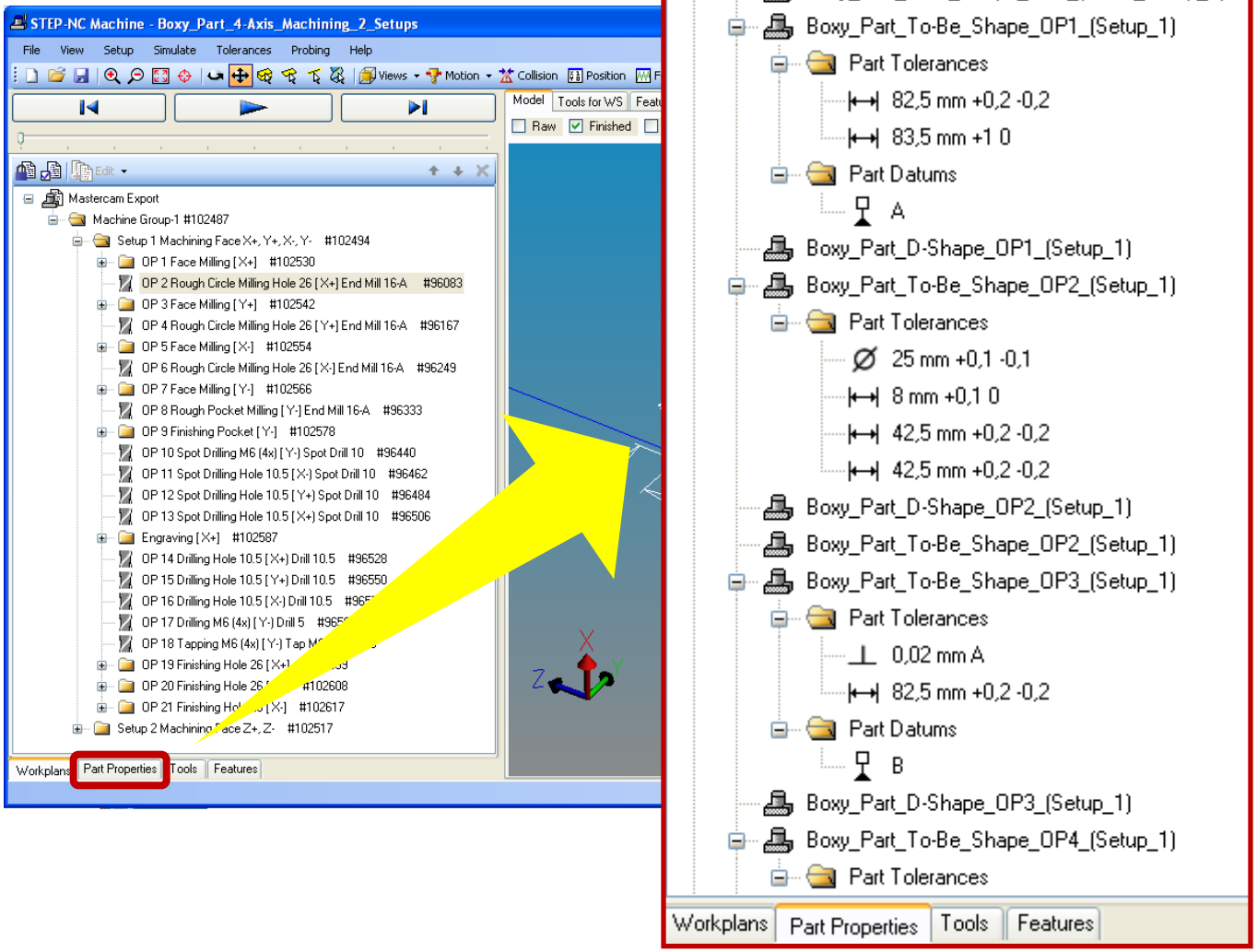
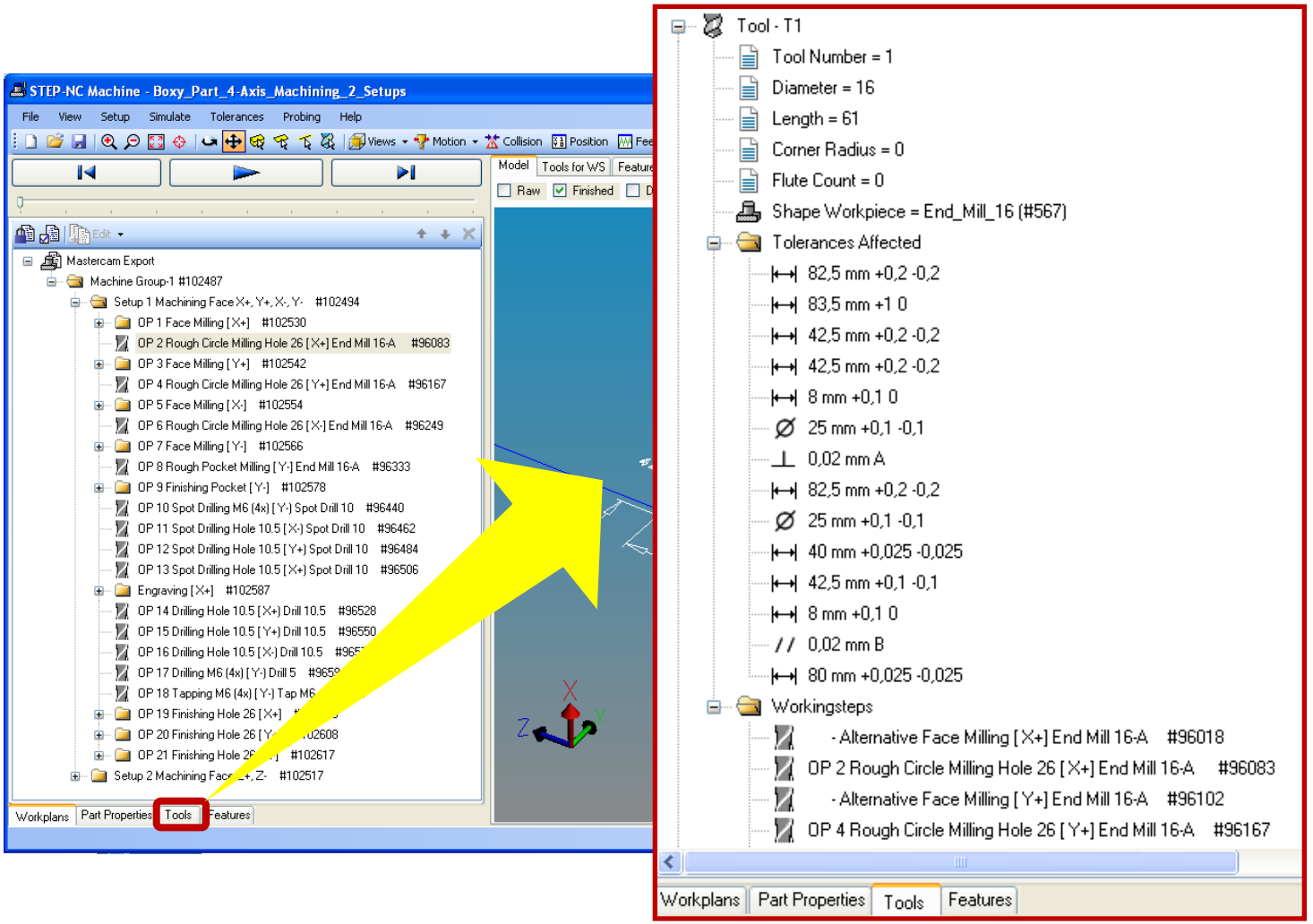


KTH Industrial Engineering and Management



KTH Industrial Engineering and Management



5-Axis / 2 setups

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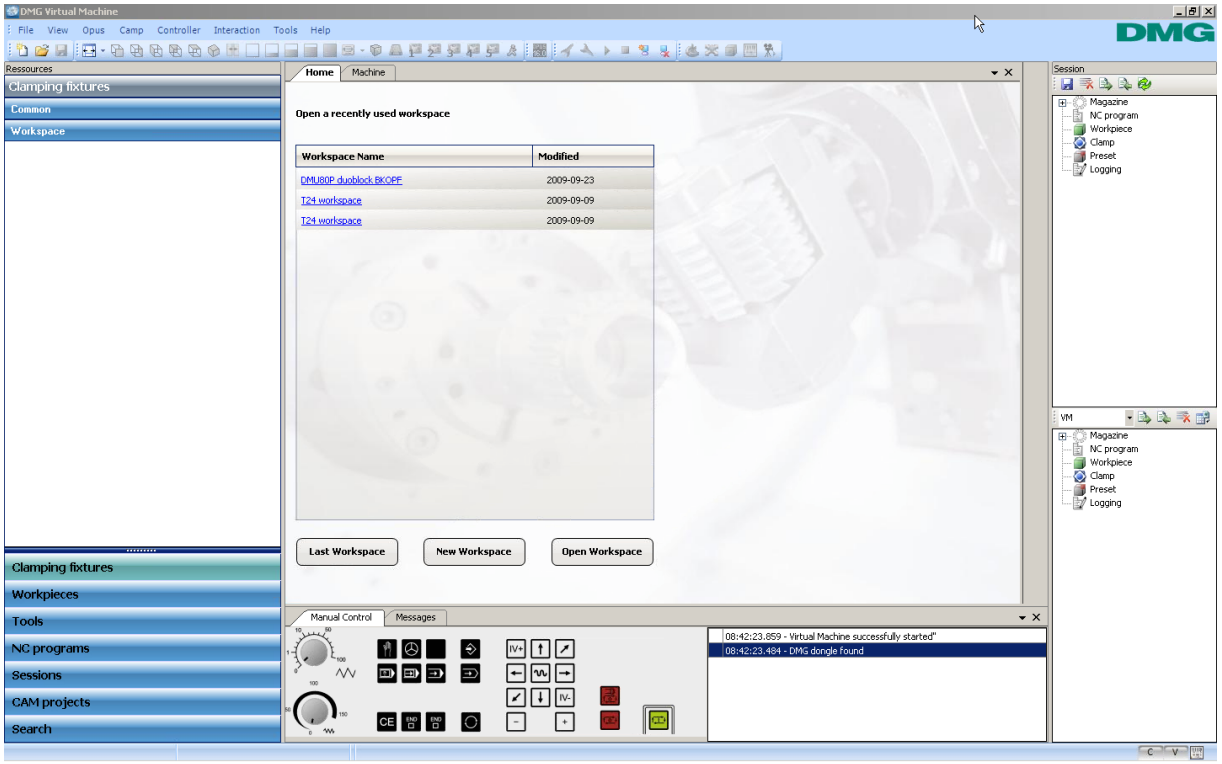
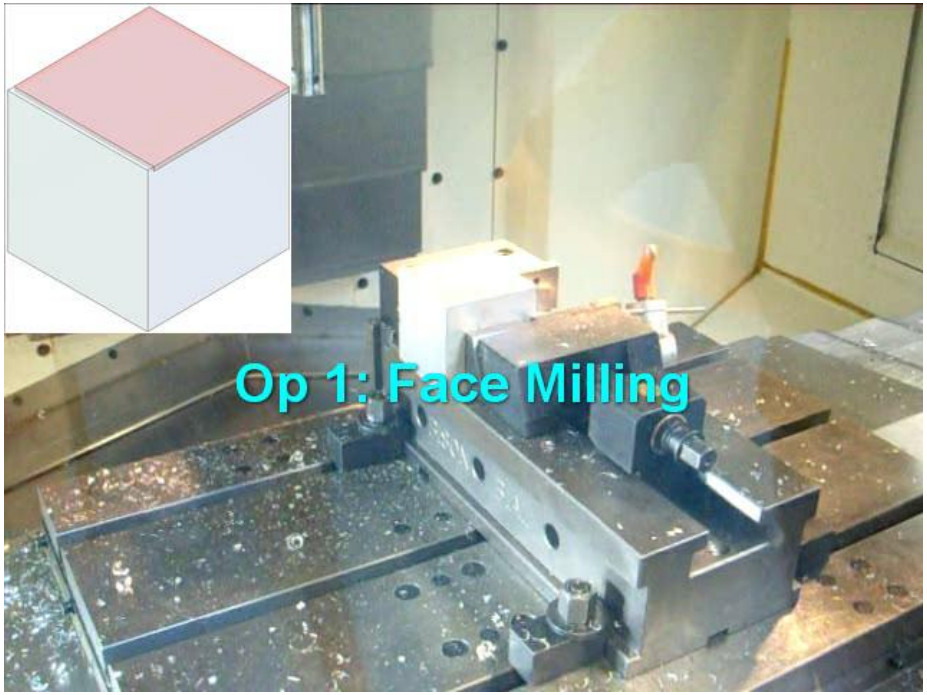
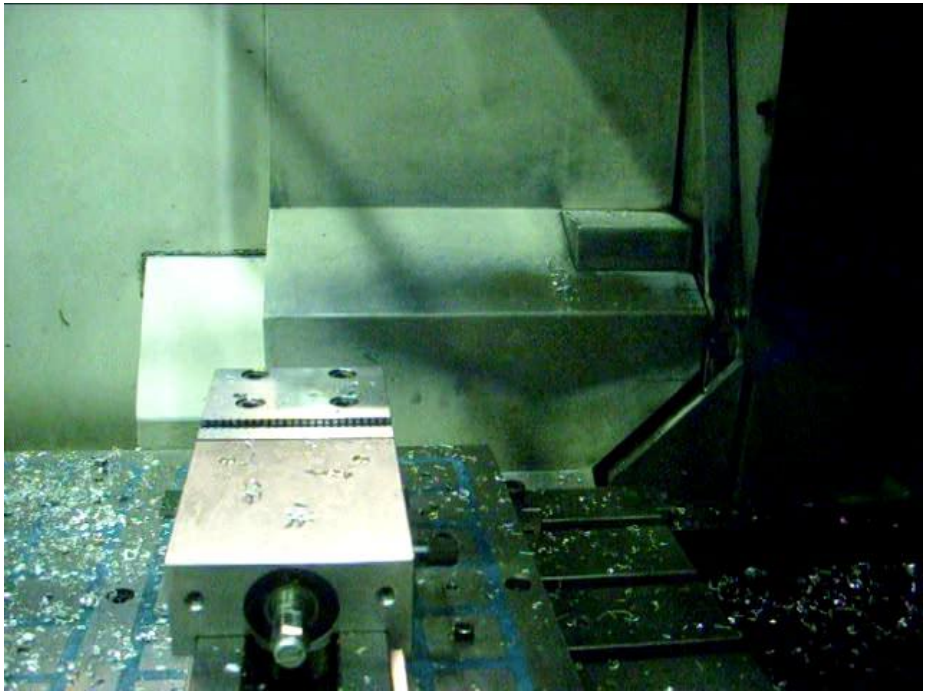


5-Axis Machining in Virtual DMG

3-Axis / 6 setups

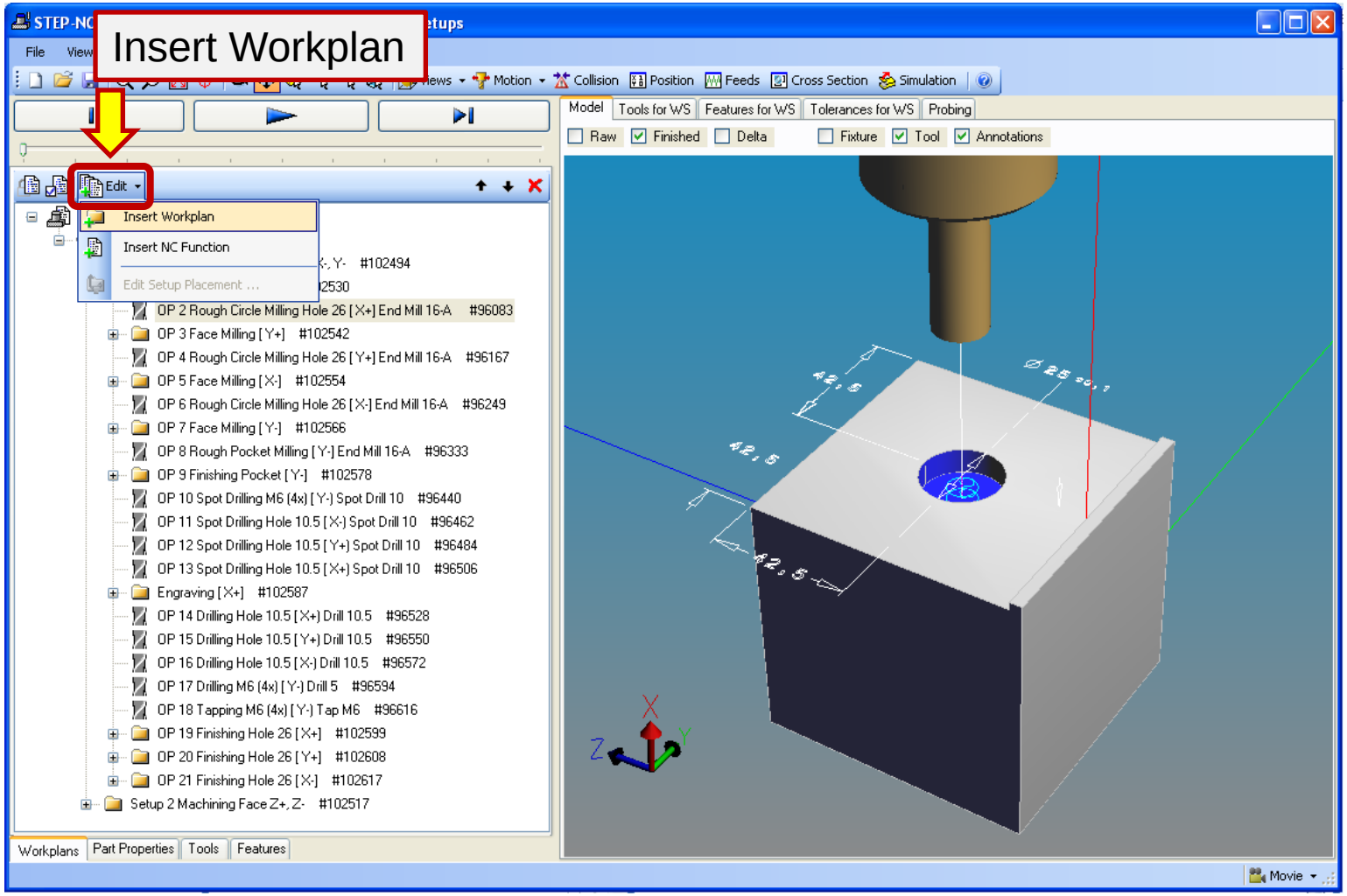


Machining Setup 1 at Scania



Machining Setup 1 at KTH

KTH Industrial Engineering and Management



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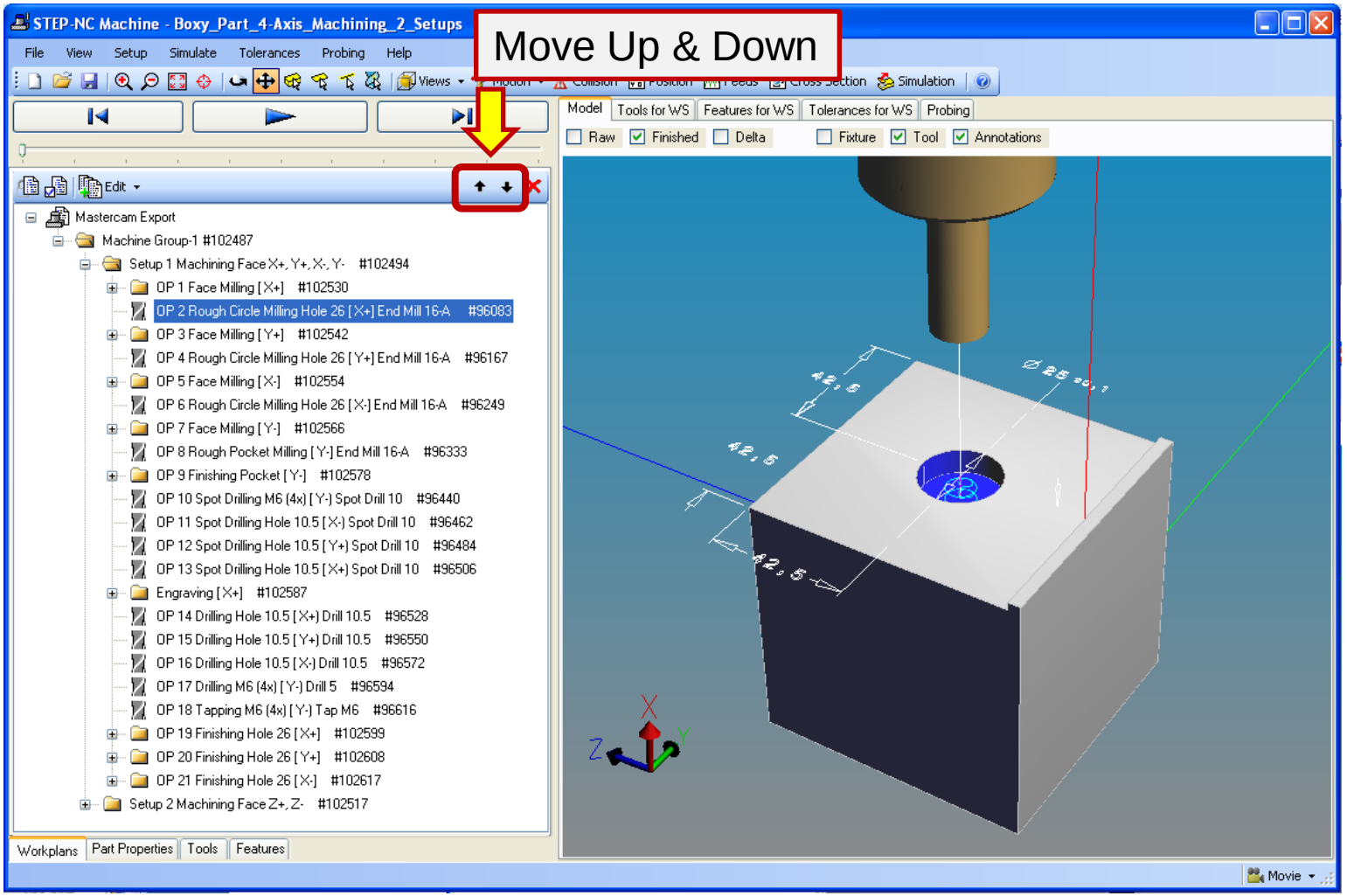

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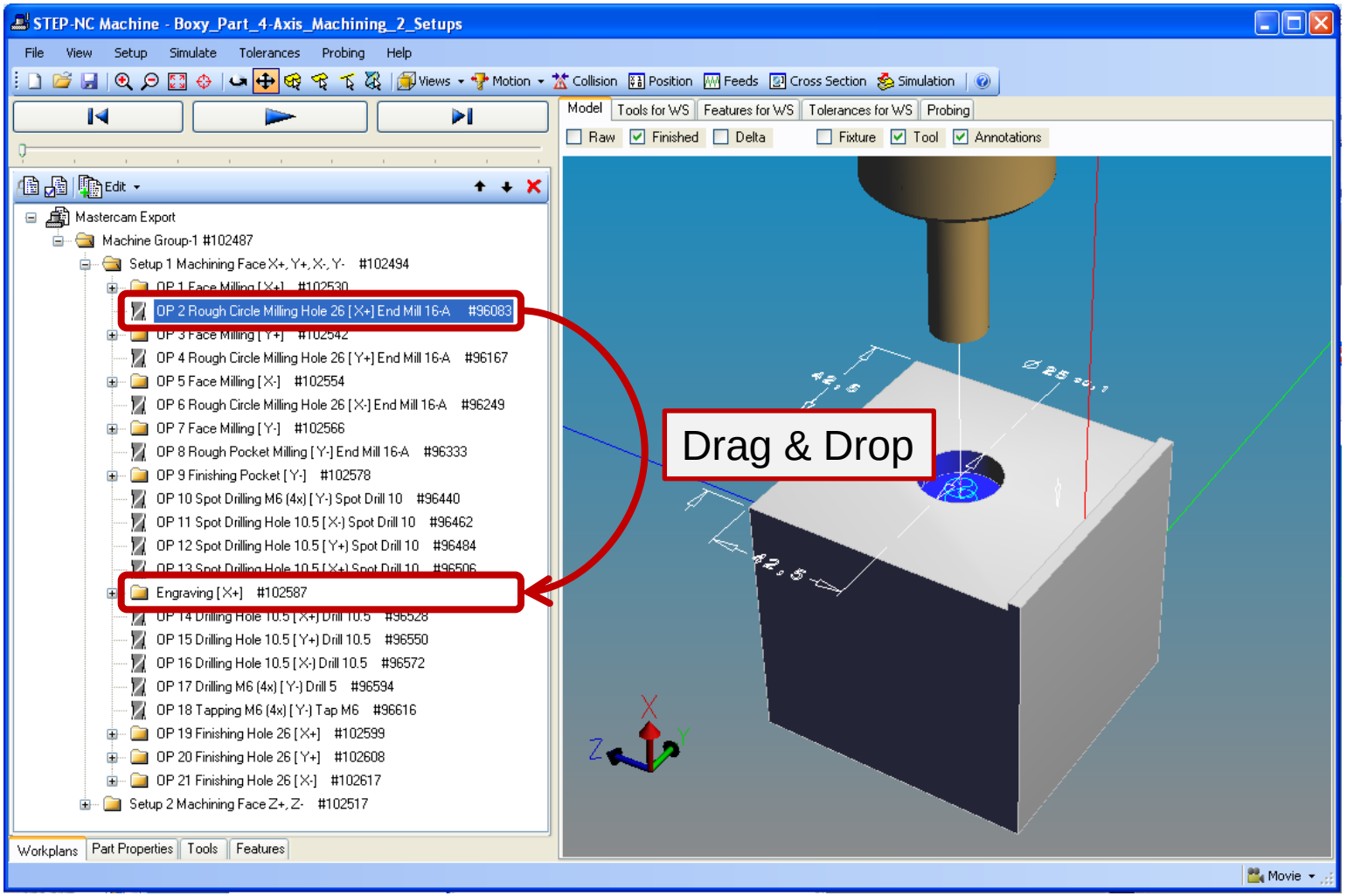
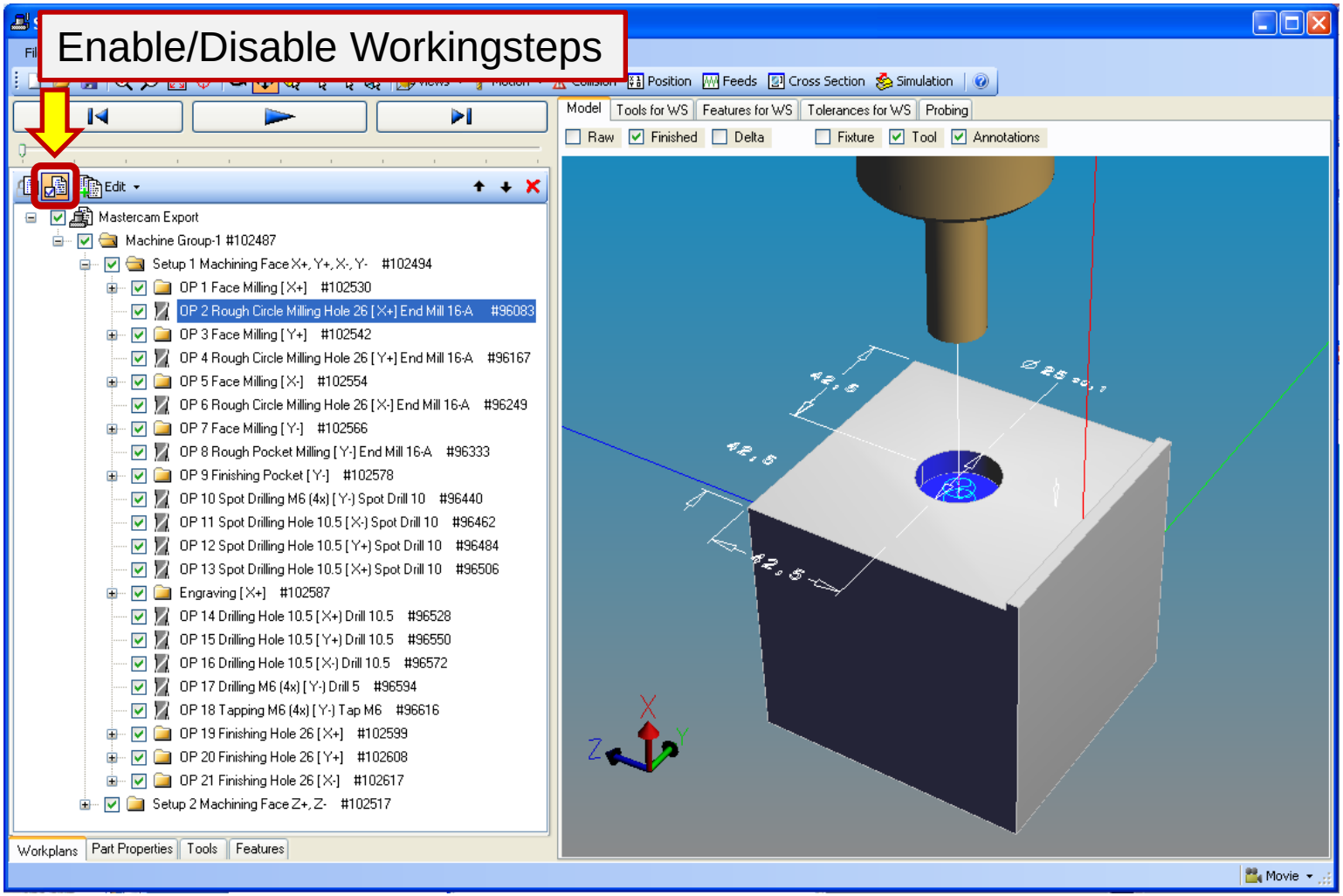


Enable/Disable Workingsteps



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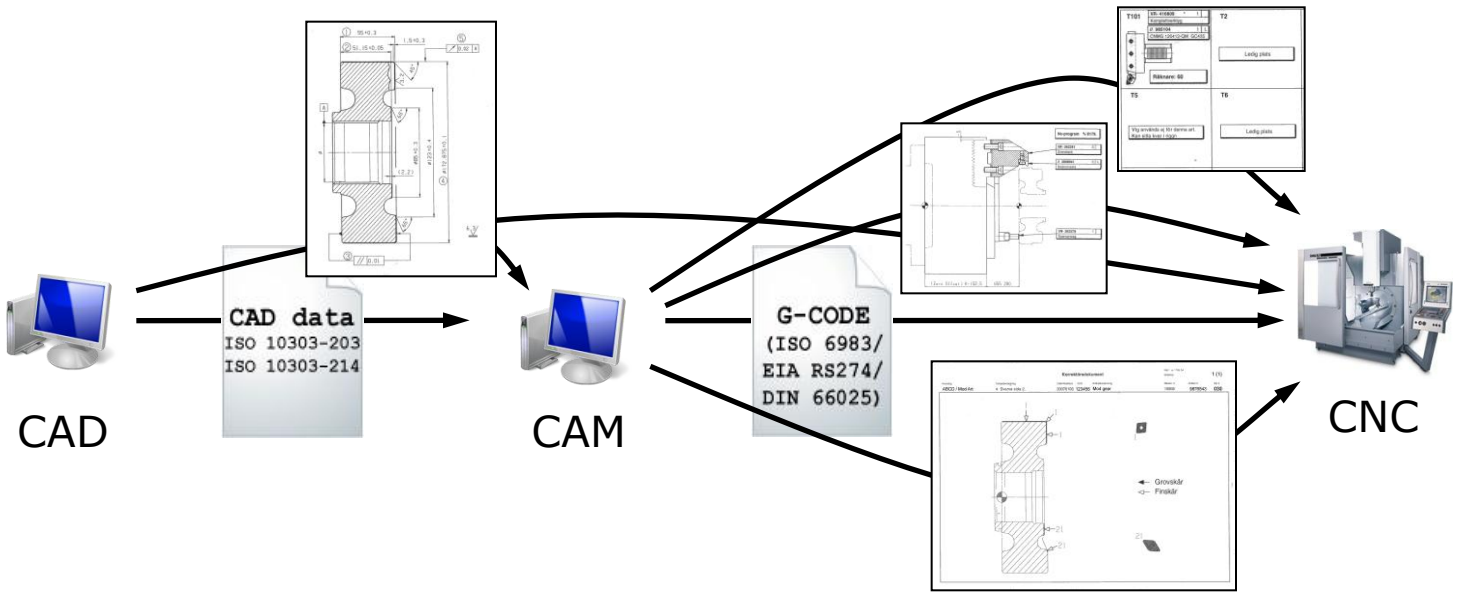
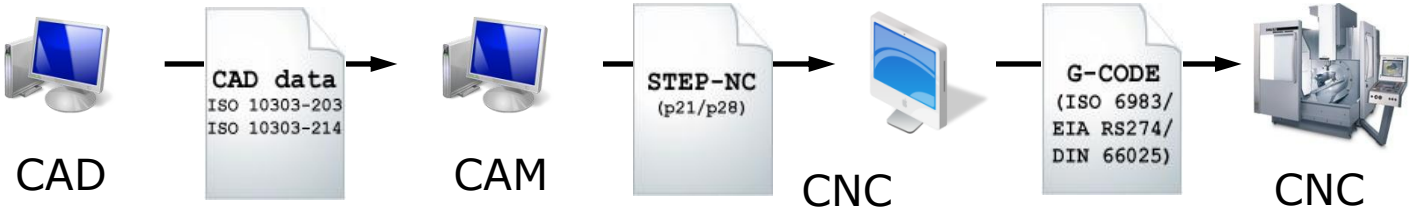


Traditional implementation

Fragmented manufacturing data

STEP-NC implementation

Consolidated manufacturing data



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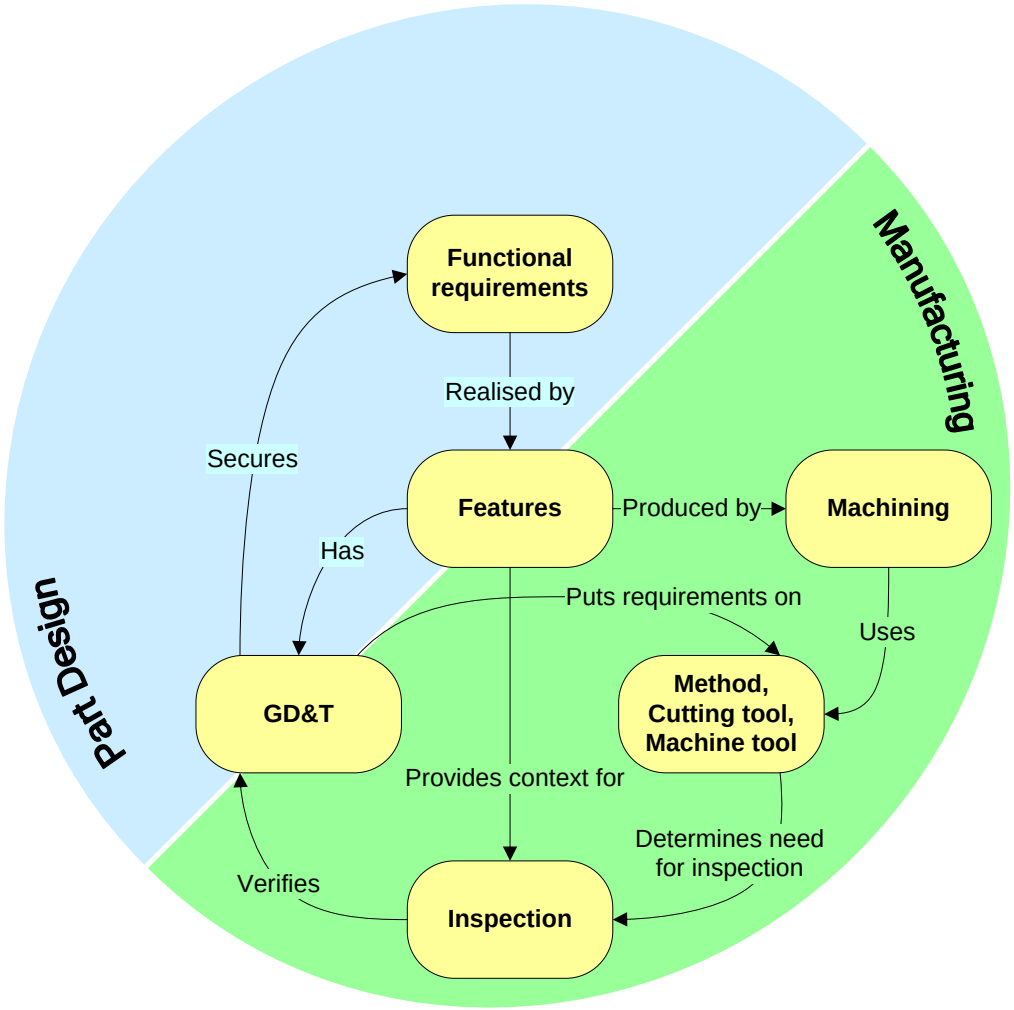
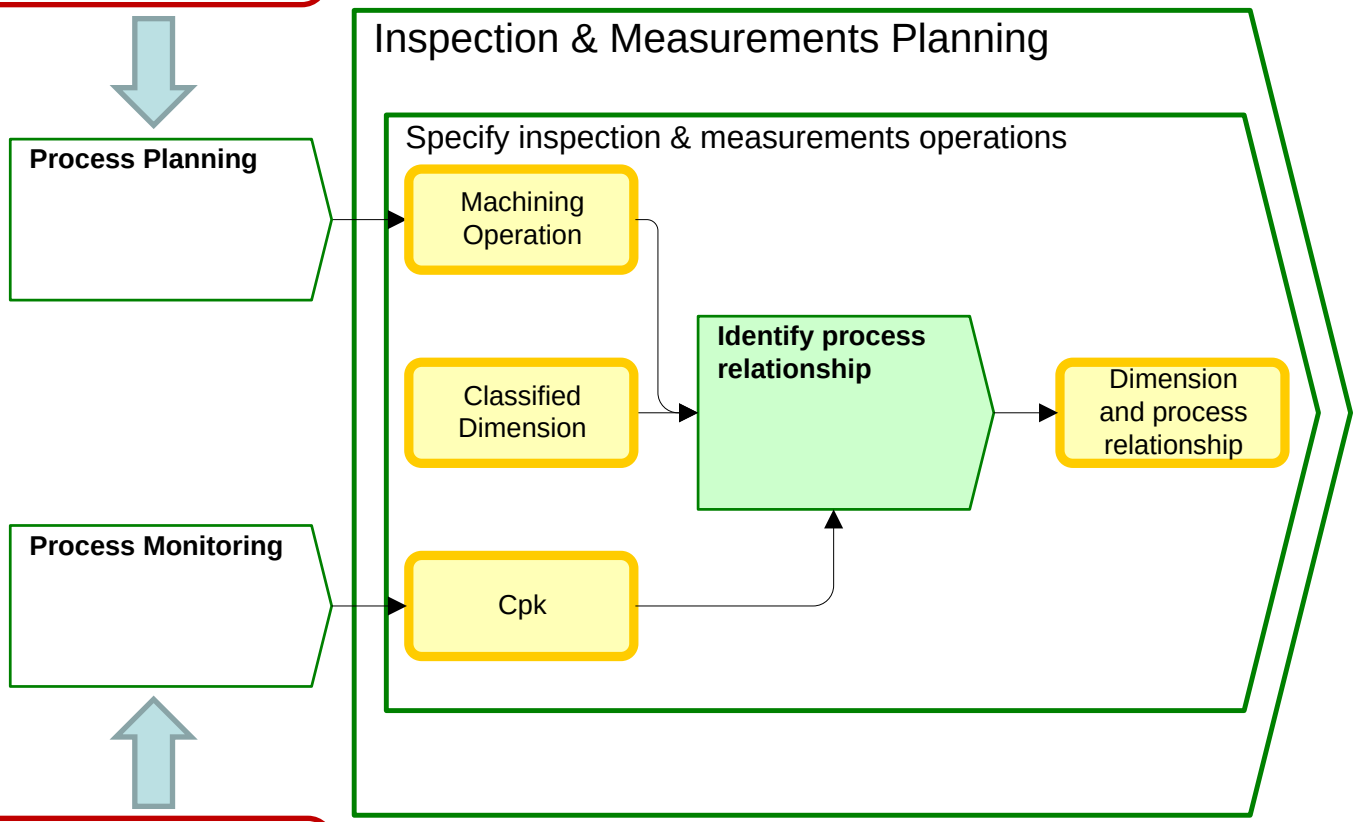


Feature, Mfg. Tolerances, Processes and Resources (machine tool, cutting tool, fixture etc), Capability? (ability to produce within an specified tolerance),



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Manufacturing feedback in a context, which machine tool, which cutting tool, which fixture, what kind of feature, etc,.

Results and conclusions

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- The ability to insert workplans and reorganize workingsteps worked very well and allowed us to adapt a master process for different machine configuration
  - 3-Axis machining in 6 setups
  - 3-Axis machining in 12 setups (more robust process)
  - 4-Axis machining in 2 setups
  - 5-axis machining in 2 setups
- Being able to also add/replace workingsteps, e.g. already existing WS from another project or new ones created in a CAM-system, i.e. CAM to CAM would be a useful improvement and perhaps a suitable challenge for next demo.

Acknowledgements

- Bengt Olsson, Sandvik Coromant for providing the cutting tools for the machining of Boxy.
- Peter Engberg, Scania - Industriskolan for machining of a Boxy in their Hardinge VMC 600 II
- Jan Stamer & Björn Sandberg, KTH for machining of a Boxy at KTH

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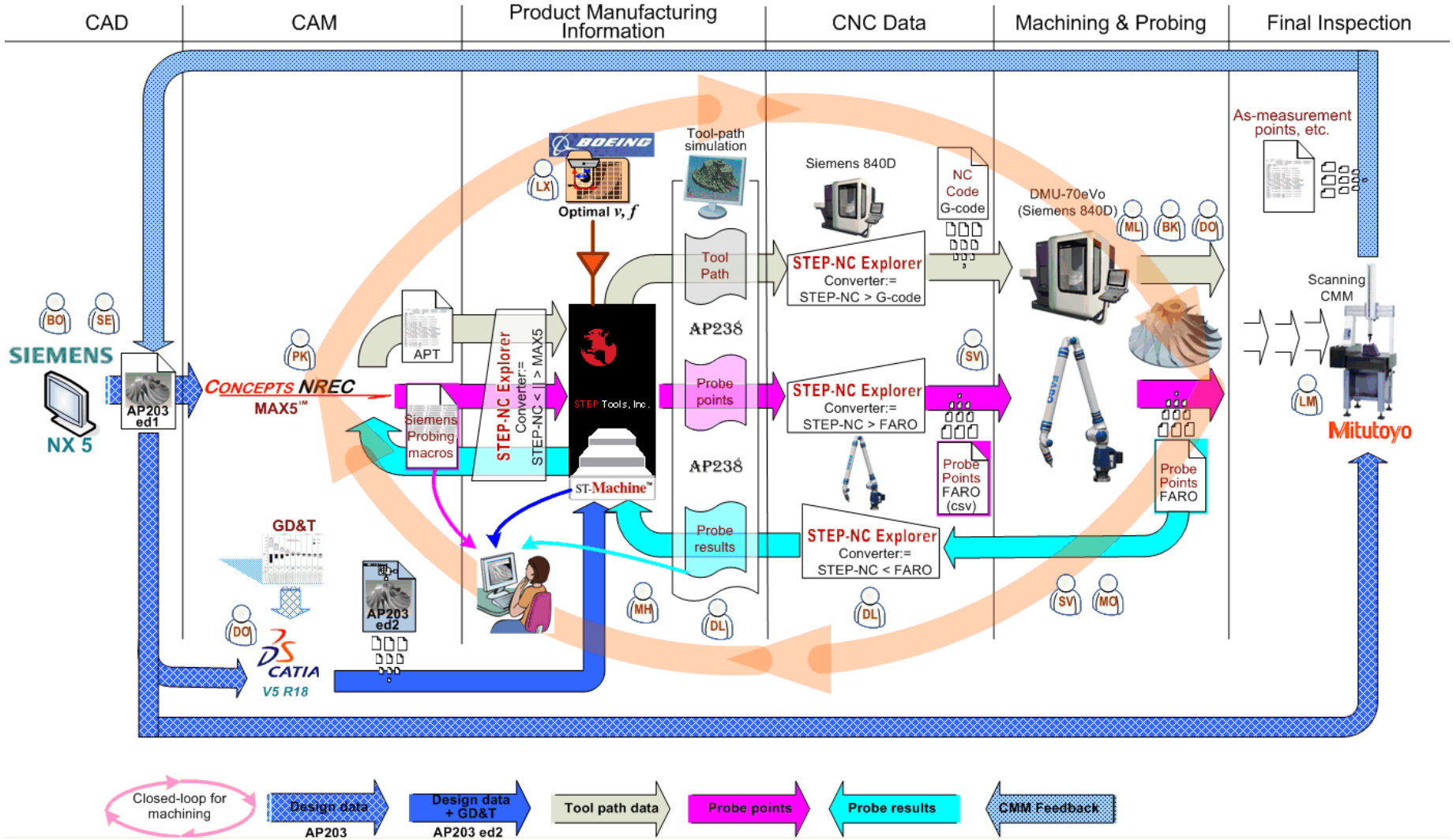
Finish Milling of Impeller Blade

Peter Klein
Concepts NREC

Step Manufacturing Demonstration
1.Oct.2008

CONCEPTS NREC

Closed Loop Machining



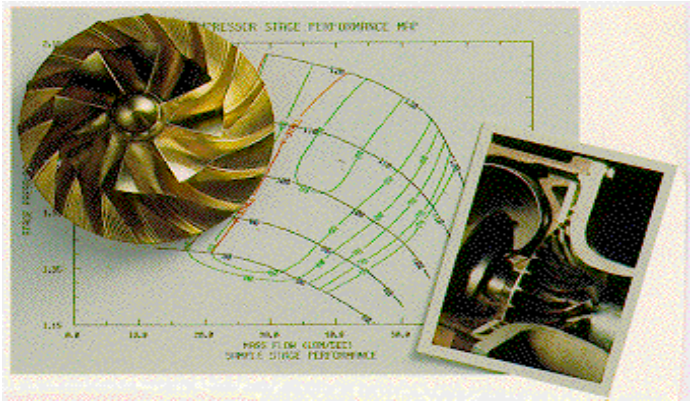
CONCEPTS NREC

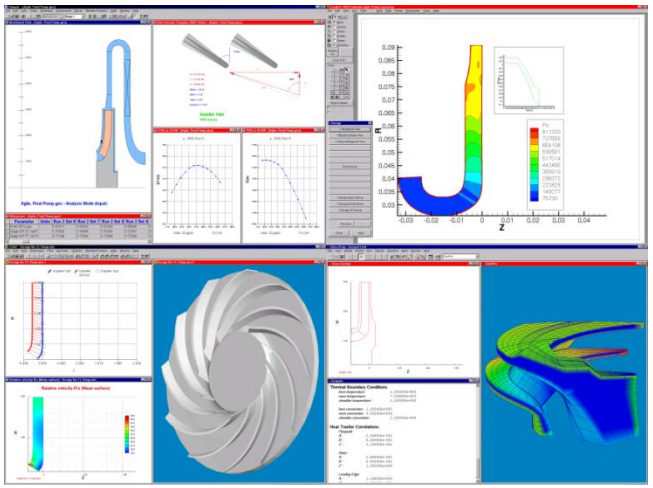
Who is Concepts NREC?

- Independent company specializing in turbomachinery technology.
- Involved in all technical disciplines related to turbomachinery.
  - cycle analysis; fluid / aerodynamic; stress / vibration;
  - thermal / mechanical; rotordynamics, bearings, seals;
  - manufacturing; life prediction; troubleshooting; and combustion.
- Headquarters in Wilder, VT

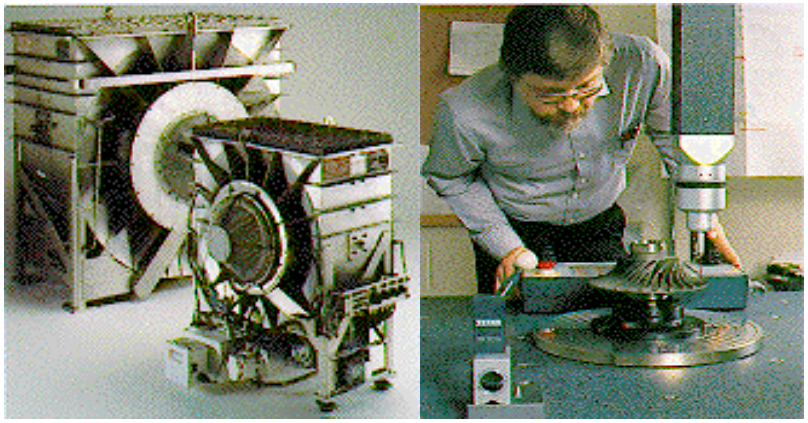
Business Units

Engineering and Testing Services





Products (Equipment / Manufacturing Services)



CAE/CAM Software:

The Agile Engineering System

CONCEPTS NREC

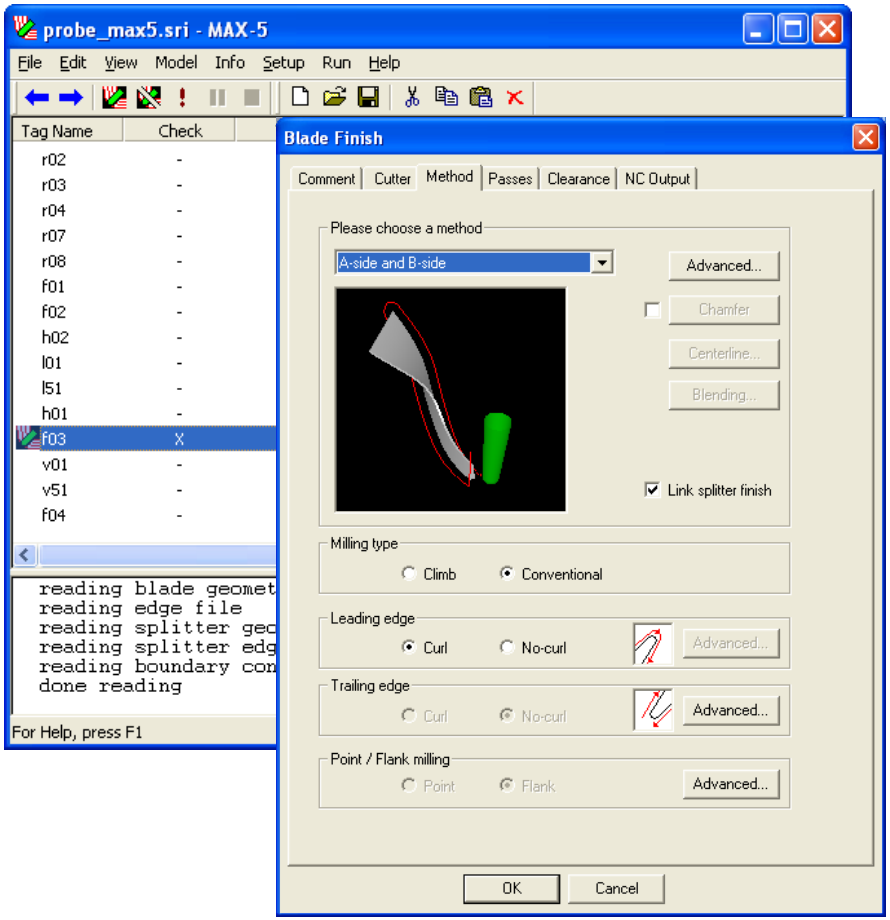
Product Center in Woburn, MA

- CAM Software Development
- In-house machine shop
  - Contract machining
  - Product development
- 5-axis Machines
  - Hermle C40U
  - Mikron HSM-600U
  - Mitsui Seiki HS5A-80
  - BostoMatic 1000
- Support and test equipment
  - 2 lathes
  - Spin pits
  - Balancing
  - Zeiss CMM

CONCEPTS NREC

MAX-PAC™ CAM Software

- Commercial product developed by Concepts NREC since 1985
- Specialized for 5-axis milling of impellers and blisks

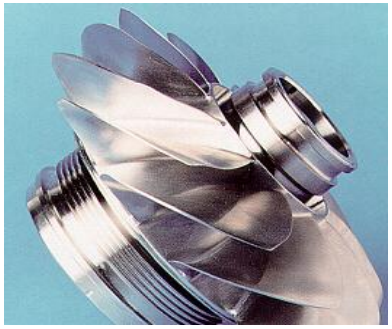


CONCEPTS NREC

MAX-PAC CAM Suite

MAX-5

Flank-milling of ruled-surface blades



MAX-AB

Point-milling of free-form blades

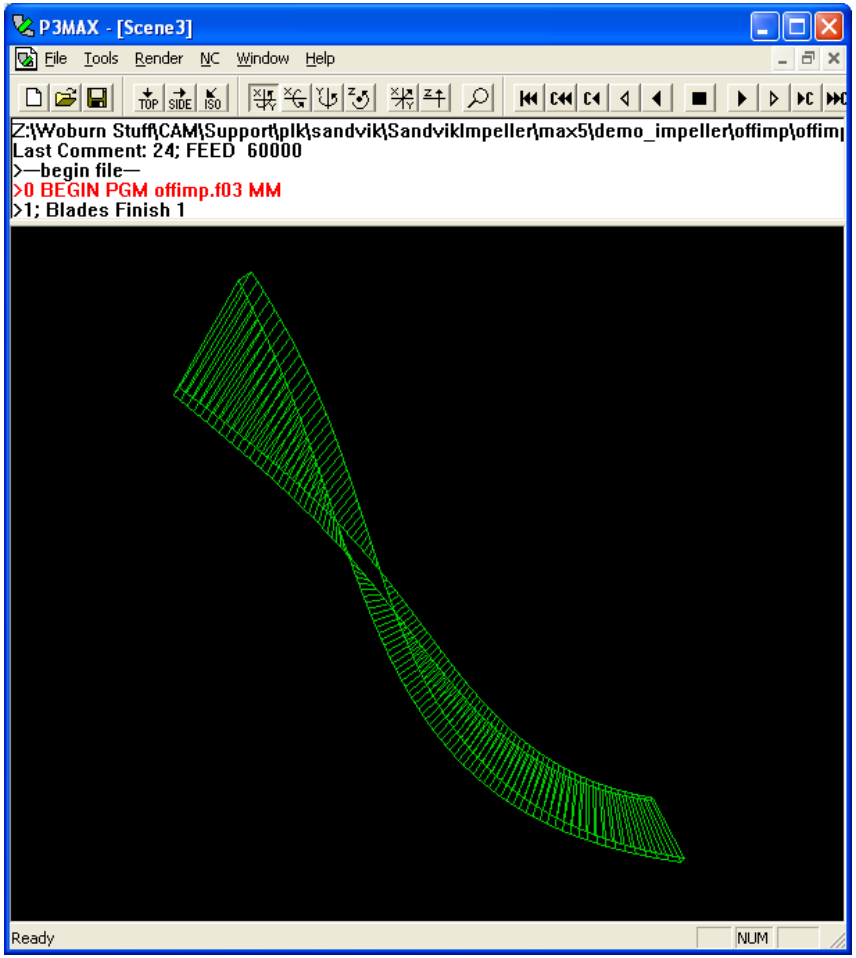
MAX-SI

Integrally shrouded

CONCEPTS NREC

Example Geometry Data

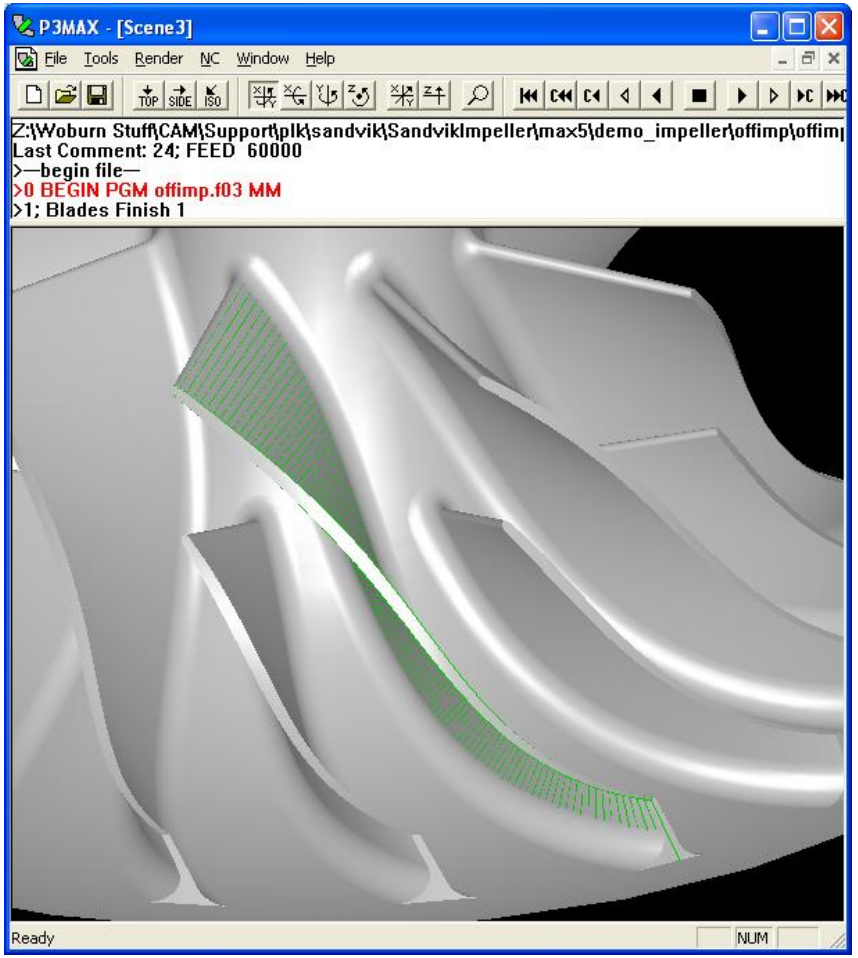
- Ruled-surface impeller blade
- 99x2 grid of XYZ points



CONCEPTS NREC

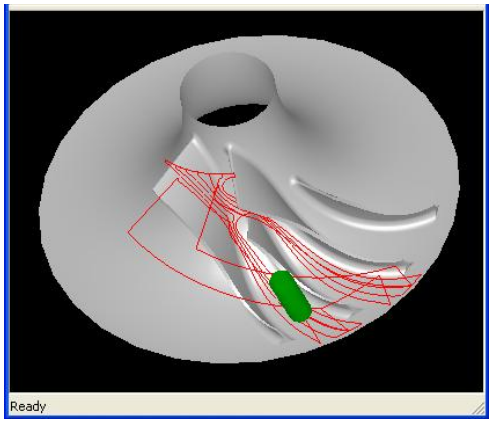
Model Construction

- MAX-5 reads data grid and constructs surface model
- Automatic constructions:
  - Round lead edge
  - Blunt trail edge
  - Tip/Hub trim
  - Fillet

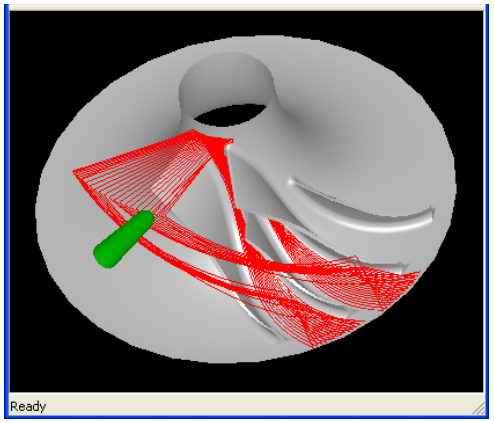


CONCEPTS NREC

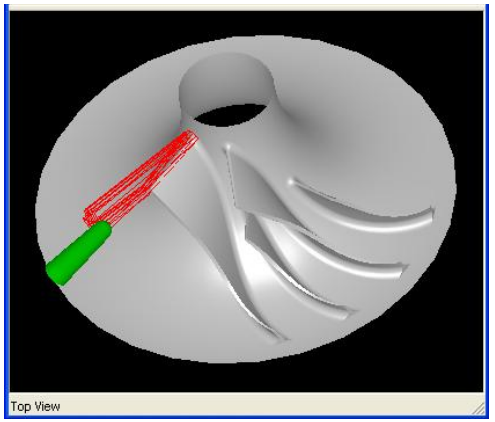
Toolpaths



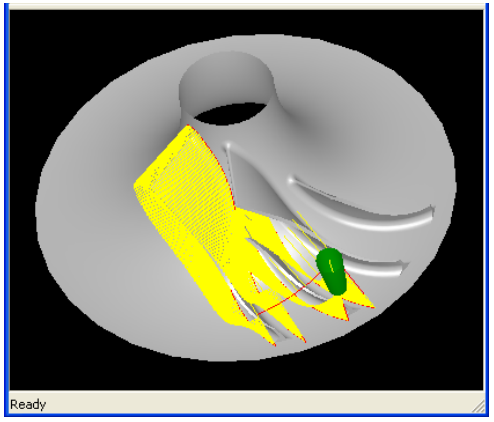
Roughing



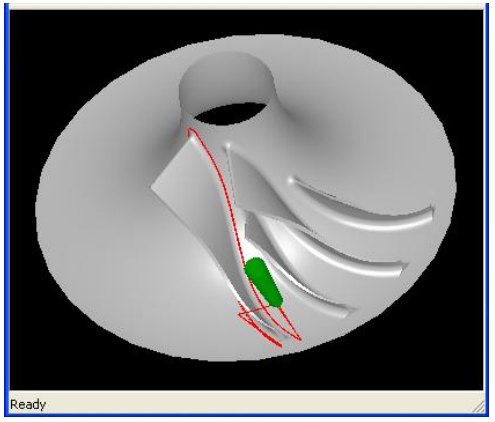
Hub Finish



Lead Edge



Blade Finish

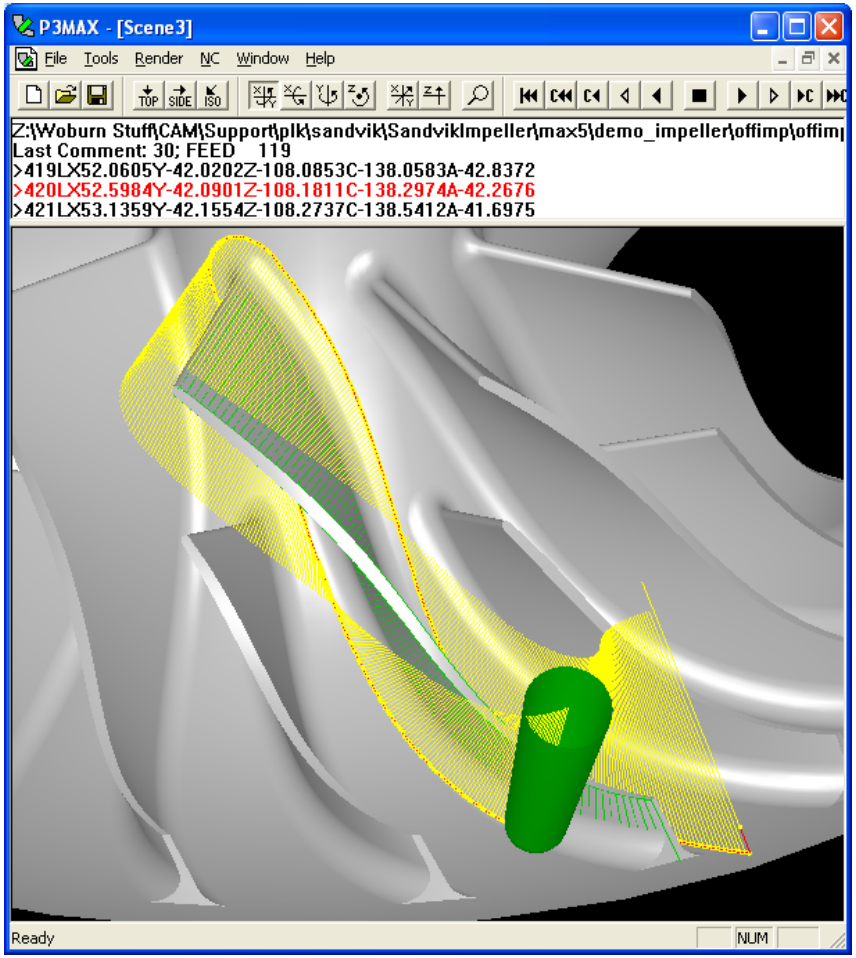


Fillet Finish

CONCEPTS NREC

Finish Toolpath

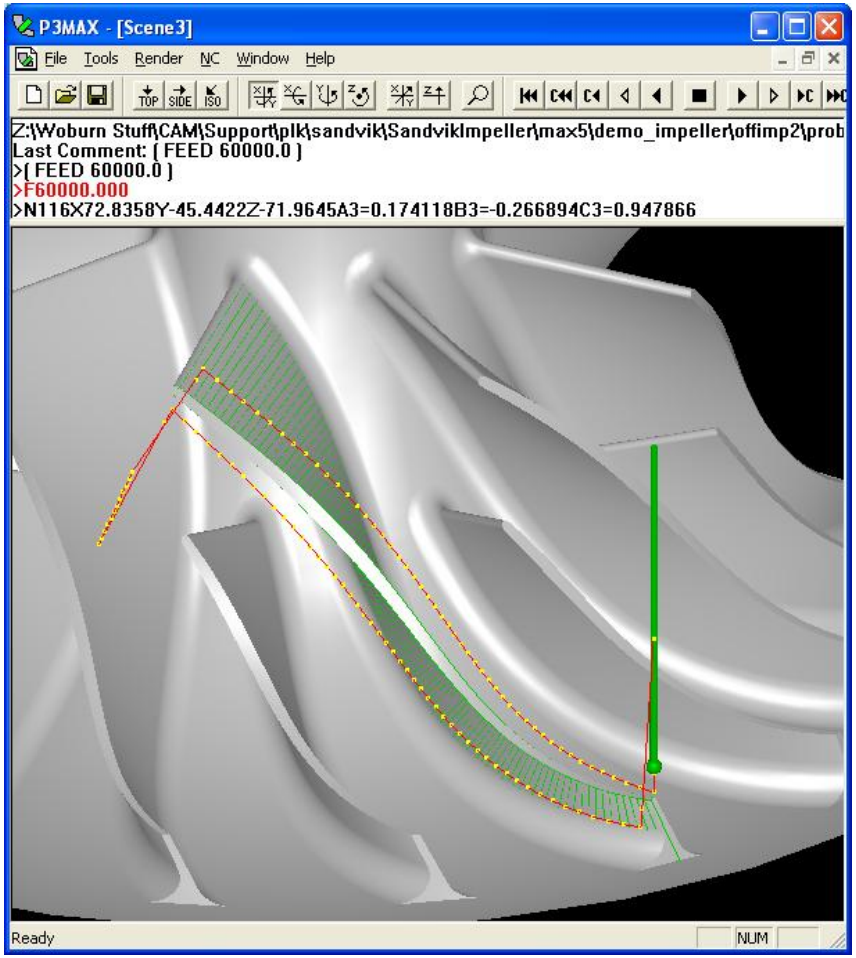
- Flank milling toolpath generated by MAX-5
- Forms blade in one pass using side of cutter
- Patented algorithm minimizes geometric deviation
- Toolpath file formats
  - APT(XYZIJK)
  - Postprocessed



CONCEPTS NREC

Inspection Path

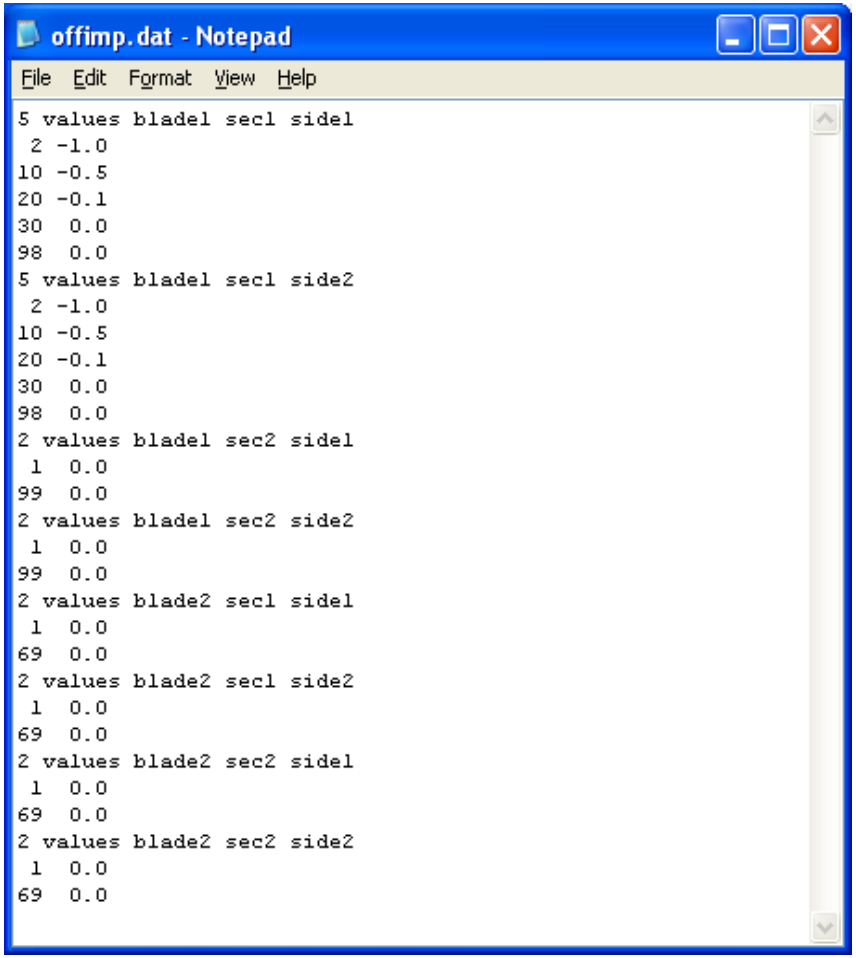
- 5-axis inspection
- Inspect at each input grid point along tip (inset 1 mm to ensure contact)
- Skip off-part points at lead and trail
- 97 points per side
- Measures deflection at blade tip
- Ignore tool deflection at blade root for this demo
- Modified Siemens format



CONCEPTS NREC

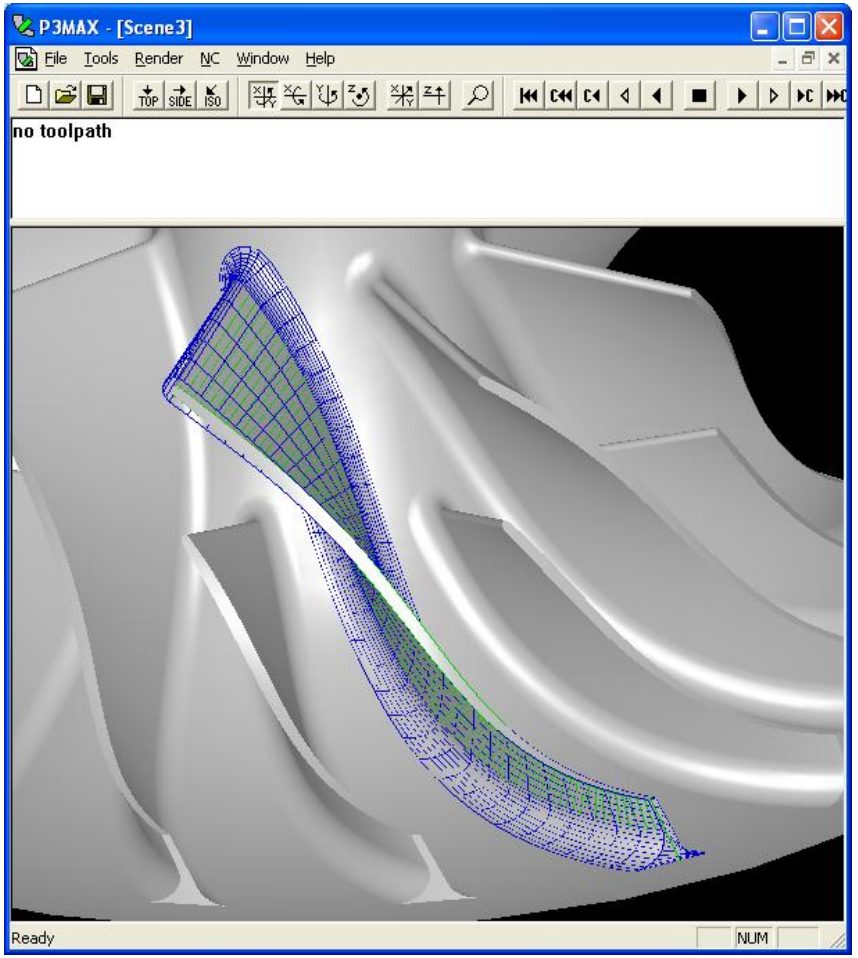
CMM Feedback

- Text file contains inspection results
- Specifies deviation at each blade grid point
- Missing values smoothly interpolated
- Used as MAX-5 feedback input to adjust blade



Adjusted Geometry

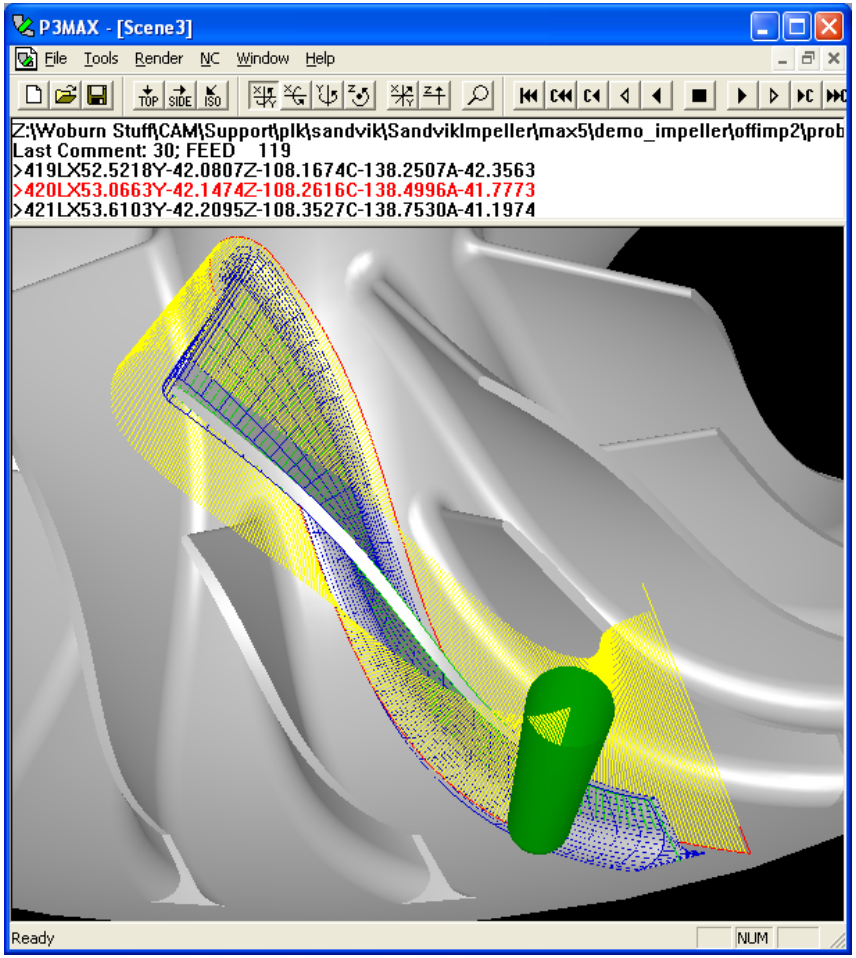
- Blade has been adjusted in high-deflection lead edge area at tip
- Blade can be thickened (shown here) or thinned



CONCEPTS NREC

Adjusted Toolpath

- New toolpath automatically generated by MAX-5 using deviation data
- Batch-mode possible with no user interaction



CONCEPTS NREC

Boeing's Evaluation of AP238 (STEP-NC) For Advanced Machining Processes

Sid Venkatesh
The Boeing Company

Present Situation

- NC machining has been used in production for approximately 50 years.
- Traditional data flow provides only low-level information to the NC machine tool.
- A lack of strong standards results in incompatibilities
  - Machine
  - Control
  - CAM

Problems

- **Not Portable**
  - Unique data must be generated for each machine control combination on which the part is to be run
- **Not Adaptable**
  - No information is provided to the machine to help it adapt to real-time changes in machining dynamics and machine tool alignment.
- **Not Bi-directional**
  - No standardization for in-process data generation

A Solution: “Smart, Standard CNC”

- Cutter movement data, instead of axis movement data is sent to the CNC.
  - Allows the data sent to the CNC to be machine independent
- High level information about the part features, materials, cutters, and dimensional tolerances can also be sent to the CNC.
  - Allows the CNC to make smart decisions in order to optimize manufacturing
- A standard method can be used to transmit in-process data
  - Simplifies and increases possibilities for closed-loop machining

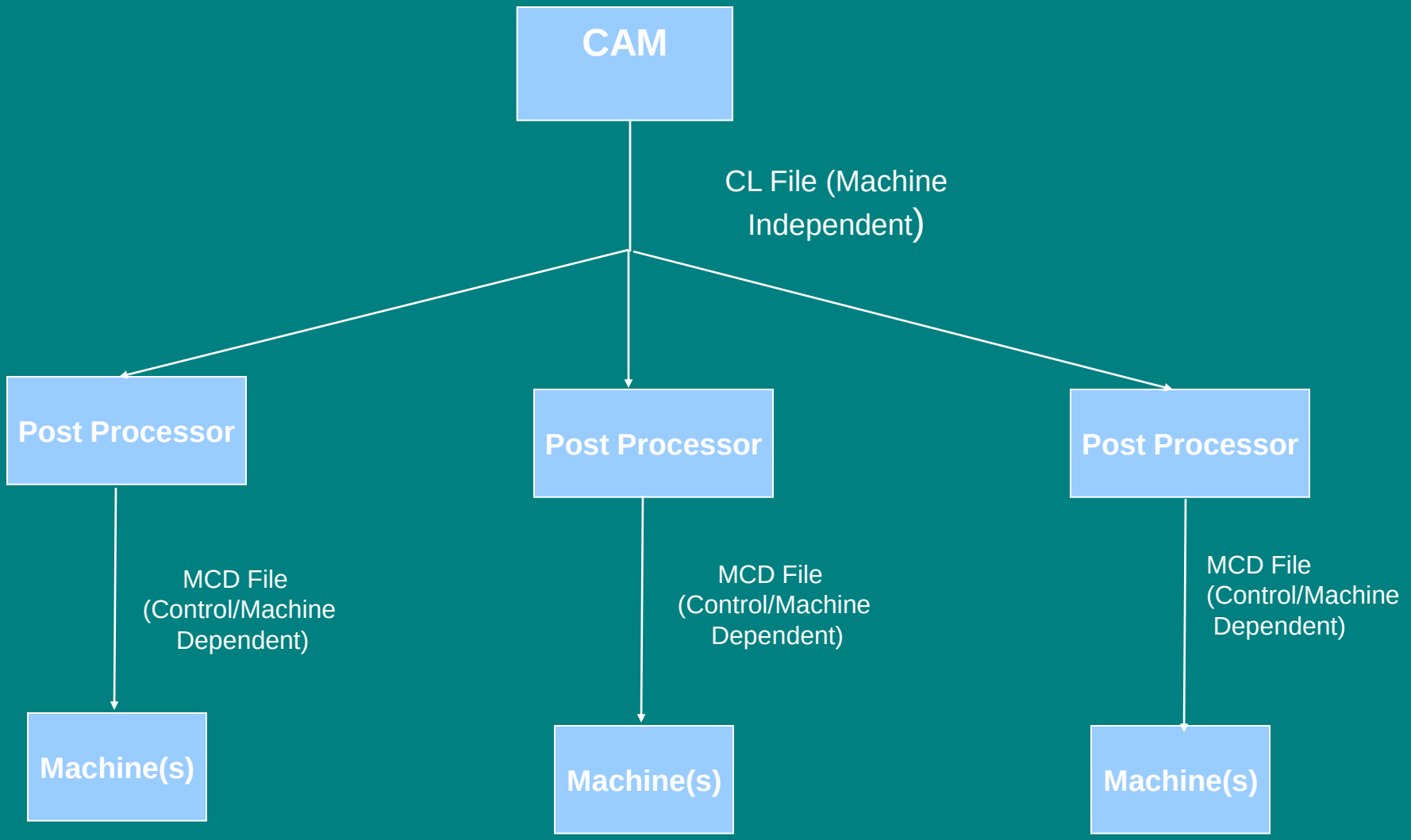
Smart, Standard CNC Benefits: Portability

- Cutter motion data is “machine neutral” and may be used directly by machines with different geometries
- Separate post-processors are not required for each unique control/machine combination
- Direct portability between machine tools/controls is possible (within reason)
- Process data collection can be commanded using a standard format
- Process data can be recovered using a standard format

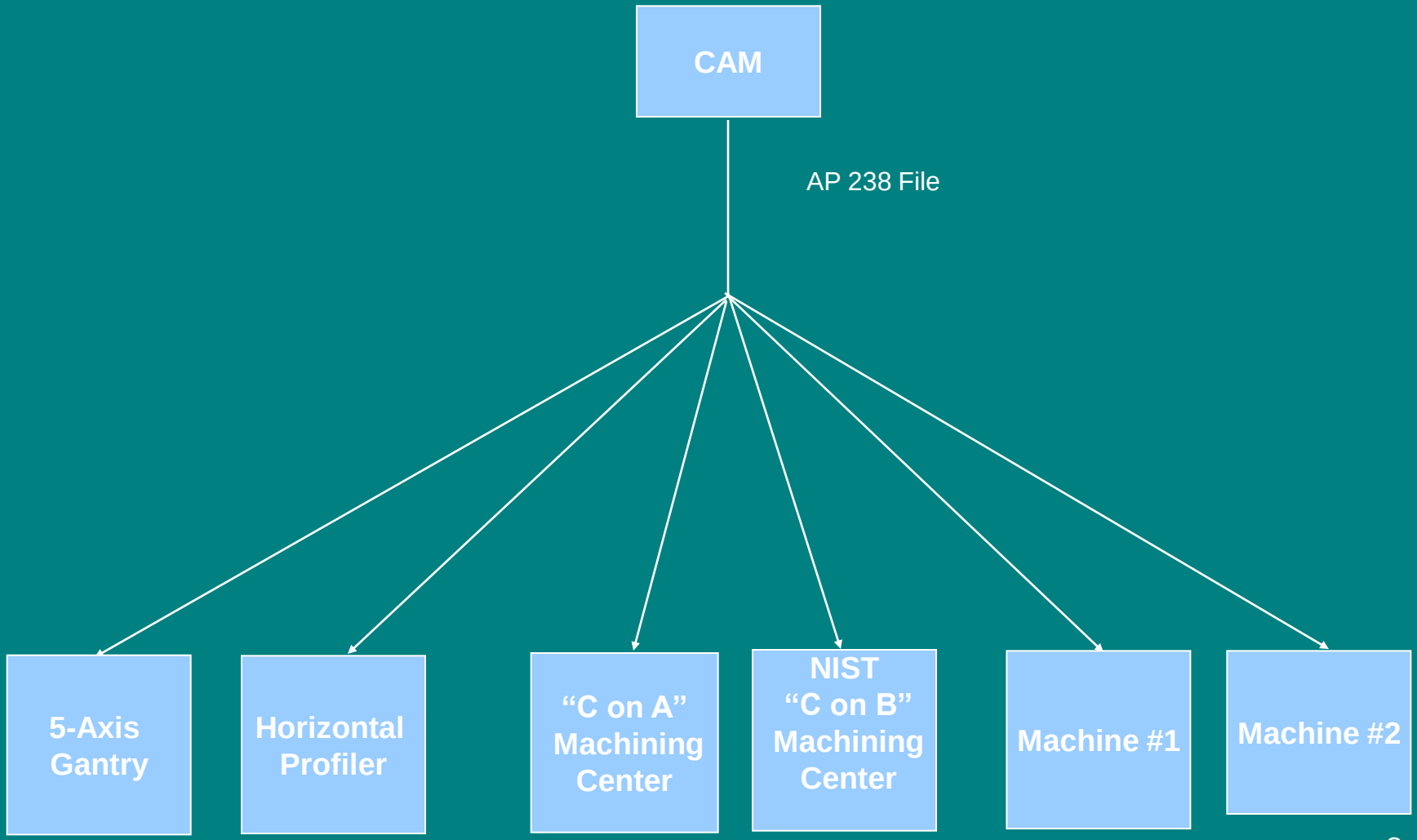
Portability Issues

- Data that is presently sent to a CNC is not portable for two main reasons:
  - No standard format followed
  - Machine geometries vary
  - Machine auxiliary functions are not implemented in a consistent, standard manner
  - No consideration has been made for the standard collection of in-process data

“Traditional CNC” Data Flow



Smart, Standard CNC Data Flow: Final



A Wide Data Path

- Other information about the part can be transmitted using AP238
  - Fixtures
  - Material
  - Cutters
  - Tolerances
  - Part Geometry
  - NC Data

Demonstration: "Real World" Practicality

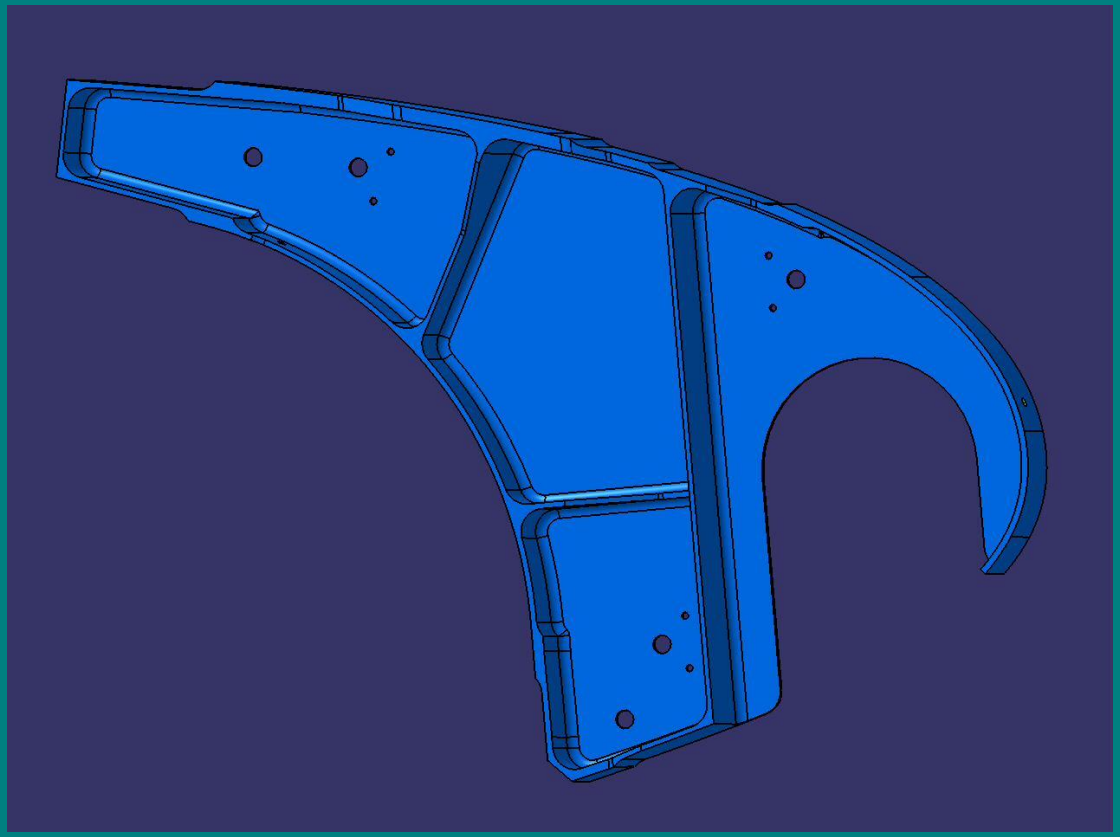
- The practicality of using AP238 to define and produce a complex, 5-axis, "real-world" part was unproven
  - Are file sizes reasonable?
  - Is processing time reasonable?
  - Can the required software be produced?
  - What other problems will be encountered?

Caveat

- AP238 allows DATA portability. It does not guarantee PROCESS portability.
  - Machine work envelope
  - Spindle capability
  - Machining philosophy
  - Cultural Issues
- Presently, in-process data collection functionality is incomplete

Test Part for Demonstration B

5-axis
Aerospace Part



49th ISO TC184/SC4 meeting

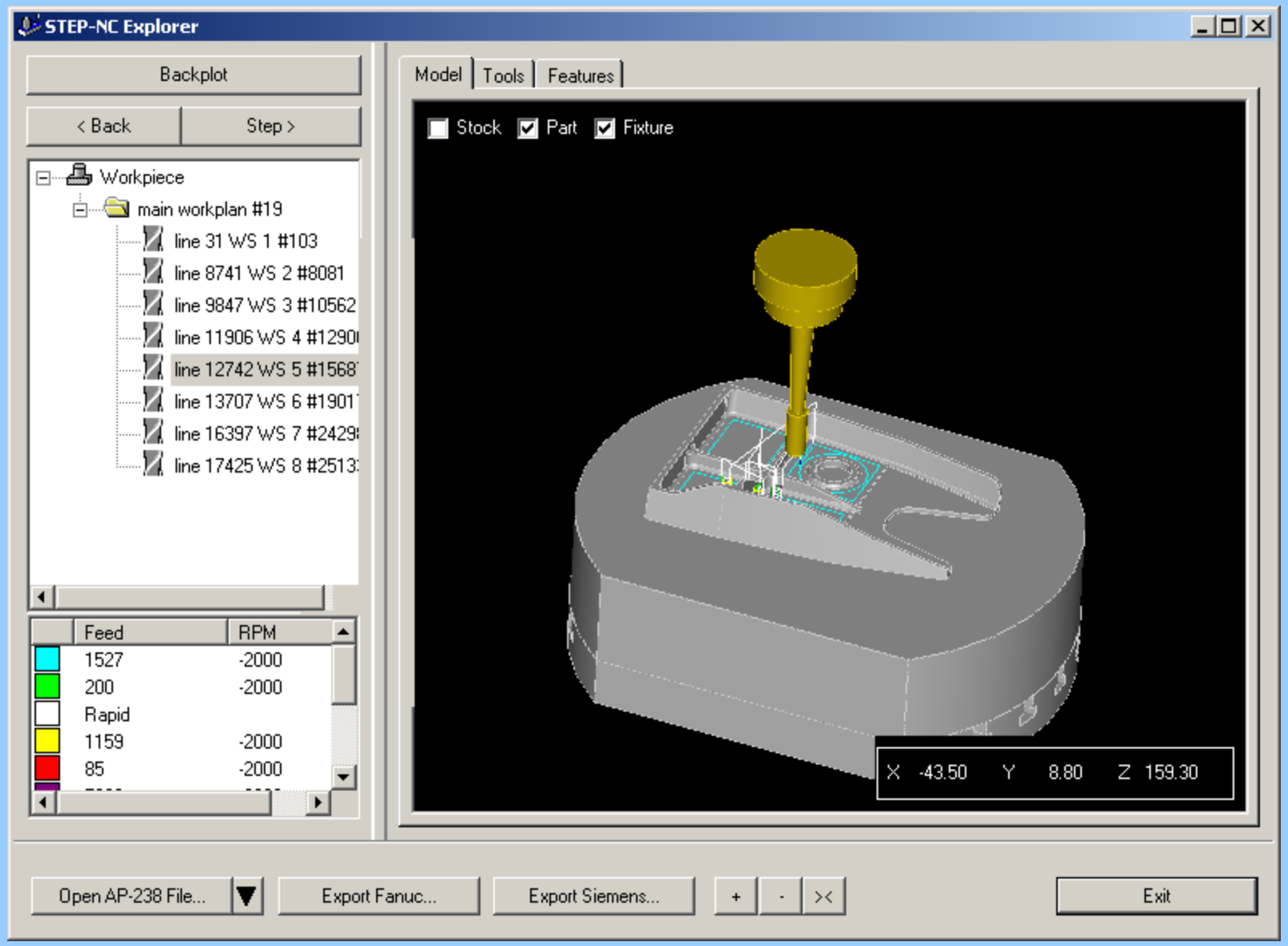
Industry Day

STEP-NC AP-238

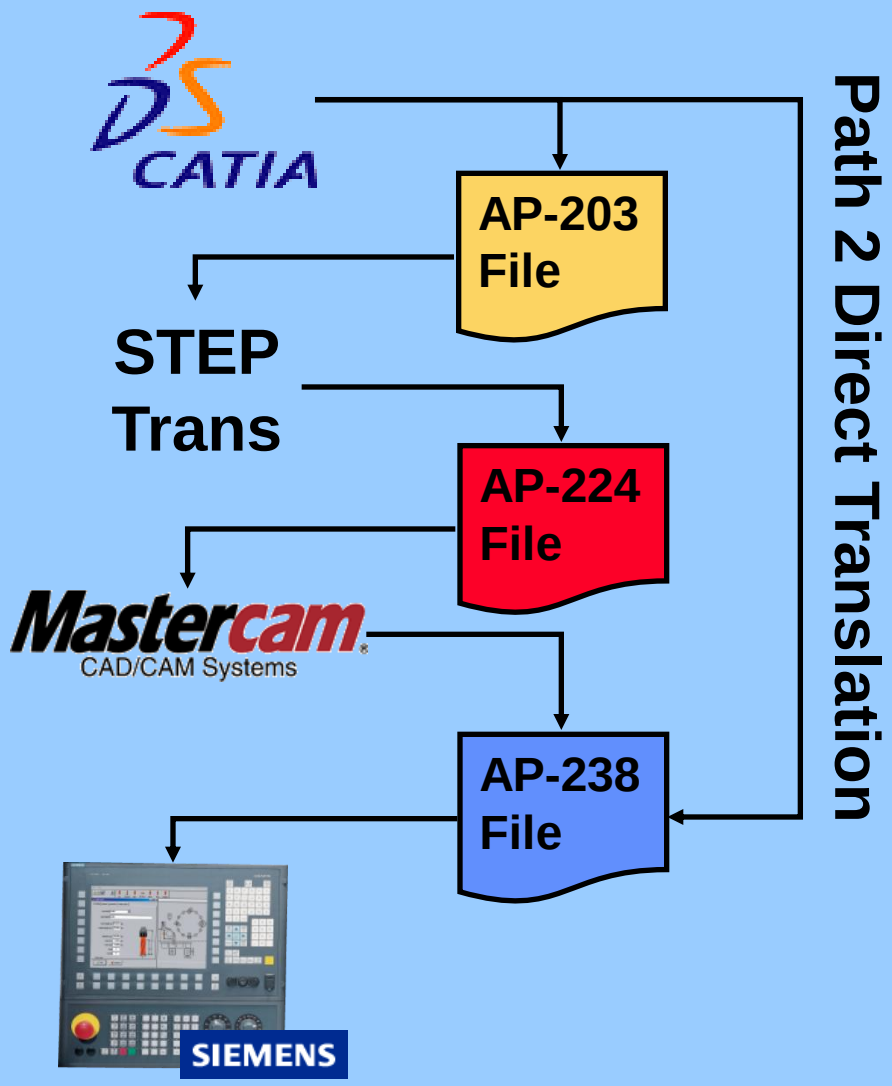
Martin Hardwick

STEP Tools, Inc.

Finishing


STEP-NC Explorer
Backplot
< Back
Step >
Workpiece
main workplan #19
line 31 WS 1 #103
line 8741 WS 2 #8081
line 9847 WS 3 #10562
line 11906 WS 4 #1290
line 12742 WS 5 #1568
line 13707 WS 6 #1901
line 16397 WS 7 #2429
line 17425 WS 8 #2513
Feed
RPM
1527
-2000
200
-2000
Rapid
1159
-2000
85
-2000
Model
Tools
Features
Stock
Part
Fixture
X -43.50
Y 8.80
Z 159.30
Open AP-238 File...
Export Fanuc...
Export Siemens...
+
-
><
Exit

Finishing



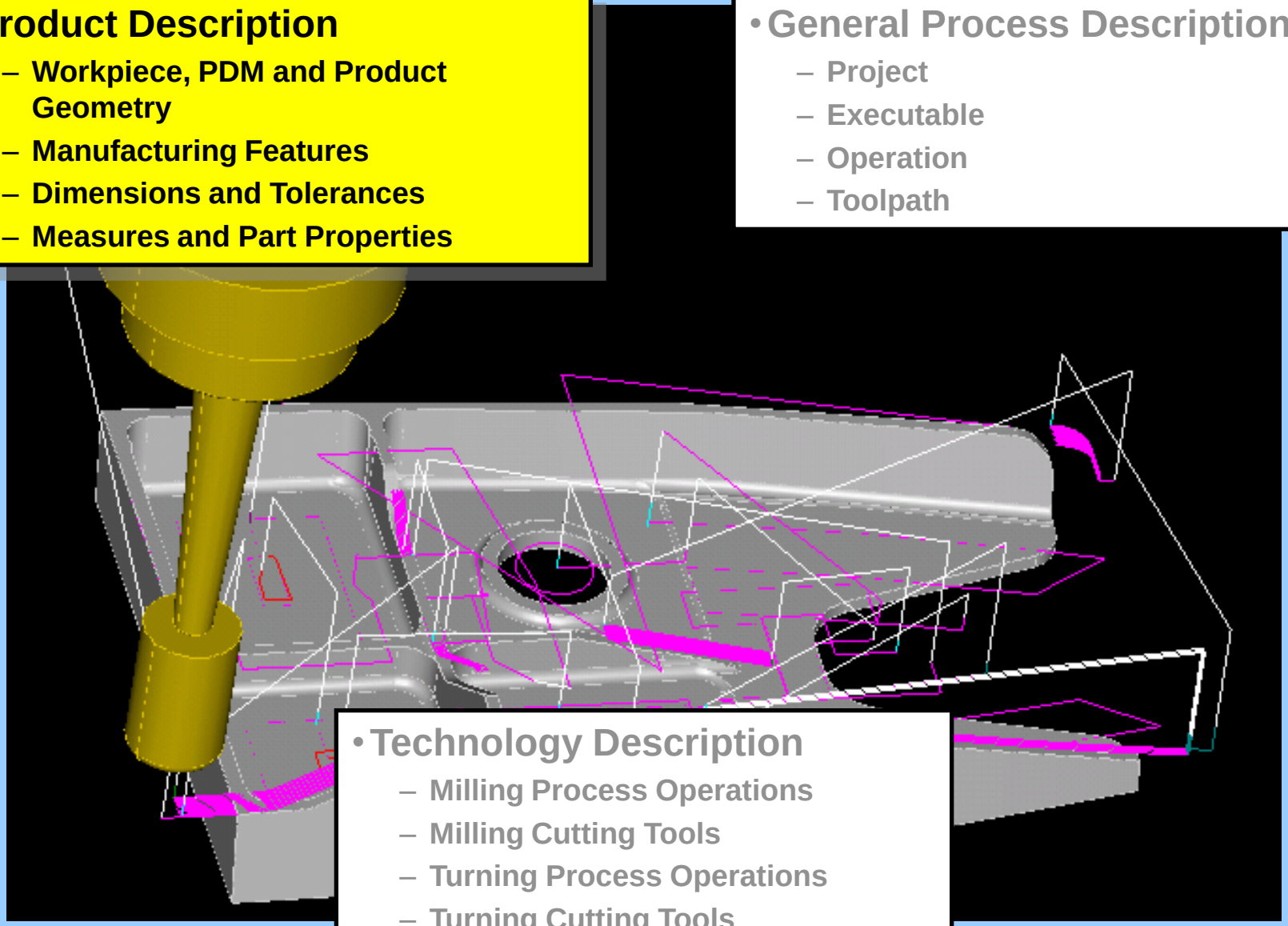
Path used for Roughing

Path used for Finishing

AP-238 Units of Functionality

- **Product Description**
  - **Workpiece, PDM and Product Geometry**
  - **Manufacturing Features**
  - **Dimensions and Tolerances**
  - **Measures and Part Properties**

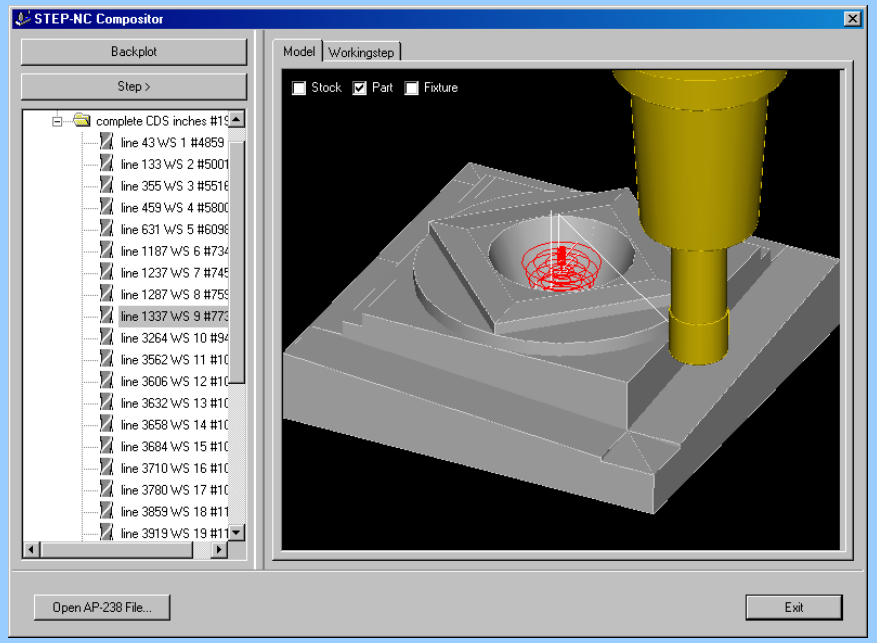
- General Process Description
  - Project
  - Executable
  - Operation
  - Toolpath

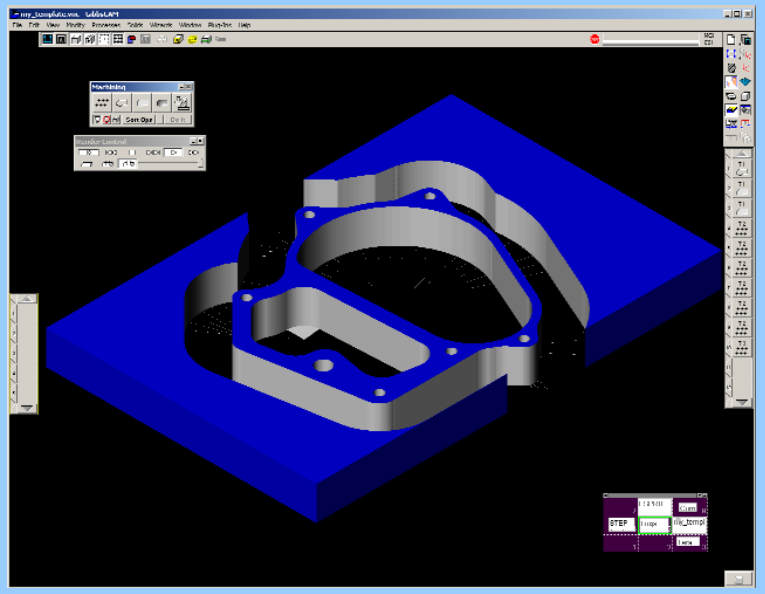


- Technology Description
  - Milling Process Operations
  - Milling Cutting Tools
  - Turning Process Operations
  - Turning Cutting Tools

Workpiece, Shape, and PDM

- Workpiece is a STEP product description
- Has owner information, approvals, dates and times.
- Material and material properties

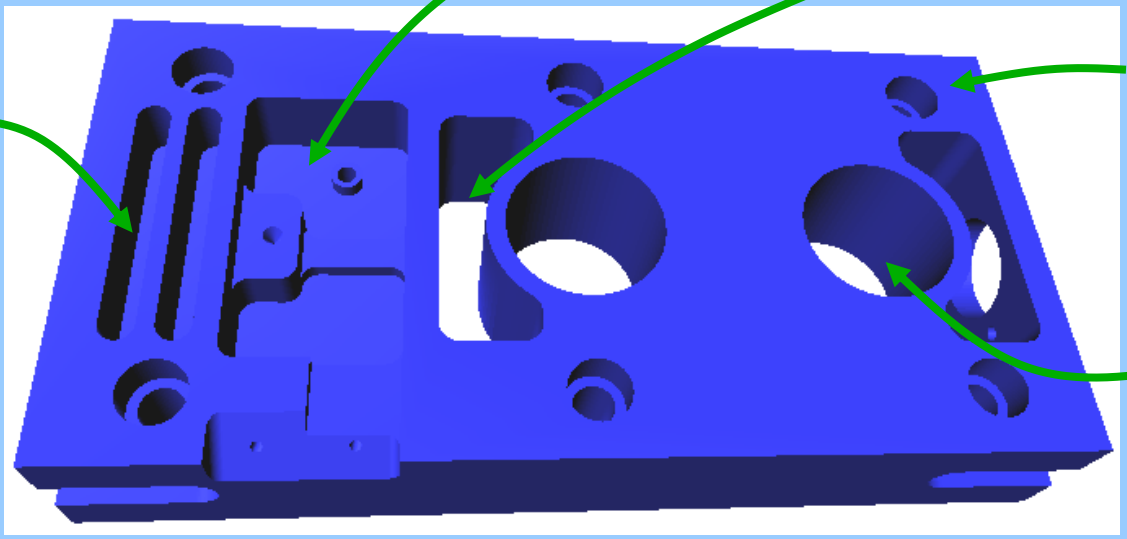




- Workpiece uses the same STEP shape representations as AP203, AP214, AP224 and other STEP APs.
- Produced by any CAD system that supports STEP.

Machining Features

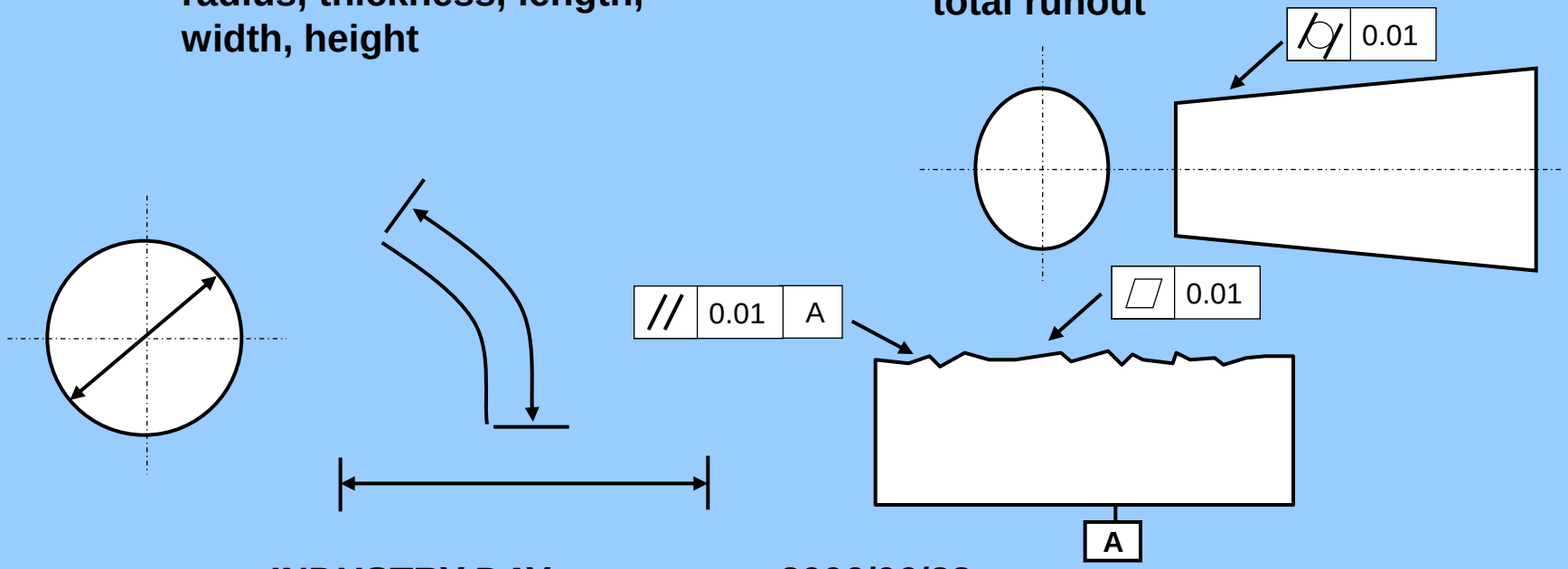
- 2.5D milling features
  - Hole, pocket, slot, step, etc
- Transition features
  - Edge round and chamfer
- Replicate feature
  - Patterns of repeated features
- Region features
  - Surfaces for freeform milling
- Turning features
  - Outer round, knurl, groove



Dimensions and Geometric Tolerances

- Dimensions defining location
  - Location defined by a linear distance
  - Location defined by a distance along a curve
  - Location defined by an angle
- Dimensions defining size
  - Curves, angle, diameter, radius, thickness, length, width, height

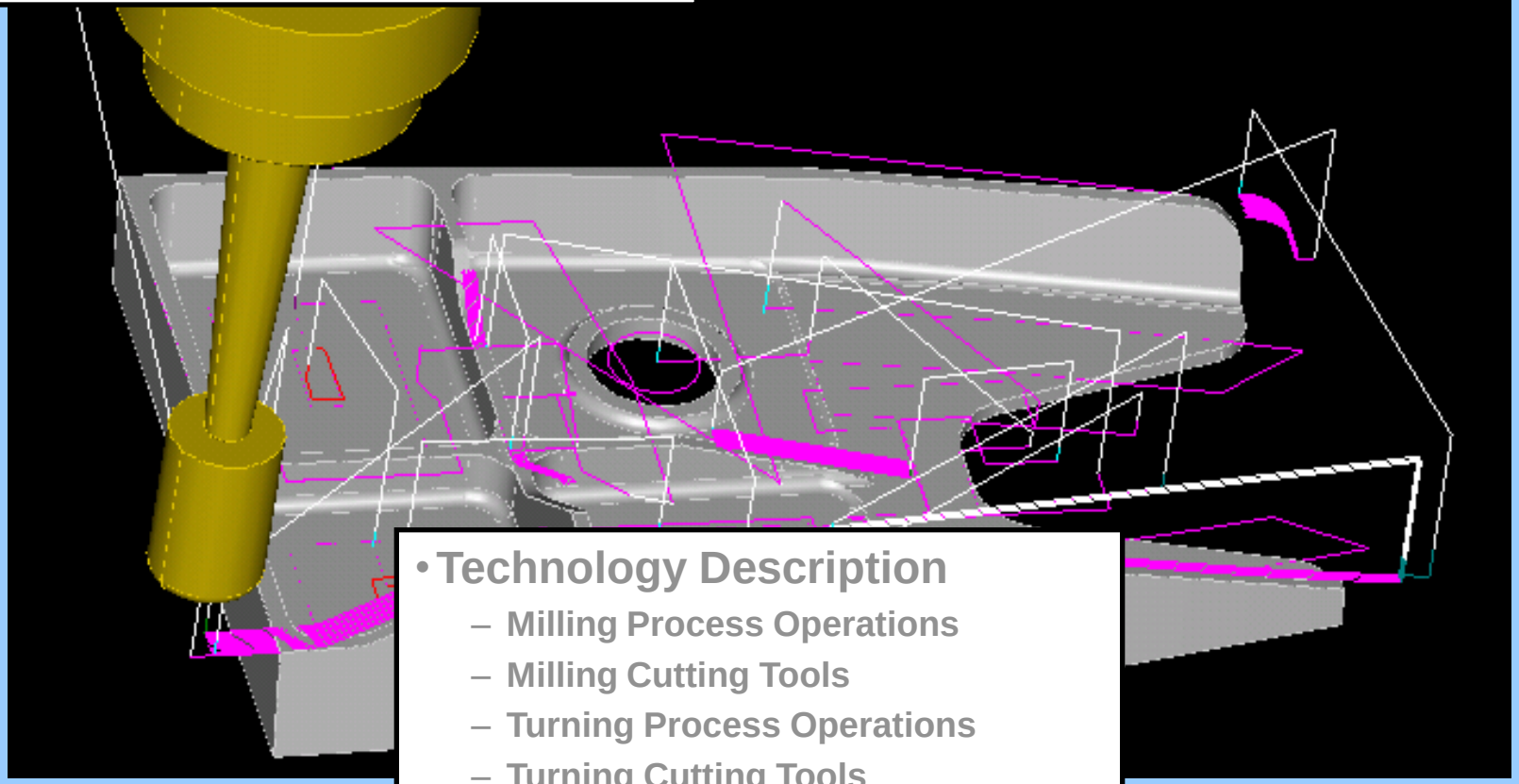
- Geometric characteristics with datums as needed.
  - angularity, circular runout, coaxiality, concentricity, cylindricity, flatness, line profile, parallelism, perpendicularity, position, roundness, straightness, surface profile, symmetry, total runout



AP-238 Units of Functionality

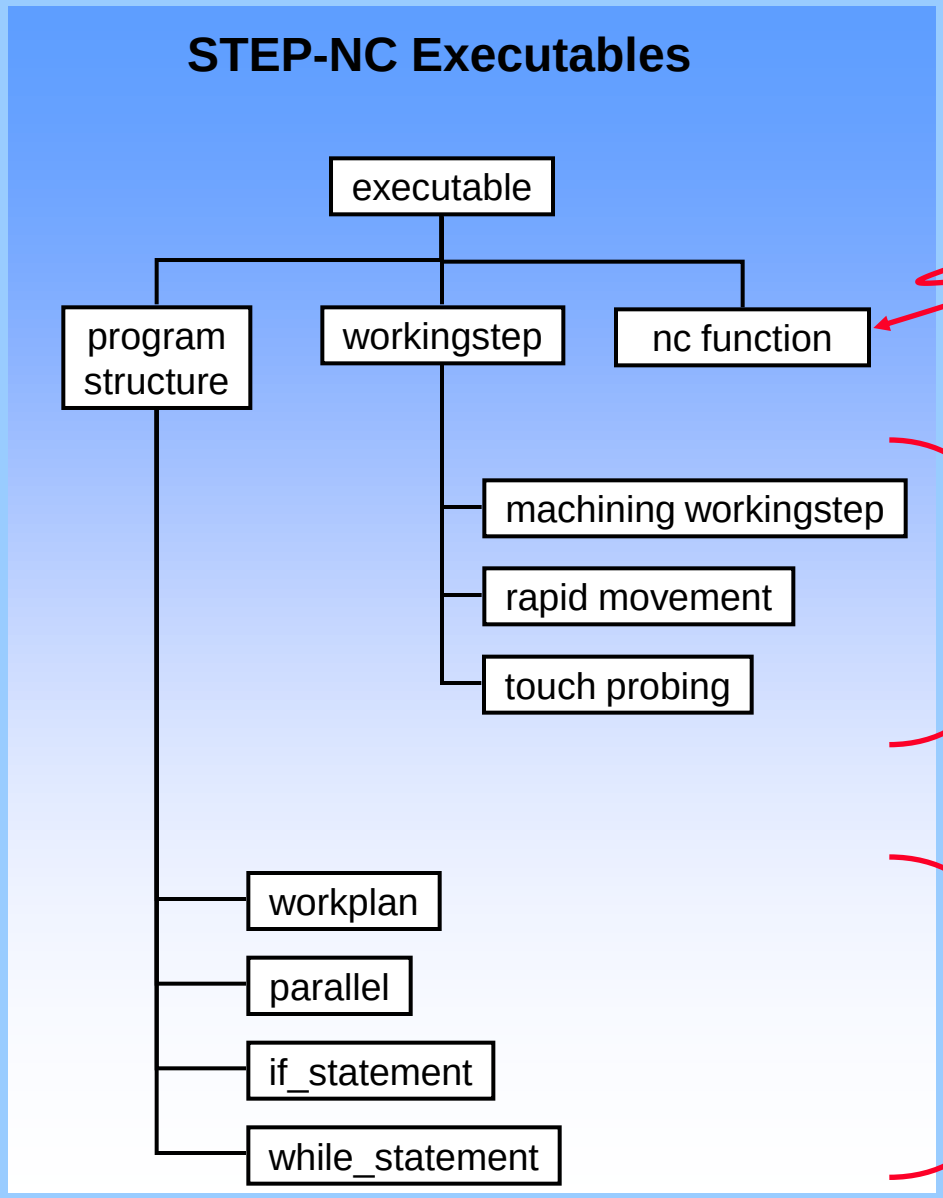
- Product Description
  - Workpiece, PDM and Product Geometry
  - Manufacturing Features
  - Dimensions and Tolerances
  - Measures and Part Properties

- **General Process Description**
  - **Project**
  - **Executable**
  - **Operation**
  - **Toolpath**



- Technology Description
  - Milling Process Operations
  - Milling Cutting Tools
  - Turning Process Operations
  - Turning Cutting Tools

Control Flow and Sequencing



Program steps that do not move any machine axes (display message, etc.)

Program steps that move the machine axes

Control flow for the machining program

Toolpaths

- **Used for explicit control of the tool motion for an operation.**
  - **Can use splines or other curves to describe motion and feedrates.**
  - **Can describe path as machine independent motion of tool center point or tool contact point.**
  - **Can also describe path using old-style machine dependent motion of individual axis.**

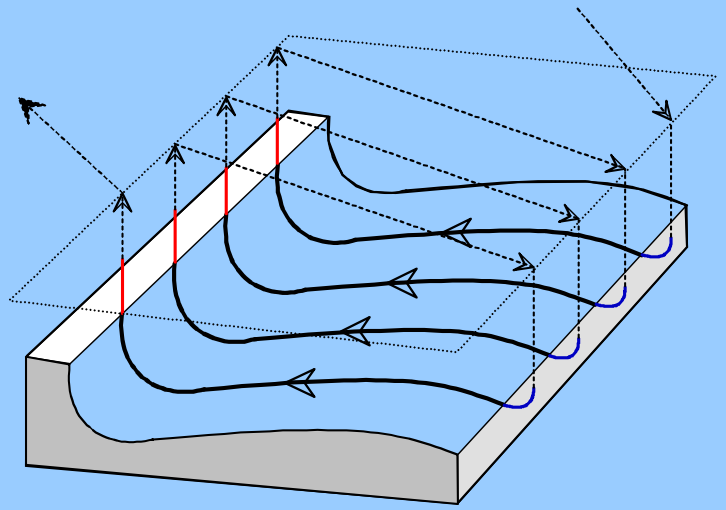
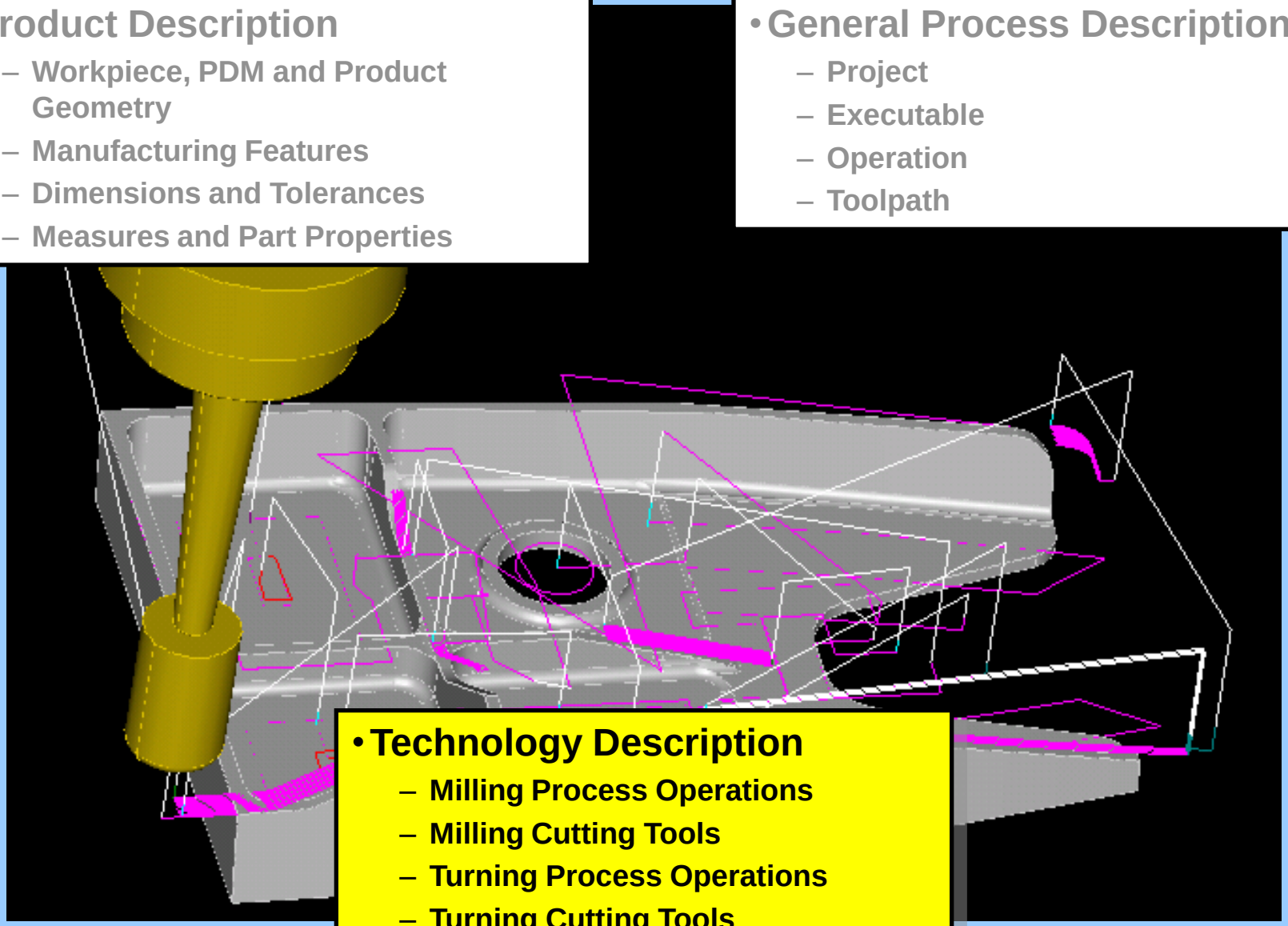


Diagram WZL RWTH Aachen

AP-238 Units of Functionality

- **Product Description**
  - Workpiece, PDM and Product Geometry
  - Manufacturing Features
  - Dimensions and Tolerances
  - Measures and Part Properties

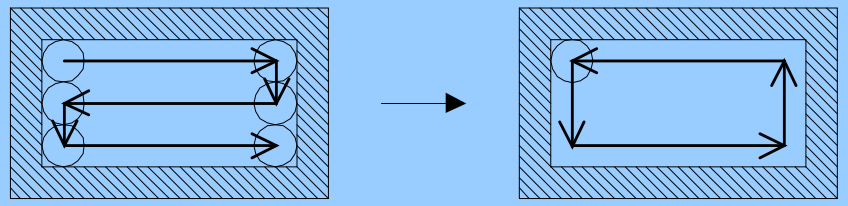
- **General Process Description**
  - Project
  - Executable
  - Operation
  - Toolpath



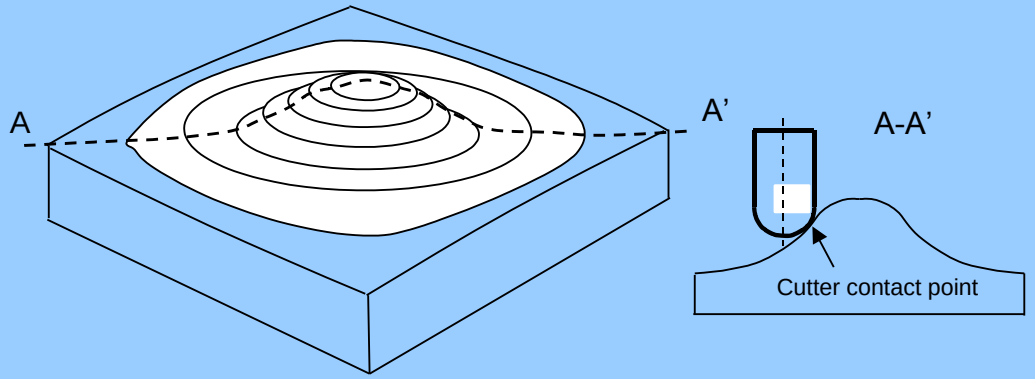
- **Technology Description**
  - Milling Process Operations
  - Milling Cutting Tools
  - Turning Process Operations
  - Turning Cutting Tools

Technology Operations

- **Drilling**
  - Drilling, boring, back boring, tapping/threading
  - Many strategy parameters

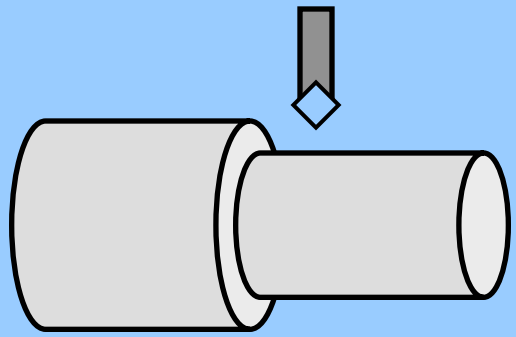


- **2.5D Machining**
  - Plane and side milling, roughing and finishing
  - Set of strategies



- **Freeform Machining**
  - 3, 4, and 5axis motion
  - Set of strategies

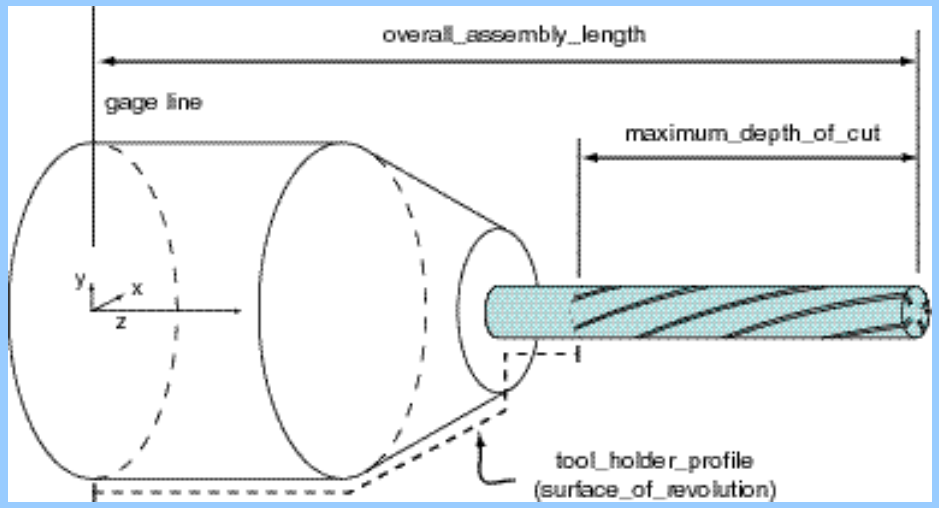
- **Turning Operations**
  - Contouring, facing, grooving, threading and knurling
  - Set of strategies



Milling and Turning Cutting Tools

- **Every operation can have a tool associated.**
  - **Calls out required characteristic tool parameters**
  - **Potential for some optimization by the controller.**

- **G&M codes just referenced tool #1, #2, etc.**
  - **Human must make sure that #1 corresponds to the right thing.**
  - **Controller not able to add any value to the process.**



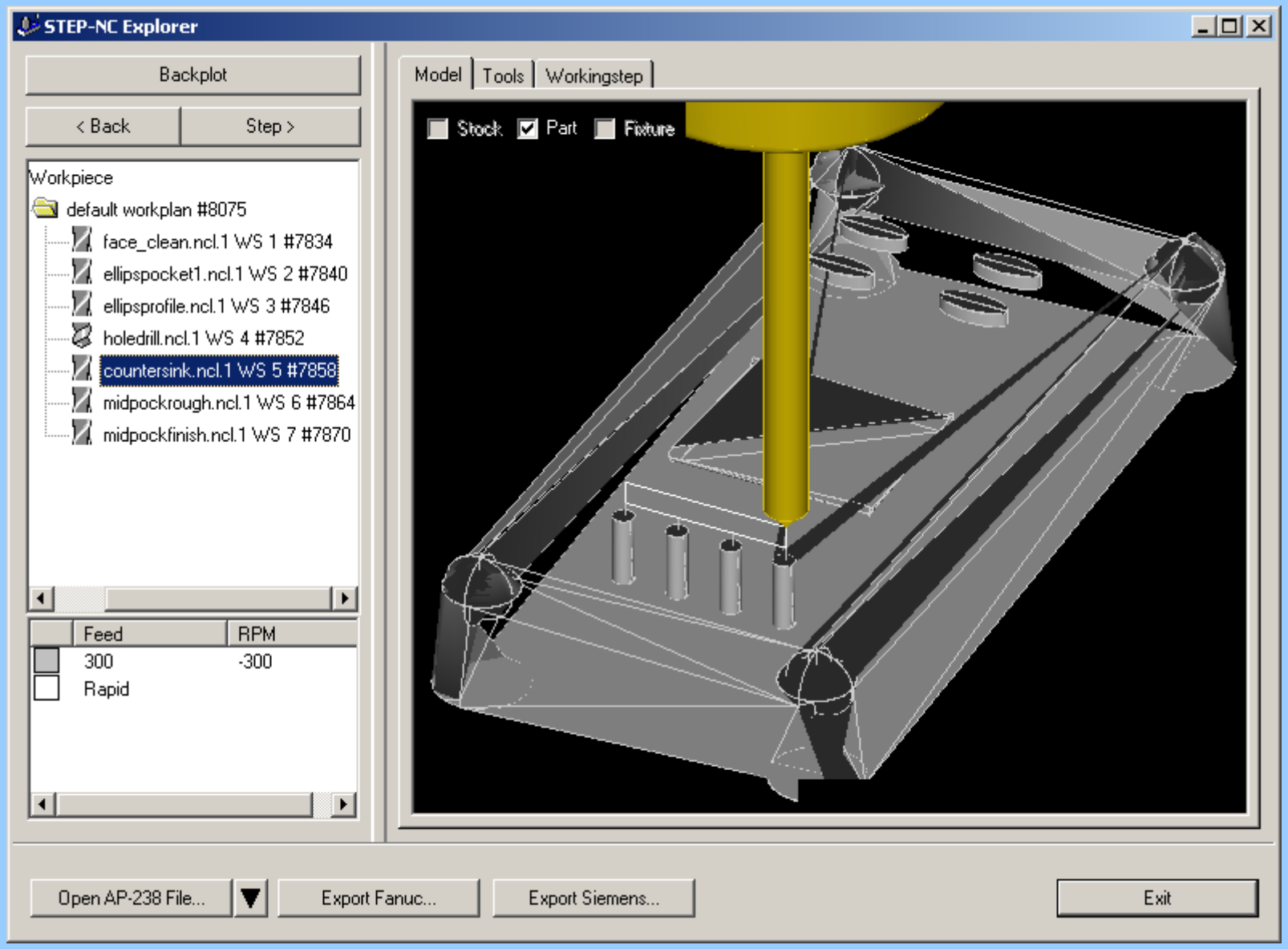
Benefits

- No more post-processors
- Collision detection on the CNC
- Rapid re-programming using features
- Visual closed loop programming
- 30% cycle time reduction

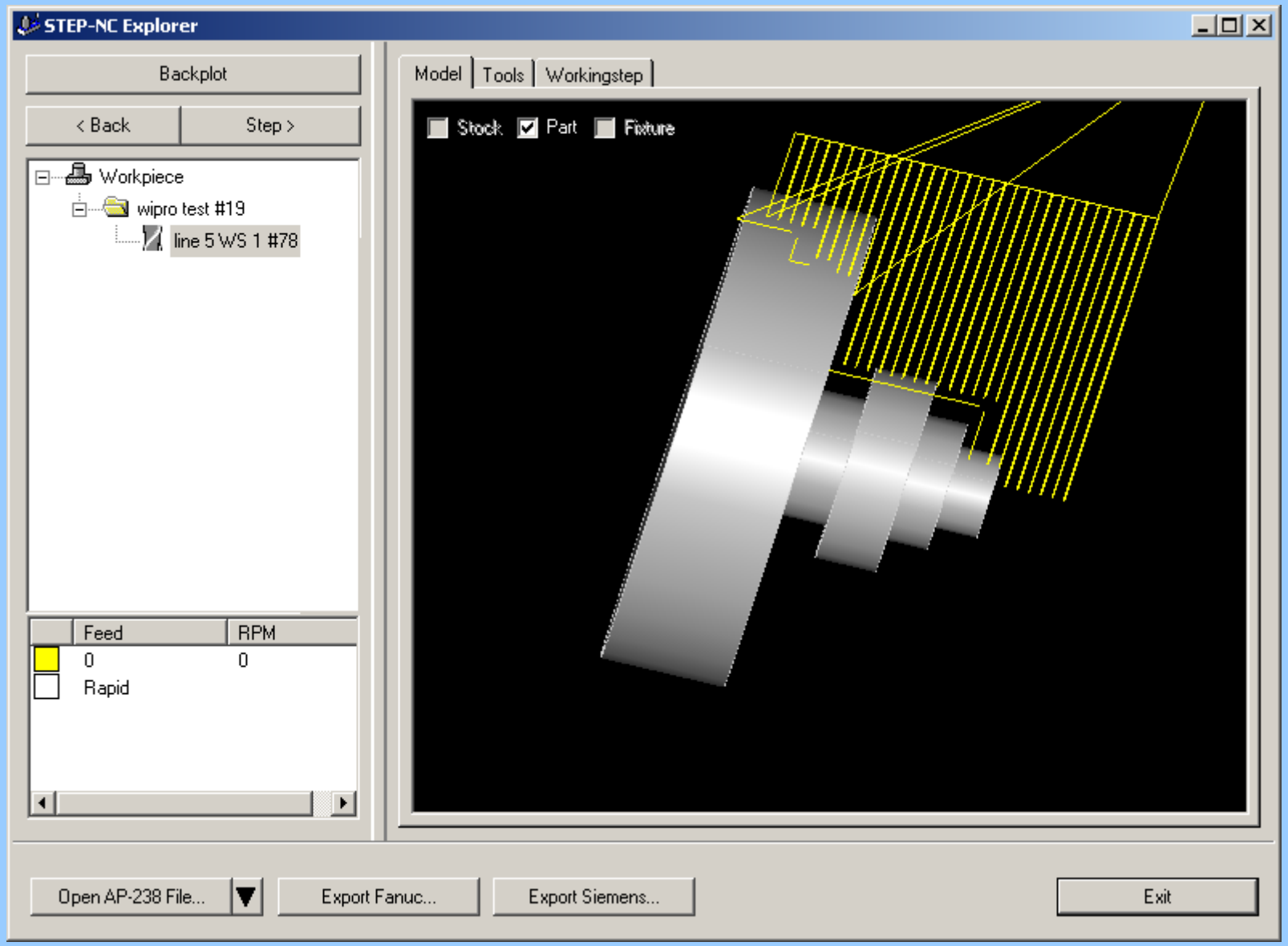
Data samples

- Made using CATIA, Pro/E and UGS
- Milled and Turned parts
- Production parts and test parts

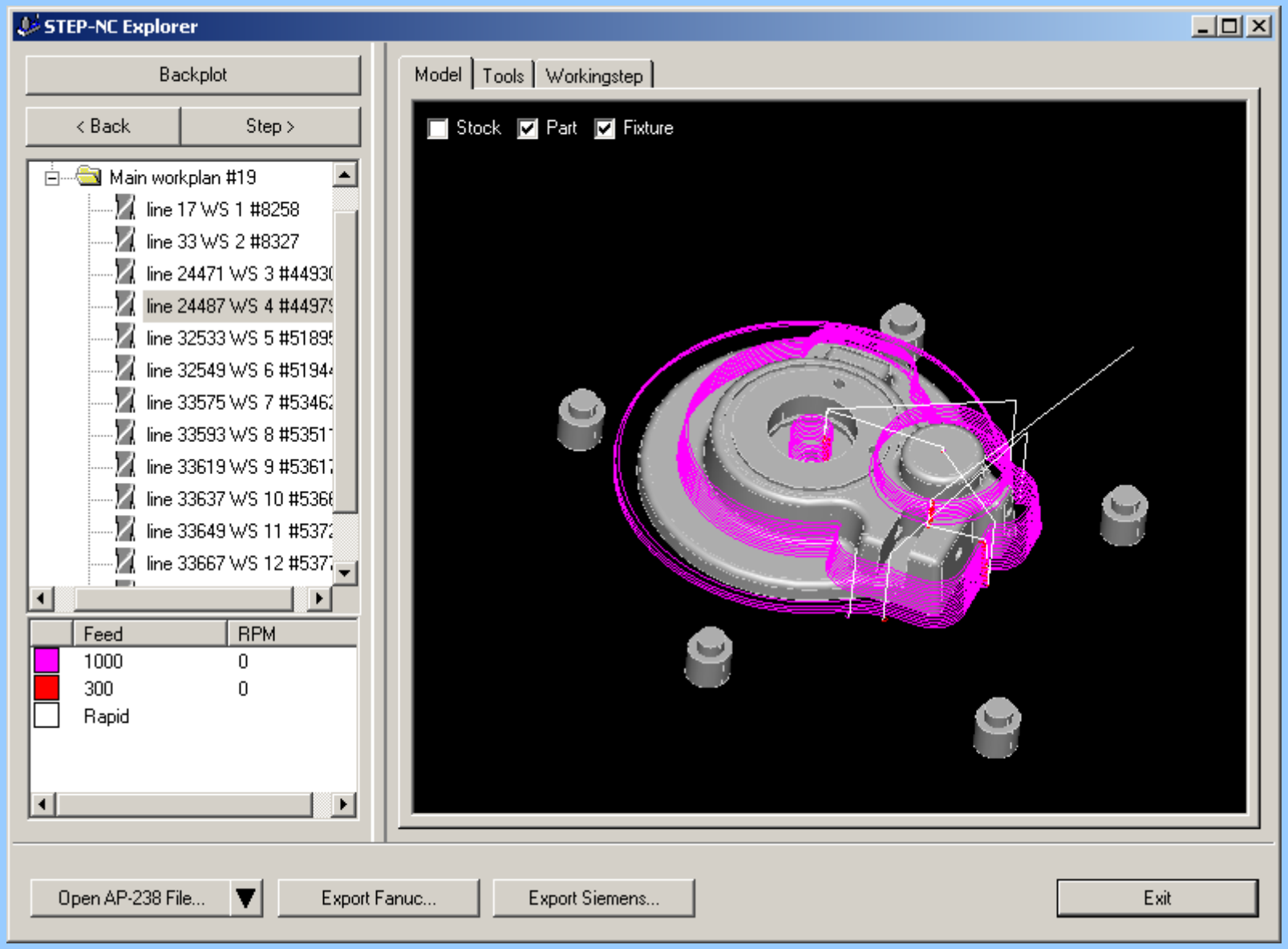
Cell phone cover



Turned part


STEP-NC Explorer
Backplot
< Back
Step >
Workpiece
wipro test #19
line 5 WS 1 #78
Feed
RPM
0
0
Rapid
Model
Tools
Workingstep
Stock
Part
Fixture
Open AP-238 File...
Export Fanuc...
Export Siemens...
Exit

Auto widget


STEP-NC Explorer
Backplot
< Back
Step >
Main workplan #19
line 17 WS 1 #8258
line 33 WS 2 #8327
line 24471 WS 3 #44930
line 24487 WS 4 #44979
line 32533 WS 5 #51895
line 32549 WS 6 #51944
line 33575 WS 7 #53462
line 33593 WS 8 #53517
line 33619 WS 9 #53617
line 33637 WS 10 #5366
line 33649 WS 11 #5372
line 33667 WS 12 #5377
Feed
RPM
1000
0
300
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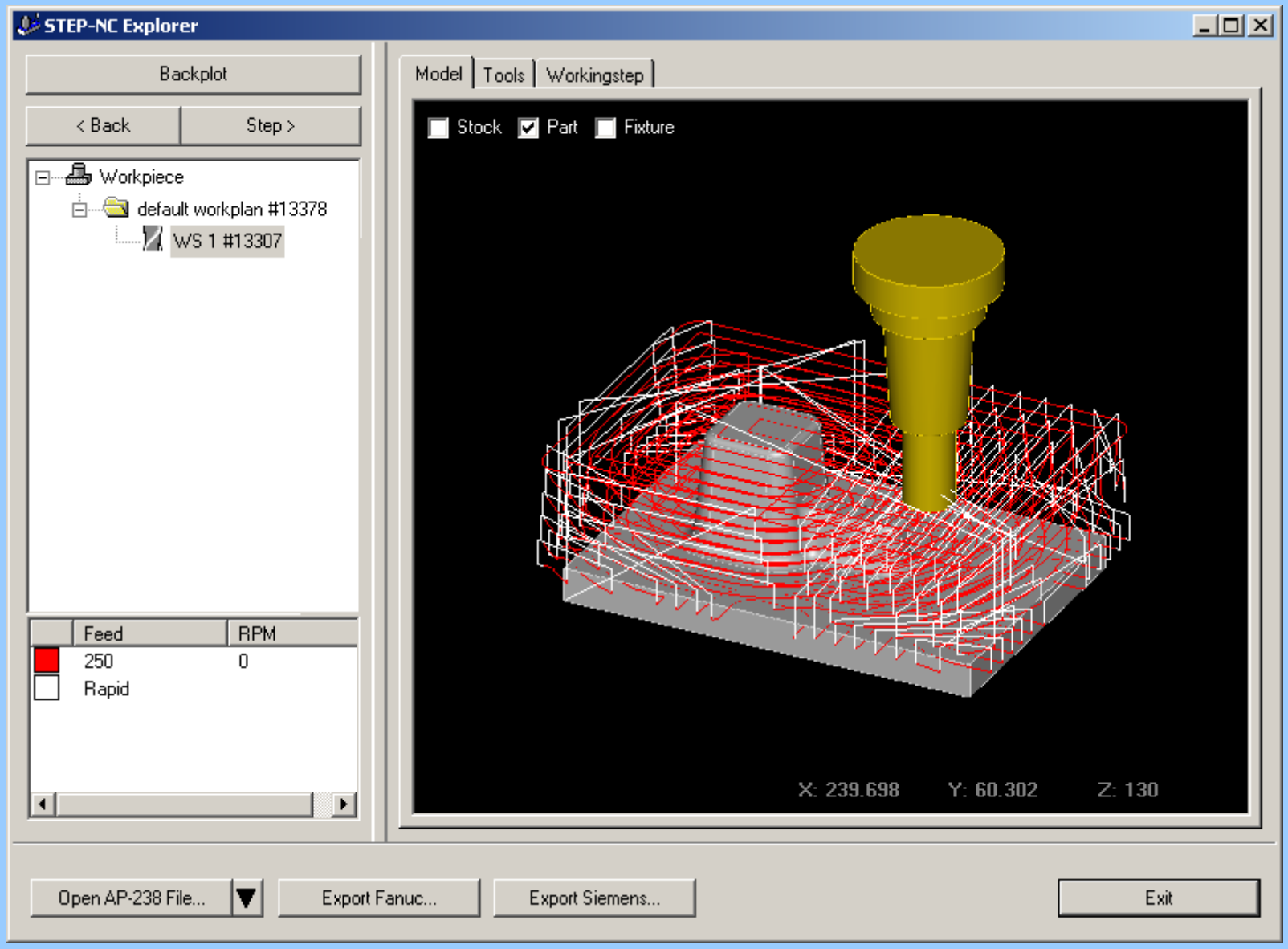
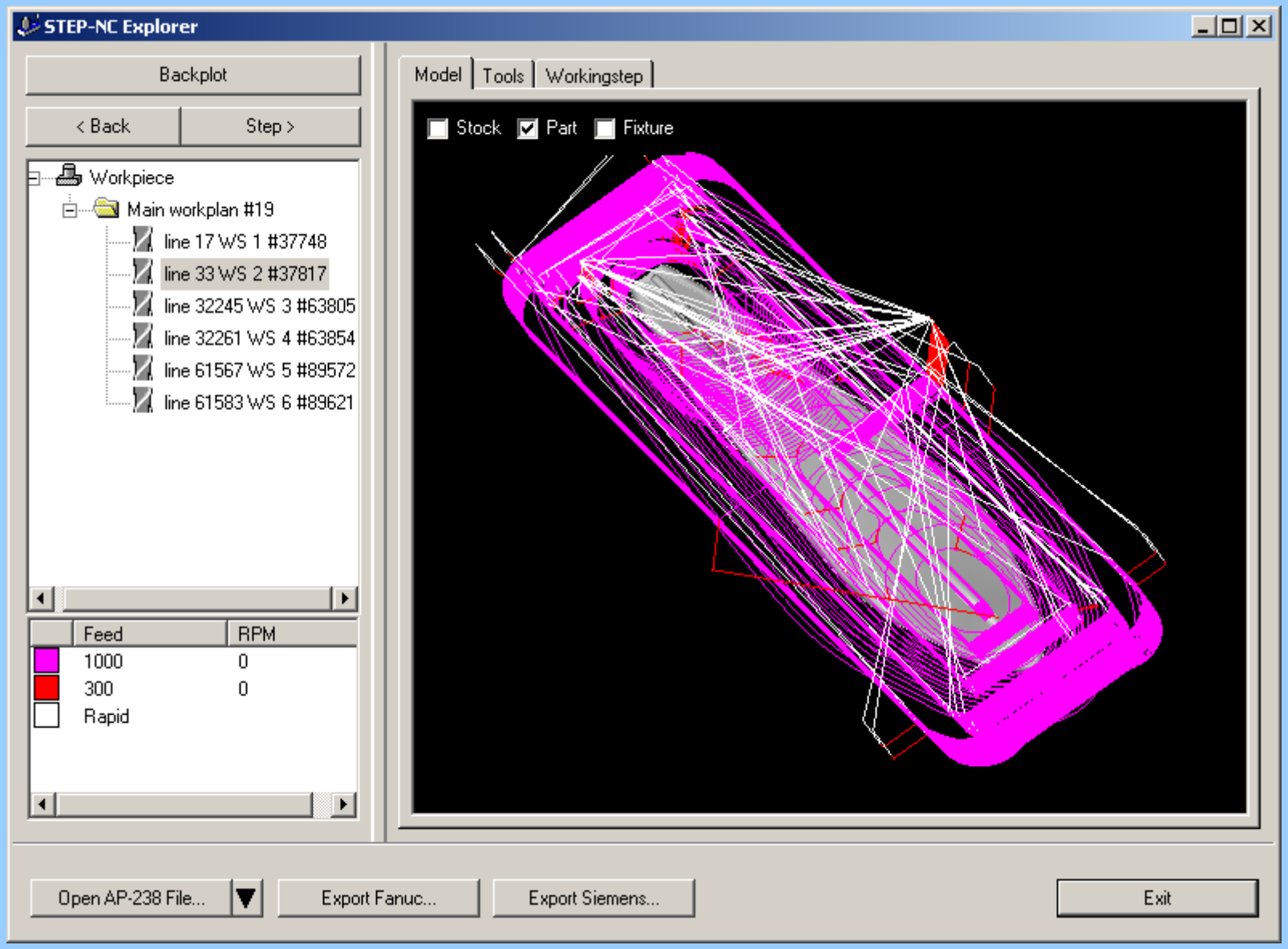
Rapid
Model
Tools
Workingstep
Stock
Part
Fixture
Open AP-238 File...
Export Fanuc...
Export Siemens...
Exit

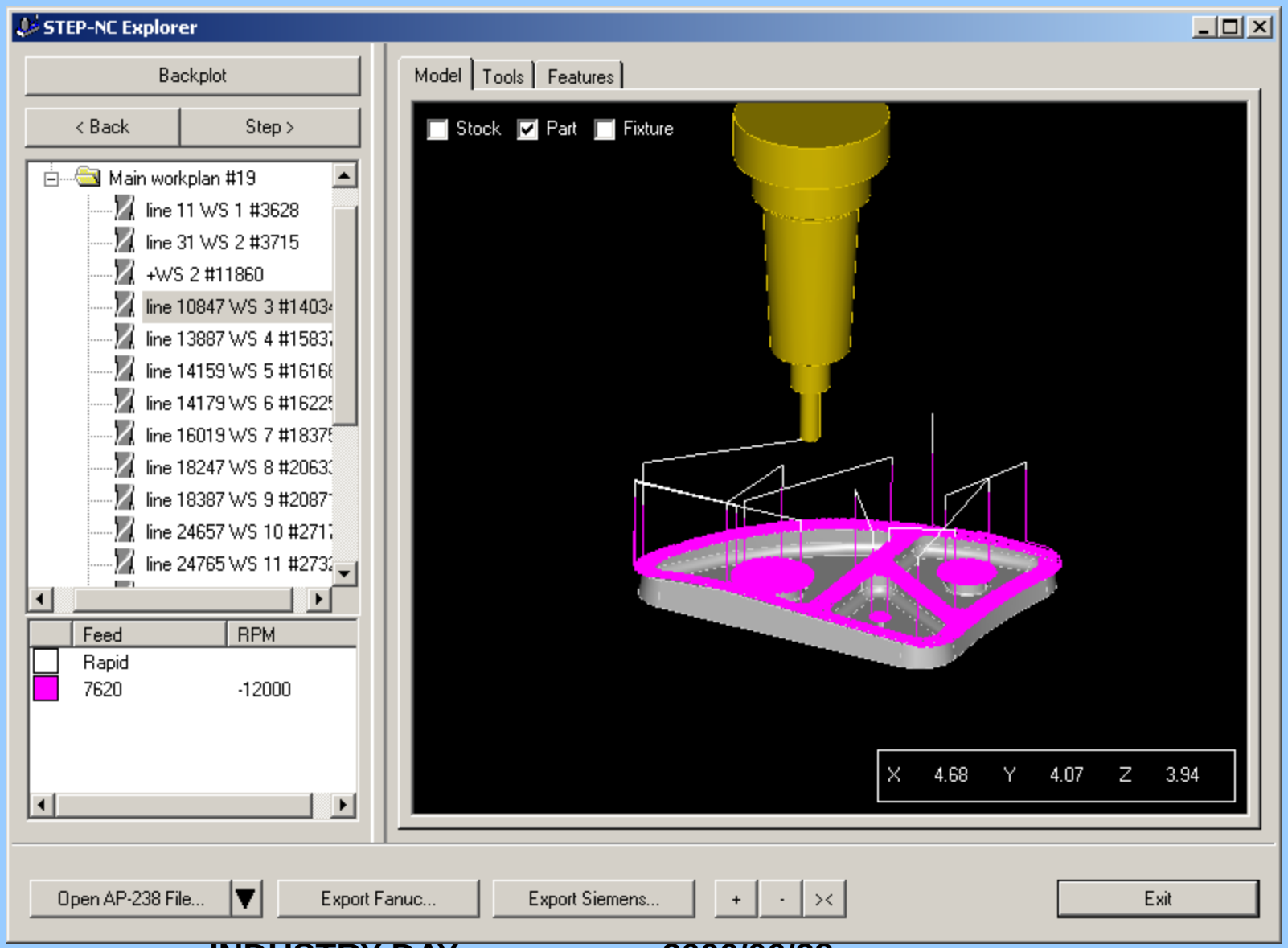
Cavity mill


STEP-NC Explorer
Backplot
< Back
Step >
Workpiece
default workplan #13378
WS 1 #13307
Feed
RPM
250
0
Rapid
Model
Tools
Workingstep
Stock
Part
Fixture
X: 239.698
Y: 60.302
Z: 130
Open AP-238 File...
Export Fanuc...
Export Siemens...
Exit

Airfoil


STEP-NC Explorer
Backplot
< Back
Step >
Workpiece
Main workplan #19
line 17 WS 1 #37748
line 33 WS 2 #37817
line 32245 WS 3 #63805
line 32261 WS 4 #63854
line 61567 WS 5 #89572
line 61583 WS 6 #89621
Feed
RPM
1000
0
300
0
Rapid
Model
Tools
Workingstep
Stock
Part
Fixture
Open AP-238 File...
Export Fanuc...
Export Siemens...
Exit

Boeing Demonstration Part



Other Demonstrations

- Orlando
  - CNC independent tool paths Fanuc and Siemens controls driven by UGS, CATIA, Mastercam and Gibbs data
- Eastec
  - Visual closed loop programming using Pratt and Whitney data
- US Army
  - Feature based programming using AP-224 data
- Nokia
  - Mold making

Summary

- STEP-NC is easy to implement
  - Basic prototype in 4 weeks
  - Level 2 by adding CAD geometry
- Machining benefits
  - CNC independent tool paths
  - Collision detection on the control
  - Feature based re-programming
  - Visual closed loop programming
- Enterprise benefits
  - Long term data retention
  - Interchange with suppliers

Introduction
to
STEP-NC and Manufacturing Standardization

Sid Venkatesh
Boeing Company

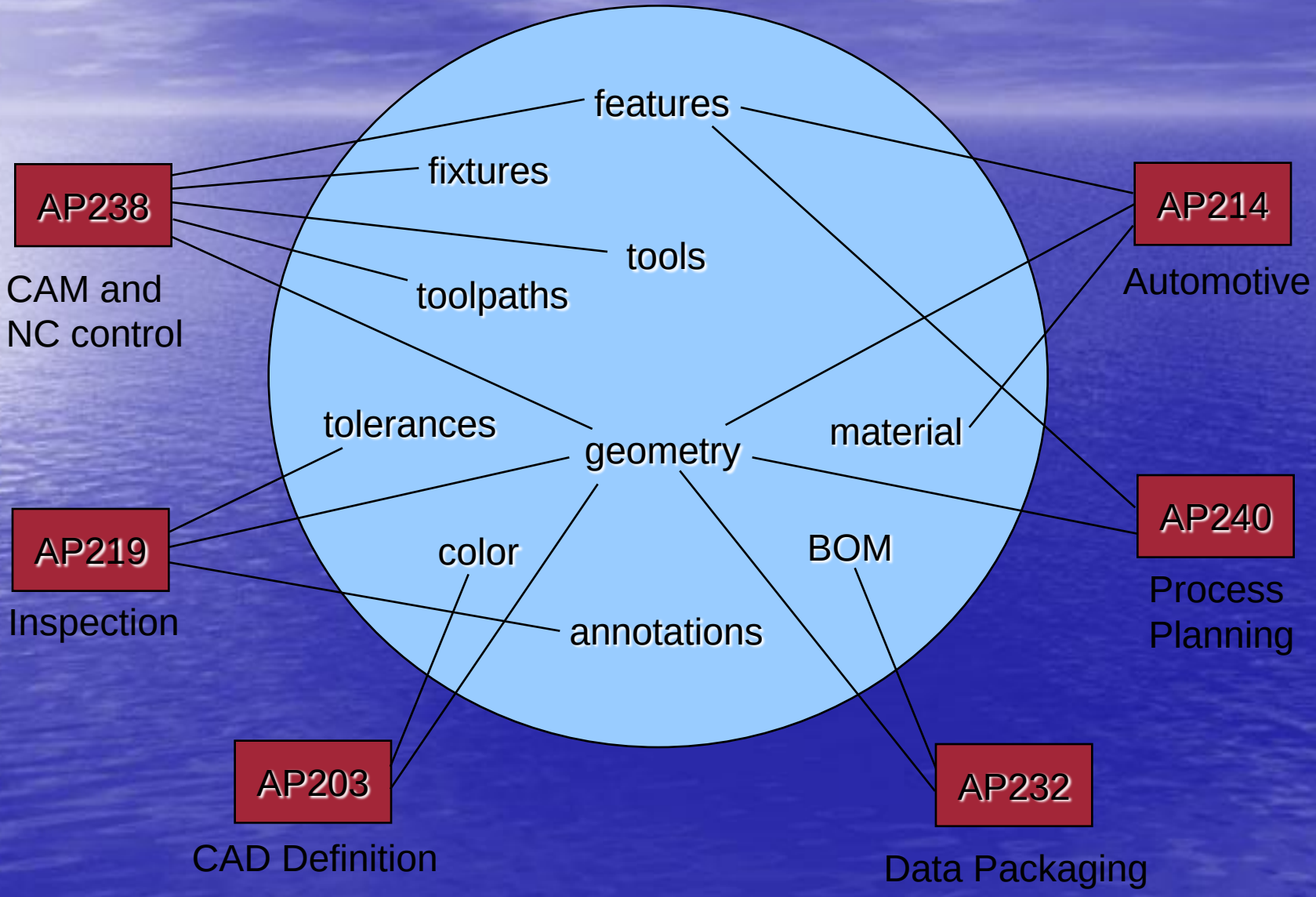
Agenda

- 777 PTQ Video
- STEP Cloud
- How will Standards Help
- What standards do we need

777 PTQ Video

Video

STEP CLOUD


features
fixtures
tools
toolpaths
tolerances
geometry
material
color
BOM
annotations
AP238
CAM and
NC control
AP214
Automotive
AP219
Inspection
AP240
Process
Planning
AP203
CAD Definition
AP232
Data Packaging

How Will Standards Help?

- **Supports every aspect of our new business model**
- **Enables flexibility – Move work to where required**
- **Supports a global** Lean **strategy**
  - **Minimize flow time**
  - **Minimize infrastructure (converters)**
  - **Drives commonality**
    - **format for files and data**

What Standards do we Need?

- **Design**
- **Manufacturing**
- **Support & Services**
- **Quality Reporting**
- **Product Traceability**
- **Supply Chain Management**
- **Project Management**

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Machinist background
Employed at Scania since 1998
During 4 year worked with machining process optimizing and cutting tool evaluation at Scania.

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B.Sc., Ph.D Student
KTH, Royal Institute of Technology
Computer System for Design and Manufacturing

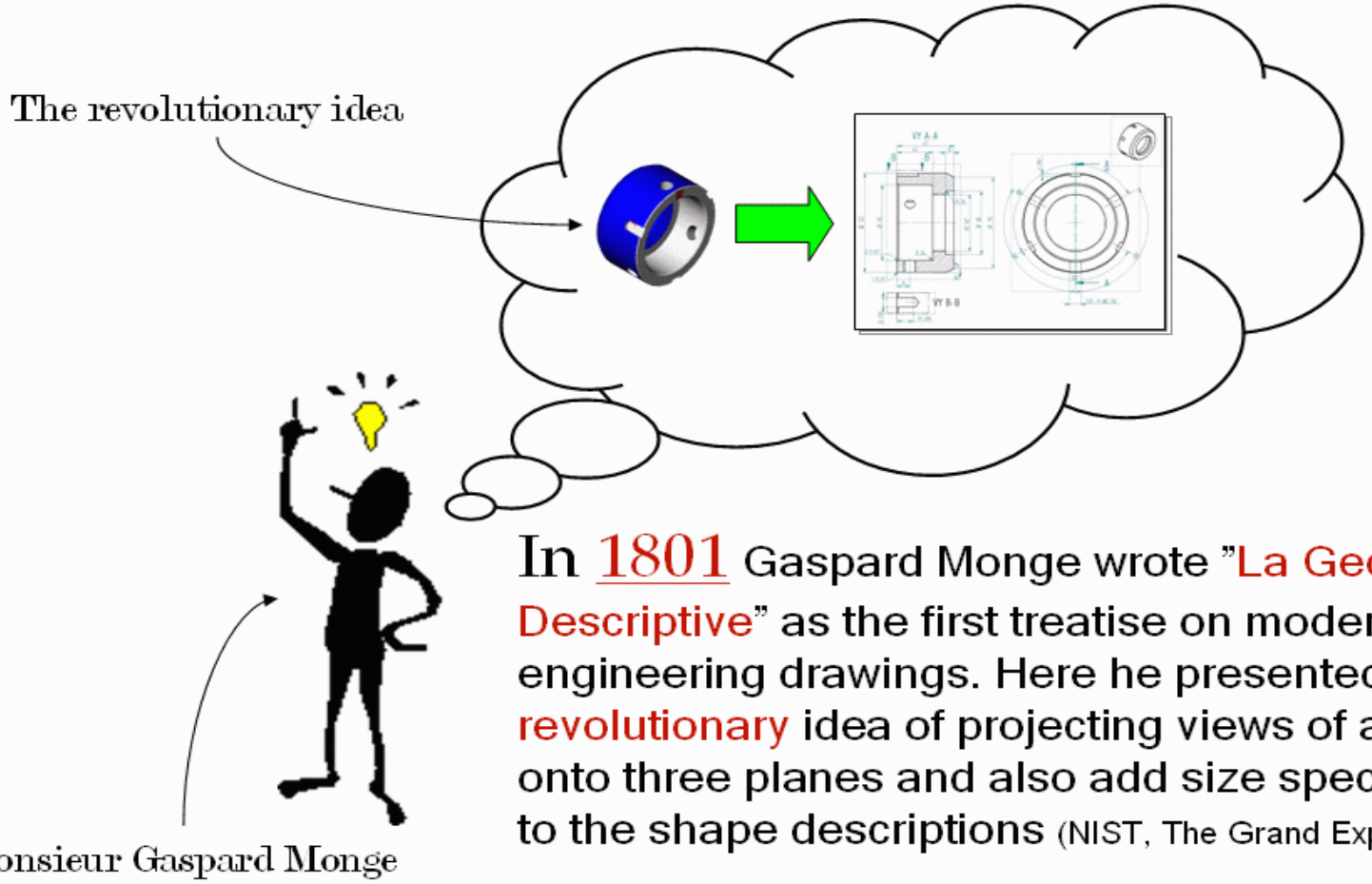
Machinist background
Has worked as CNC-operator and manufacturing engineer for about 10 years before entering studies at KTH. Graduated for B.Sc. in 2001 and after that working with education at KTH in the area of manufacturing engineering.

About KTH, Computer System for Design and Manufacturing

KTH Industrial Engineering and Management

- Computer System for Design and Manufacturing at KTH has since the late 1970-s been involved in research and development in the area of solid modeling and information modeling and its applications for design and manufacturing
- We have since the very beginning of the STEP standard being involved in its development and the development of other related standards
- During the recent years we have been deeply involved in the development of the ISO 13399 Standard for cutting tool data representation and exchange in close cooperation with Sandvik and Kennametal
- At present we are working with ISO 10303-238: STEP-NC and ISO 10303-239: PLCS concerning how to utilize these standard for expressing manufacturing knowledge through models of product, processes and resources

The main information carrier since…



In 1801 Gaspard Monge wrote "La Geometrie Descriptive" as the first treatise on modern engineering drawings. Here he presented the revolutionary idea of projecting views of an object onto three planes and also add size specifications to the shape descriptions (NIST, The Grand Experience)

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Model-driven parts manufacturing

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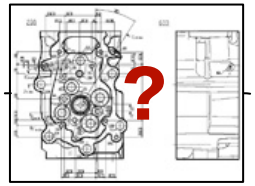
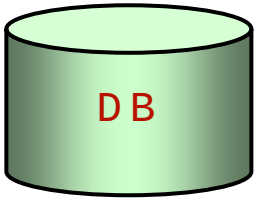
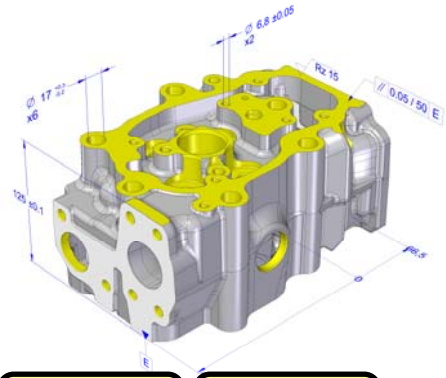


Still the main information carrier?



- Machining strategies
- Fixtures
- Cutting Tool
- Machine Tool

Gaspard Monge?



AP203 AP224

- Geometry
- Machining Features

Process Planning

AP238 ISO 14649

STEP-NC
- NC-program

STEP-NC, a feature based concept

STEP-NC describes

- How to make this geometry from this part…
- by removing these ”features”…
- in this order…
- and with tools that fulfils these requirements.

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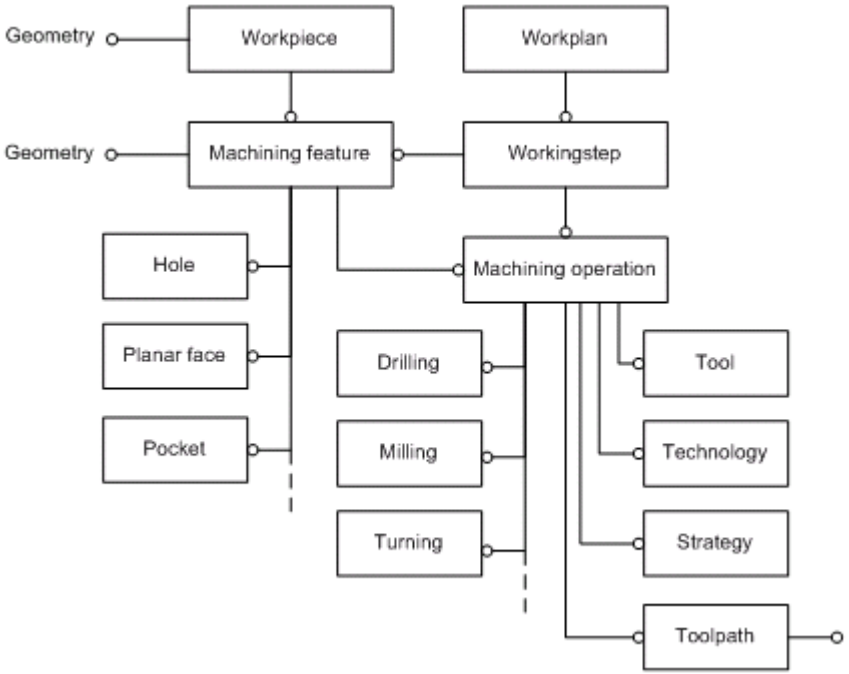

The **Workplan** defines a sequence of **Workingsteps** which associates a certain machining feature with an **Machining Operation**, which in turn describes which type of tool and machining process (drilling, milling, turning etc) that shall be used and its associated strategy.

STEP-NC implementation goals at KTH

- Make information transparent to operator
- Create understanding
- Motivate
- Enable “right from me”
- Enable feedback upstream

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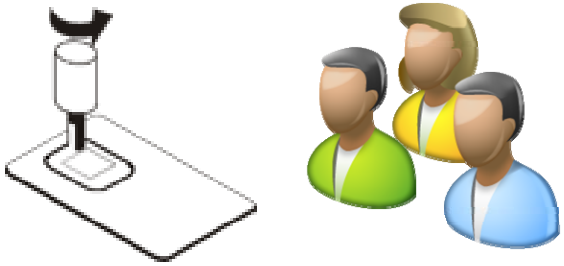

STEP-NC implemented in a CNC controller at Scania (integrated front-end application)

Case study: STEP-NC applied in heavy truck manufacturing

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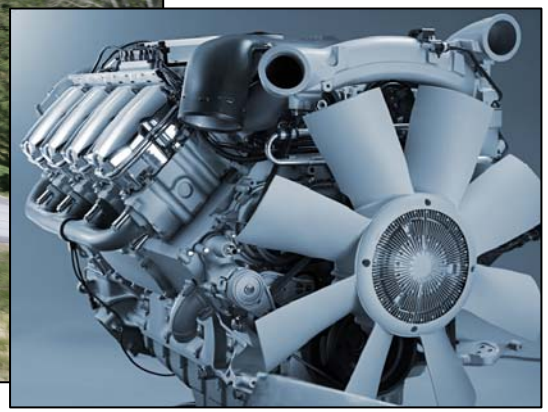

Case: Scania Cylinderhead

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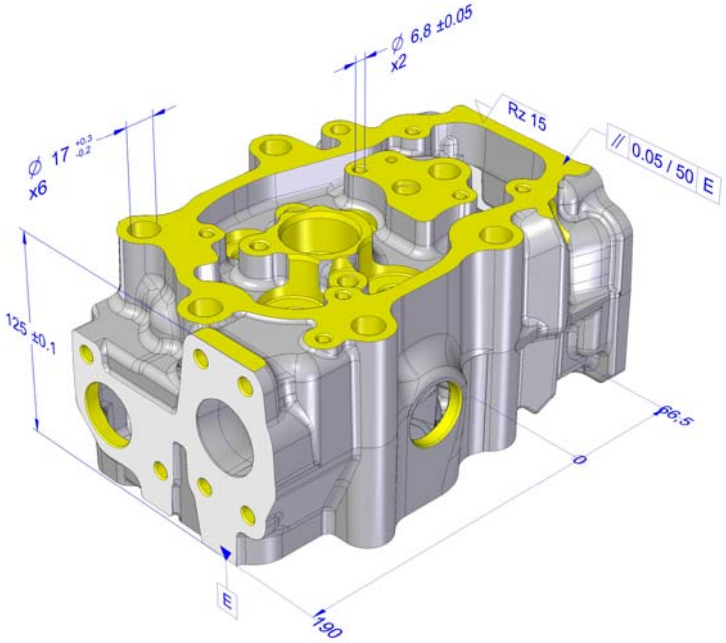
- Typical powertrain component
- Pearlitic cast iron, 210 HB
- 450 000 produced cylinderheads during year 2007
- Machining features
  - Planar face
  - Hole
  - Thread hole
- Machining operations
  - Planar mill
  - Drill
  - Ream
  - Threading



Case: Scania Cylinderhead

- Machining line with several operations
- Work instructions are important

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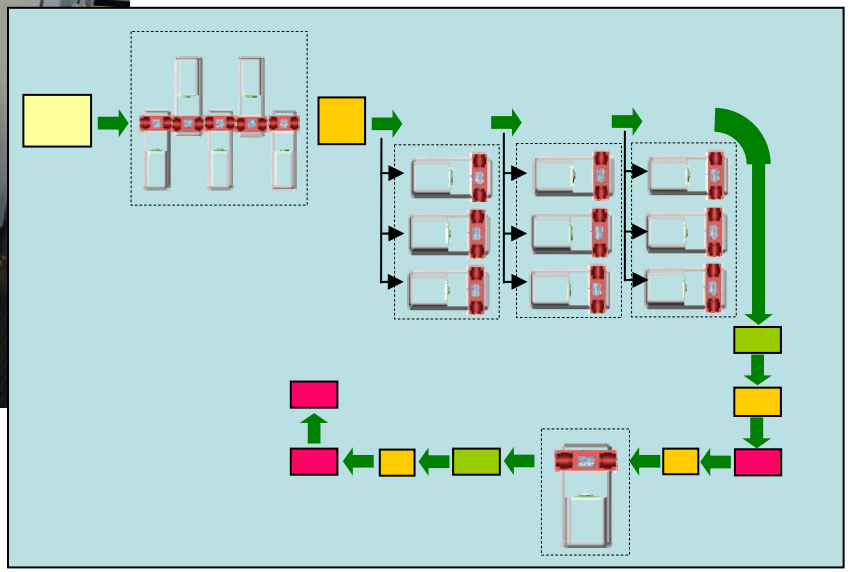

Machining descriptions

- Communicates important process information
- Creation and maintenance is time consuming, even when having an more automated creation process
- Describes the part at different stages of the manufacturing process
- Relationships between toleranced surface and used cutting tool

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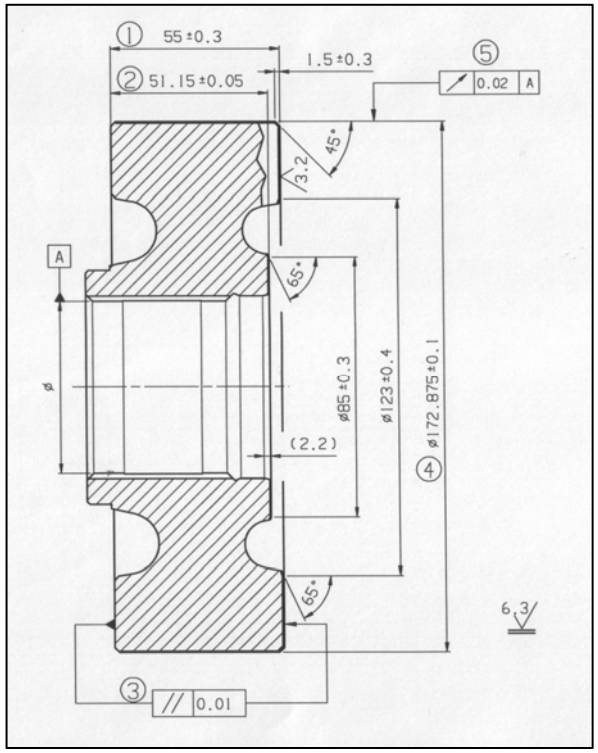

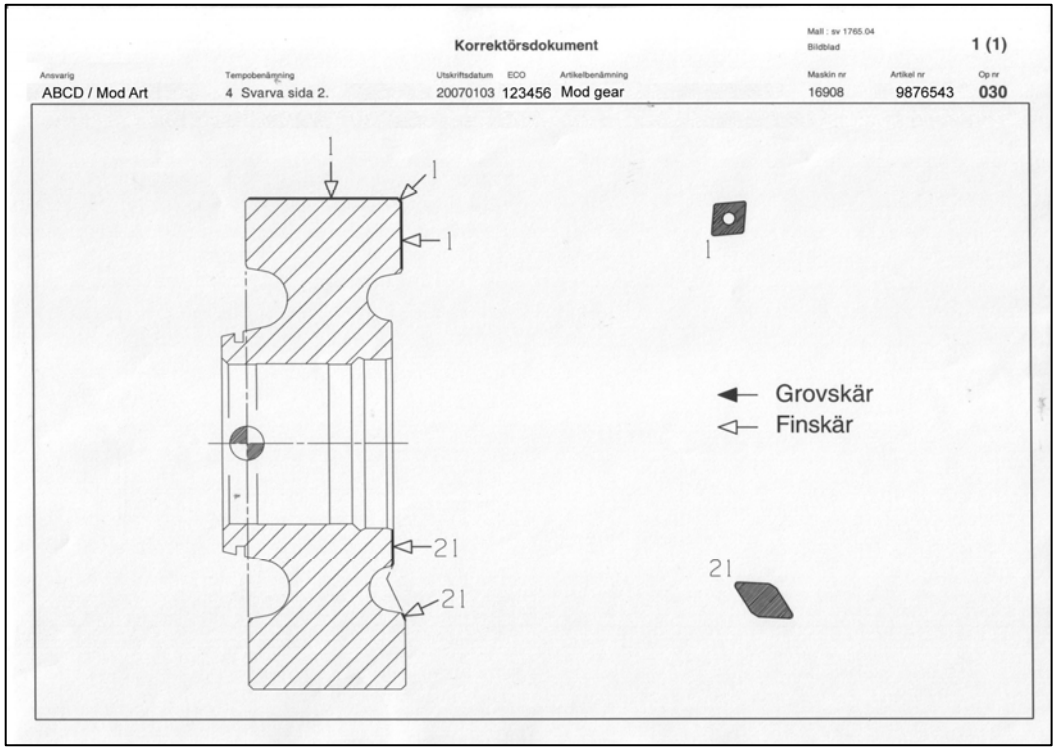

STEP-NC data

- STEP-NC is one coherent data source intended to replace today used expensive solutions
- No need for expensive and early information separation, generation and maintenance of documents

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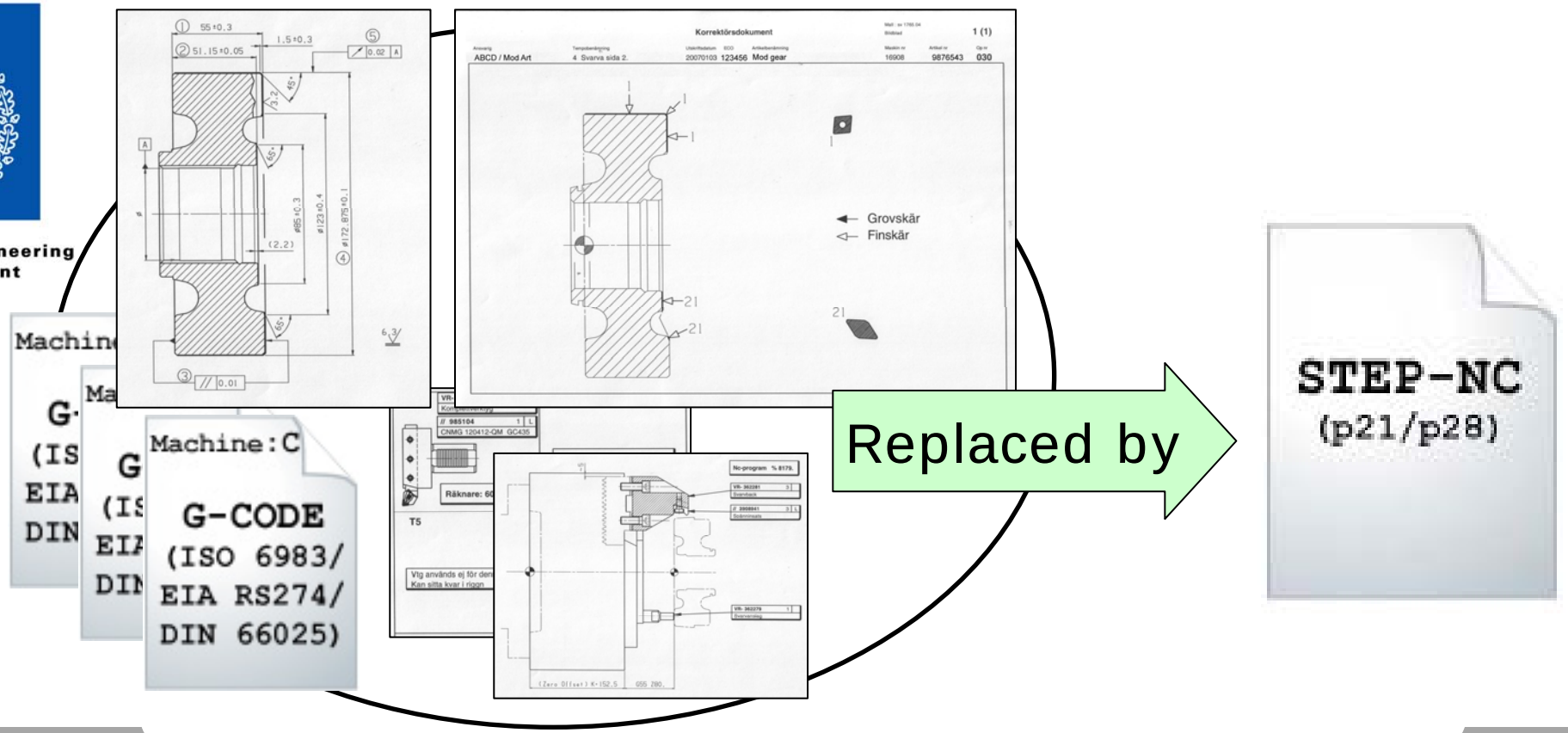

Machining description as a view of STEP-NC data

- Machining workplans and workingsteps
- Toolpath geometry with cutting speed and feed data
- Cutting tool and fixture models
- In-process geometry models of As-Is, To-Be and Removal volume

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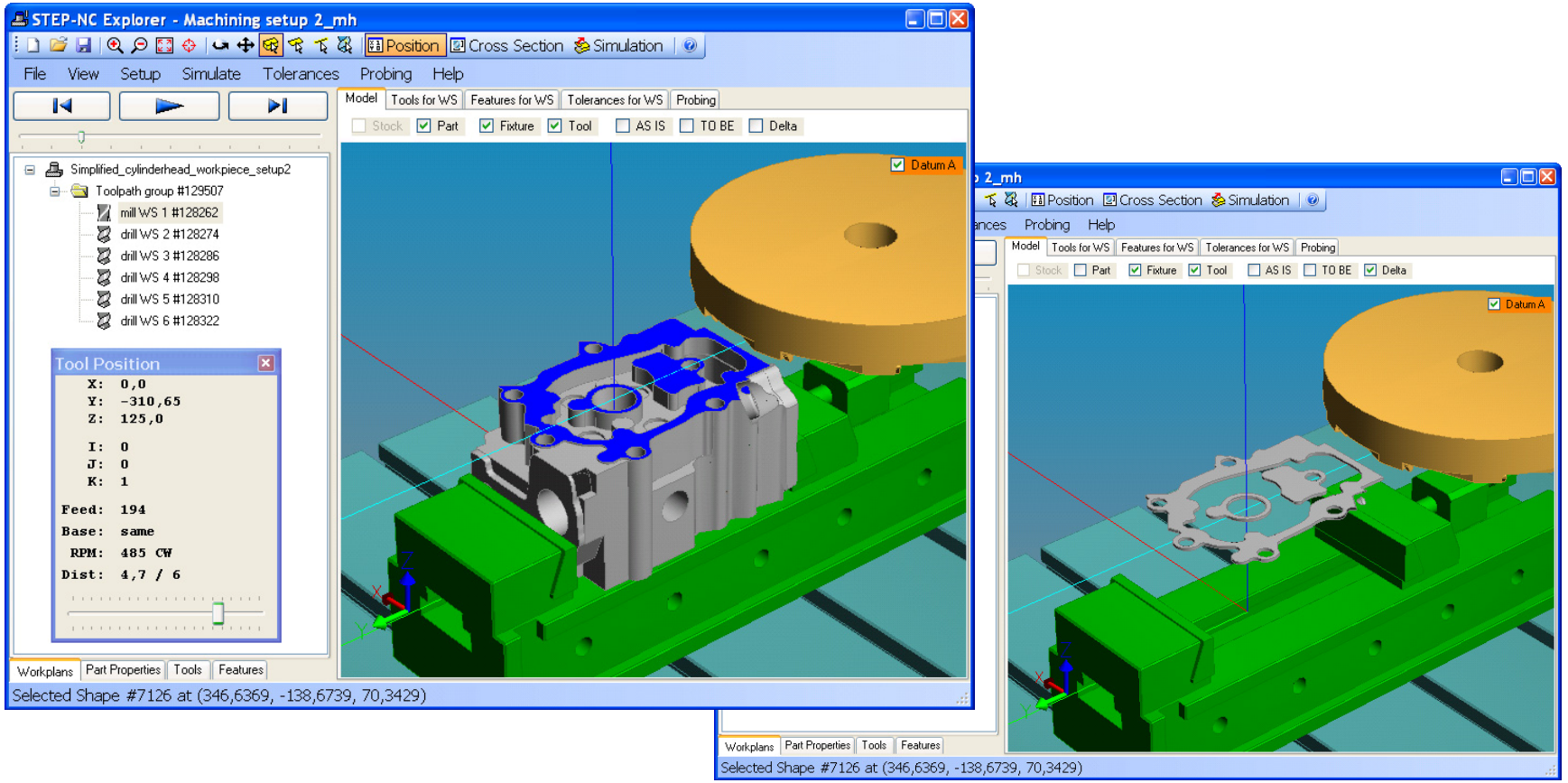

Machining description as a view of STEP-NC data

Part centric view

- STEP GD&T representation data
- Relationship between toleranced surface and used cutting tool

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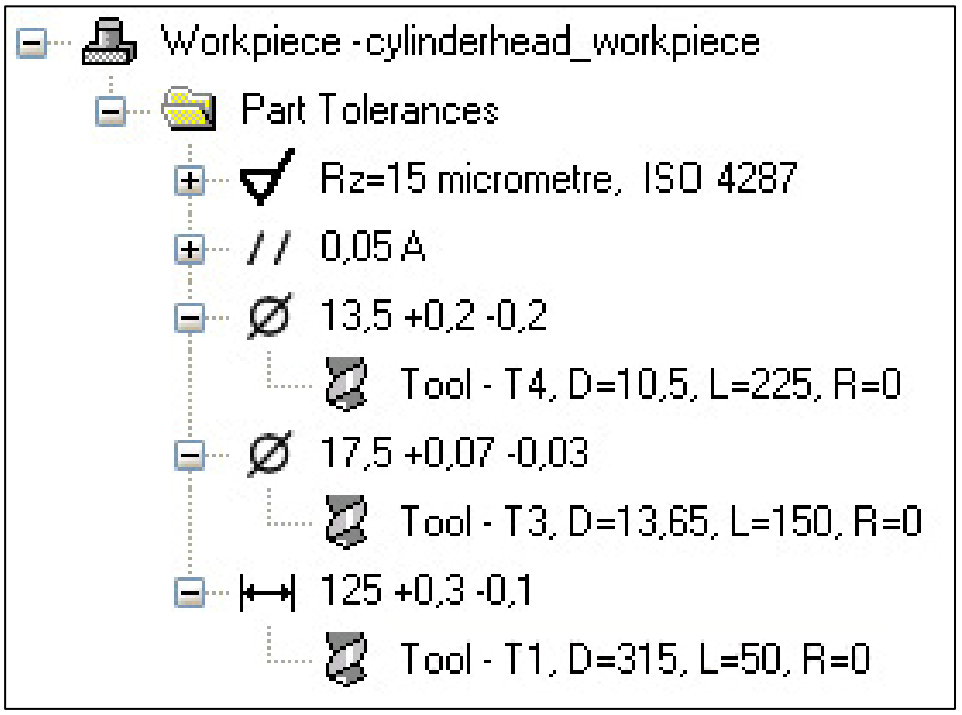

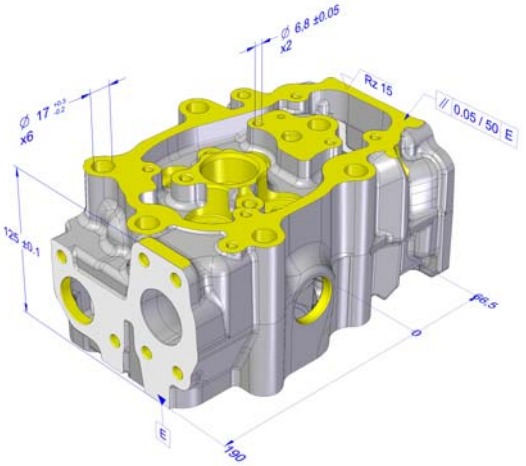

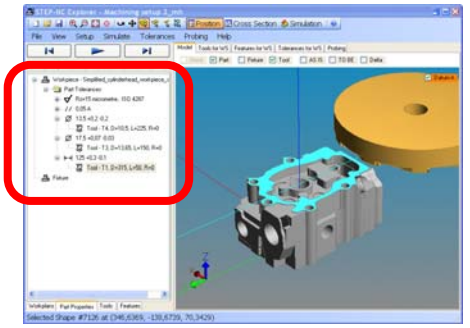

Machining description as a view of STEP-NC data

Tool centric view

- Cutting tool parameters, ISO13399
- Tolerances affected
- Used in workingsteps

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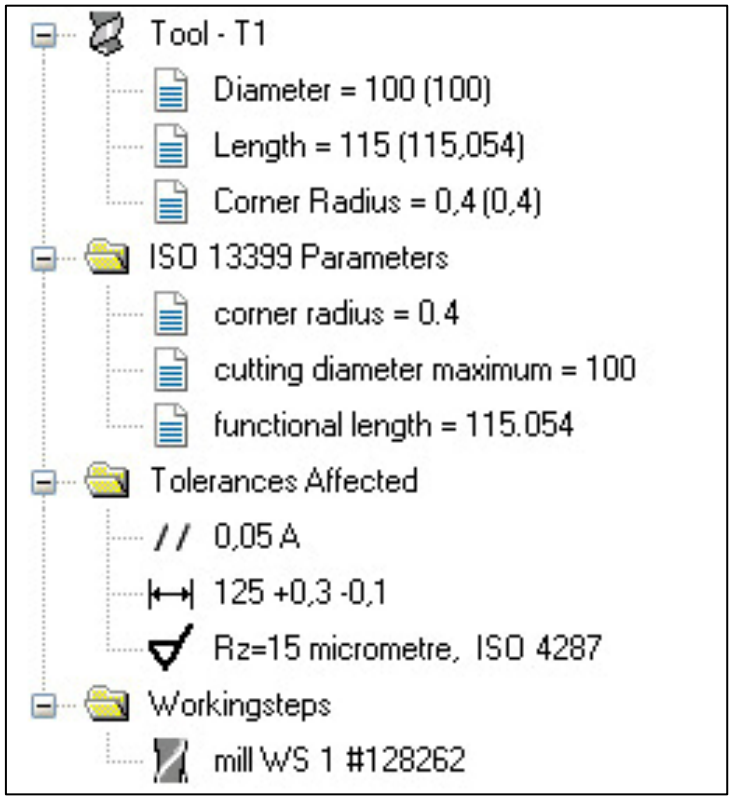

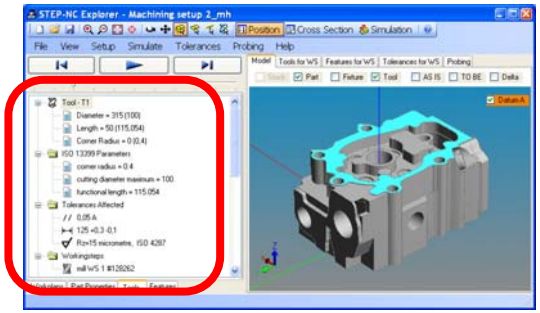

Machining description as a view of STEP-NC data

Manufacturing feature centric view

- Tolerances
- Used tools
- Workingsteps

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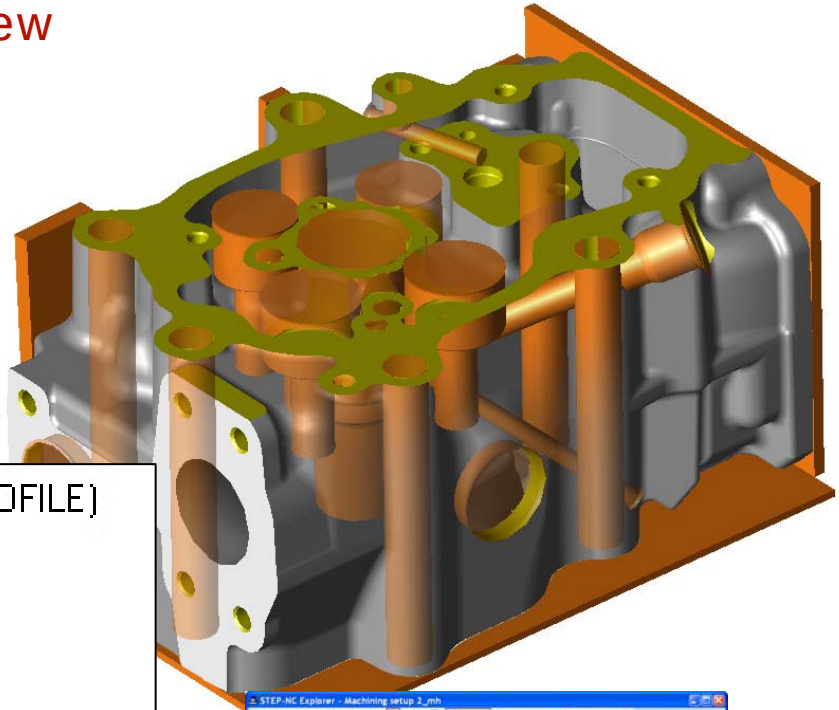

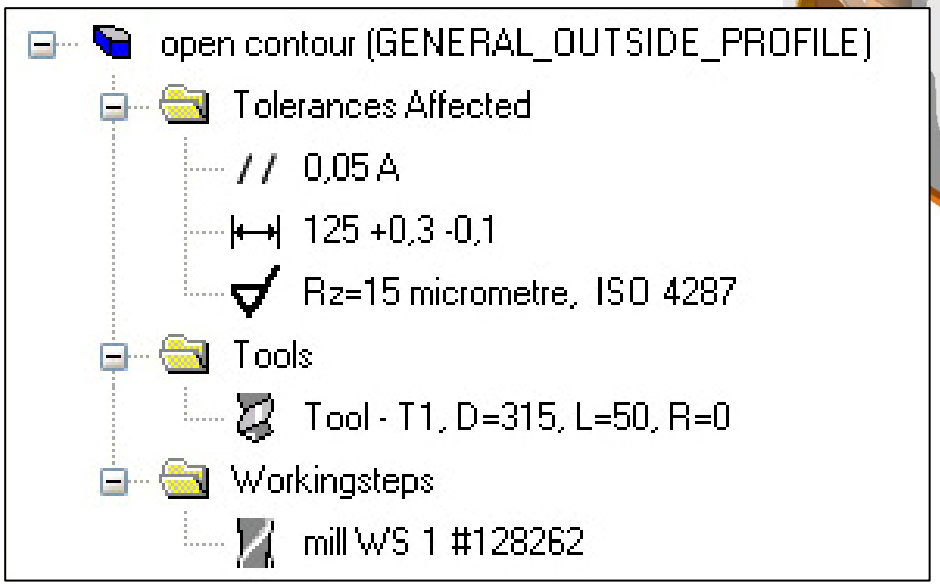

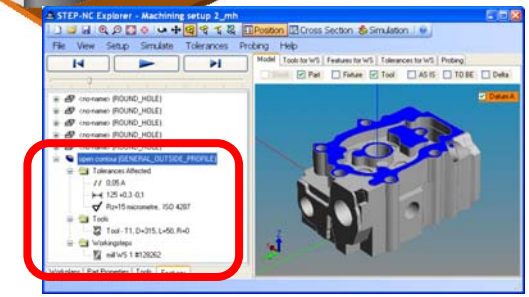

Scania case study

- CAD data with GD&T representation
  - –ISO 10303-214 (ed3)
- CAM data with manufacturing features
- CNC front-end application
  - –STEP-NC interpreter
  - –standalone or integrated in CNC

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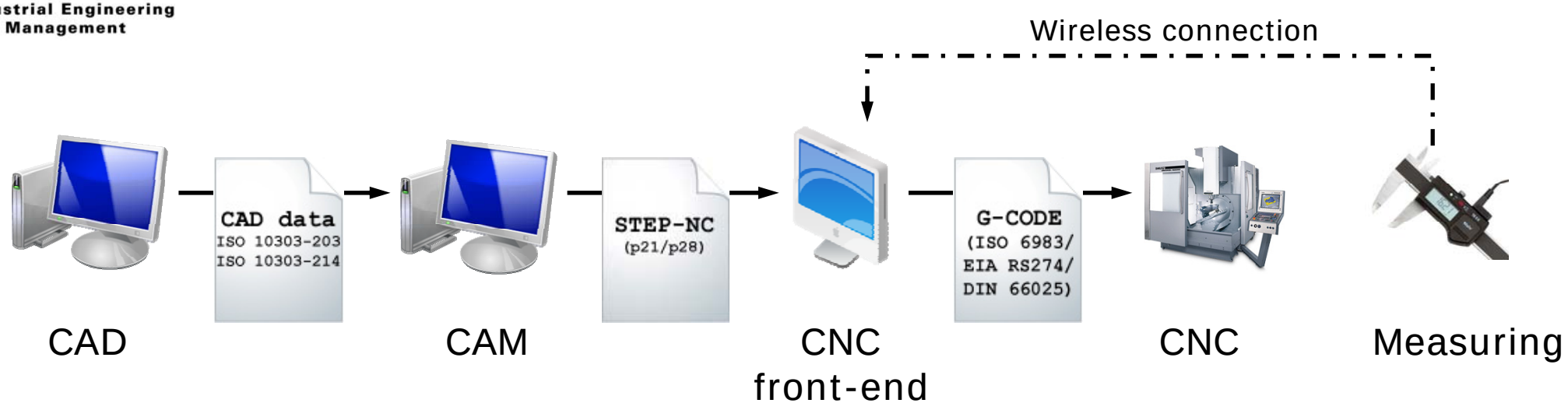

STEP-NC possible benefits today

CNC front-end solution

- Reduced need for expensive and early information separation, generation and maintenance of documents
  - Drawings
  - Used tool to surface chart
  - Setup sheets
- Simplification of postprocessor development and maintenance

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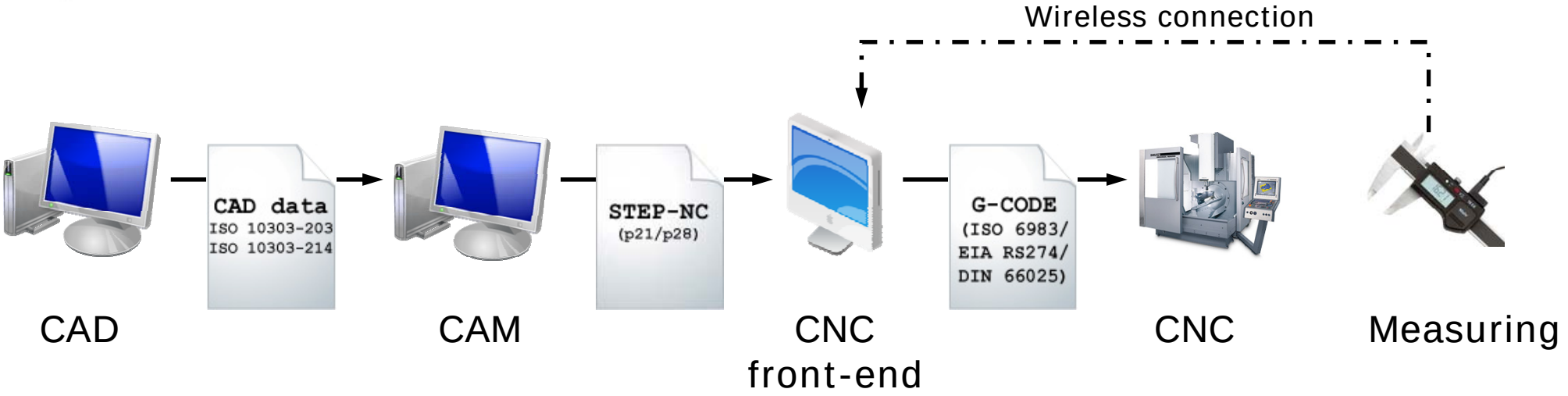

STEP-NC possible benefits today

- Shorter time to manufacturing due to elimination of unnecessary extensive work to create machining descriptions
- Secured data quality due to use and reuse of one coherent data source
- Improved machining due to visualization of complete and detailed machining process for interaction and communication
- CAM to CNC/CMM - Reduced cost of postprocessor development
- CNC/CMM to CAM - Modification of machining or measuring processes
- CAM to CAM - Subcontractors can reuse an customers machining and measuring process

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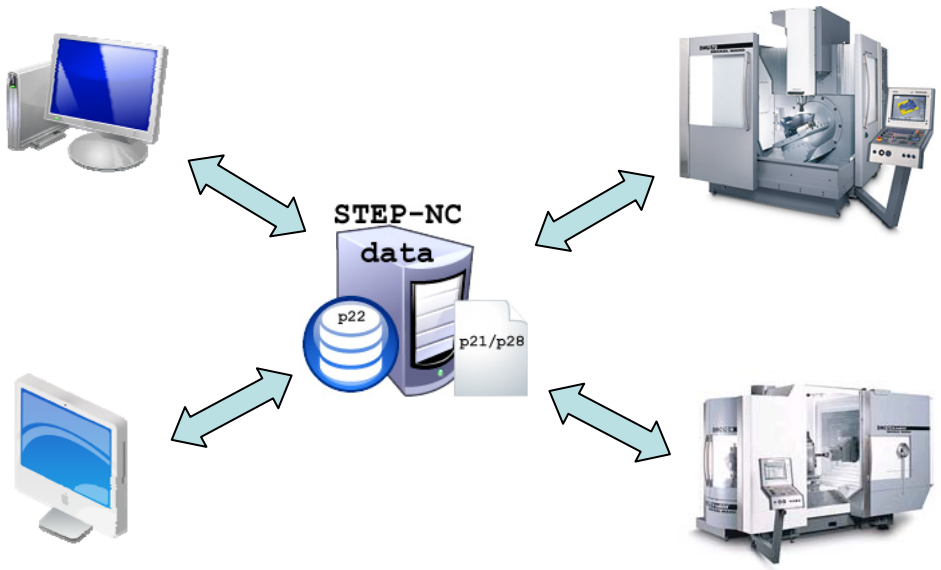

STEP-NC implementation

Scania case study experience

- Make information transparent to operator
- Create understanding
- Motivate
- Enable “right from me”
- Enable feedback upstream

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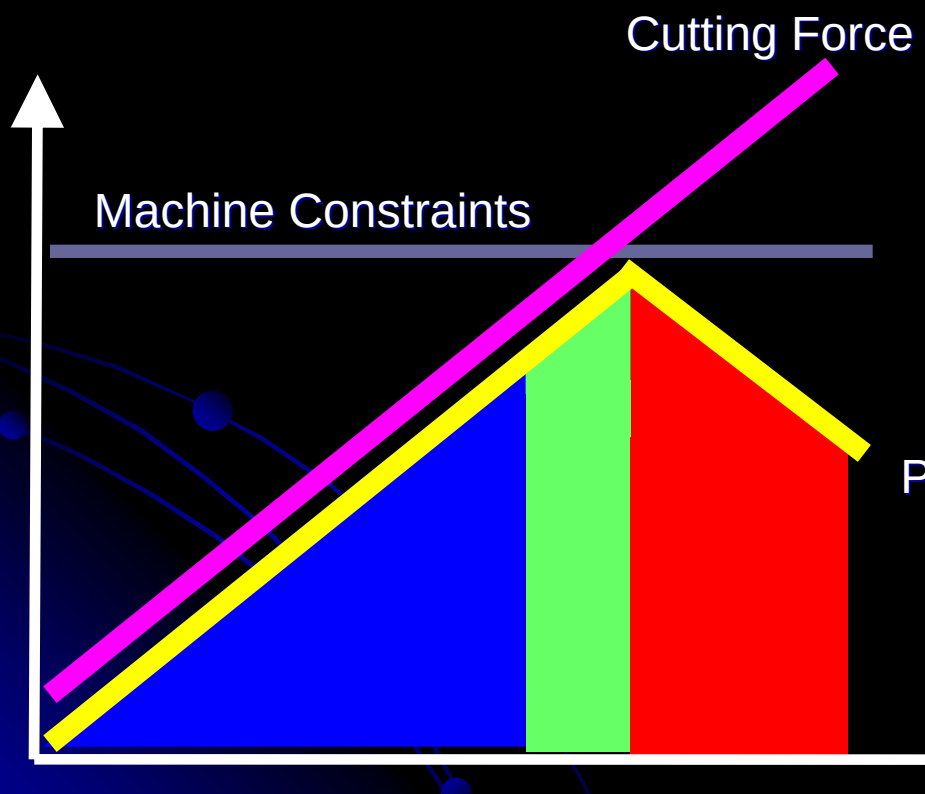
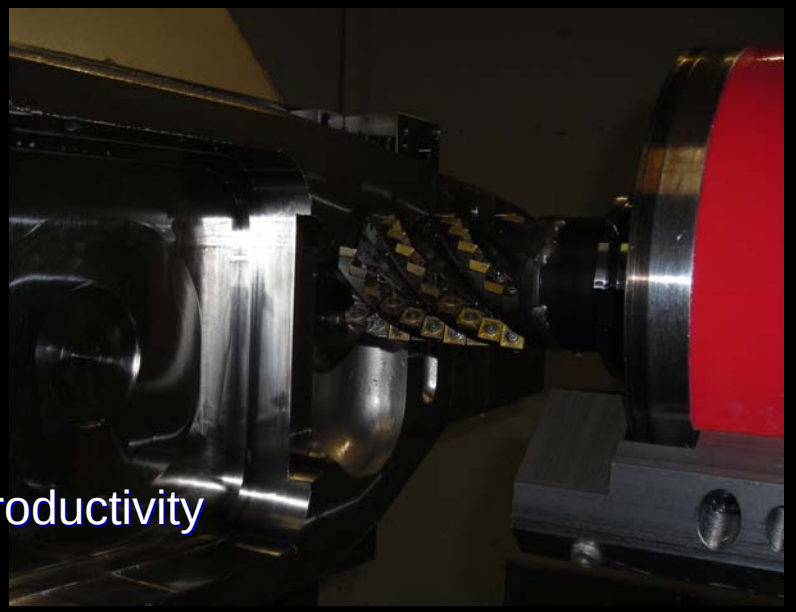
Machining Process Optimization with ISO 10303-238

Leon Xu

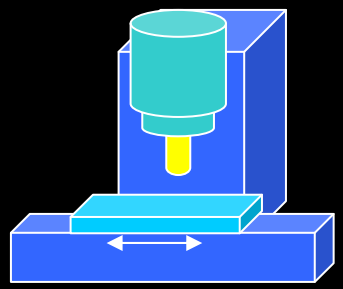
The Boeing Company

Machining Process Optimization



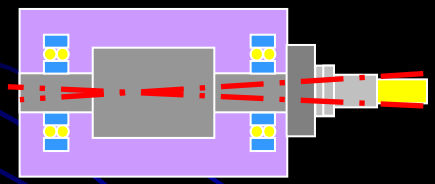


Machining System Constraints



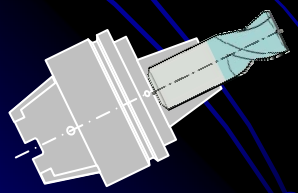
Machine/spindle capability

- -Spindle power, torque and speed
- -Spindle bearings
- -Tool holder
- -Axis torque and speed



System structural dynamics

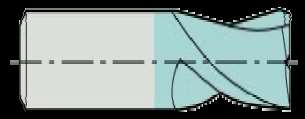
- -Machine/spindle/fixture
- -Cutting tool/holder/spindle



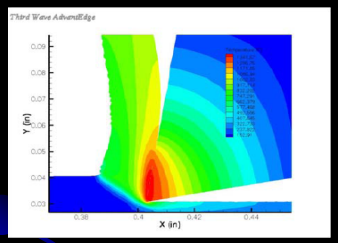
Cutting tools

- -Edge rigidity
- -Surface velocity
- -Rotational speed
- -Wear

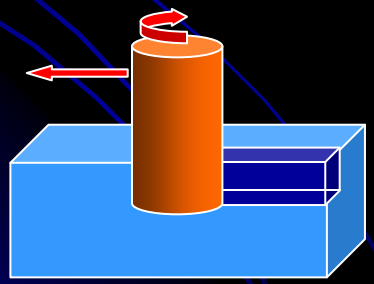
Affecting Factors



Cutting tool dimensions

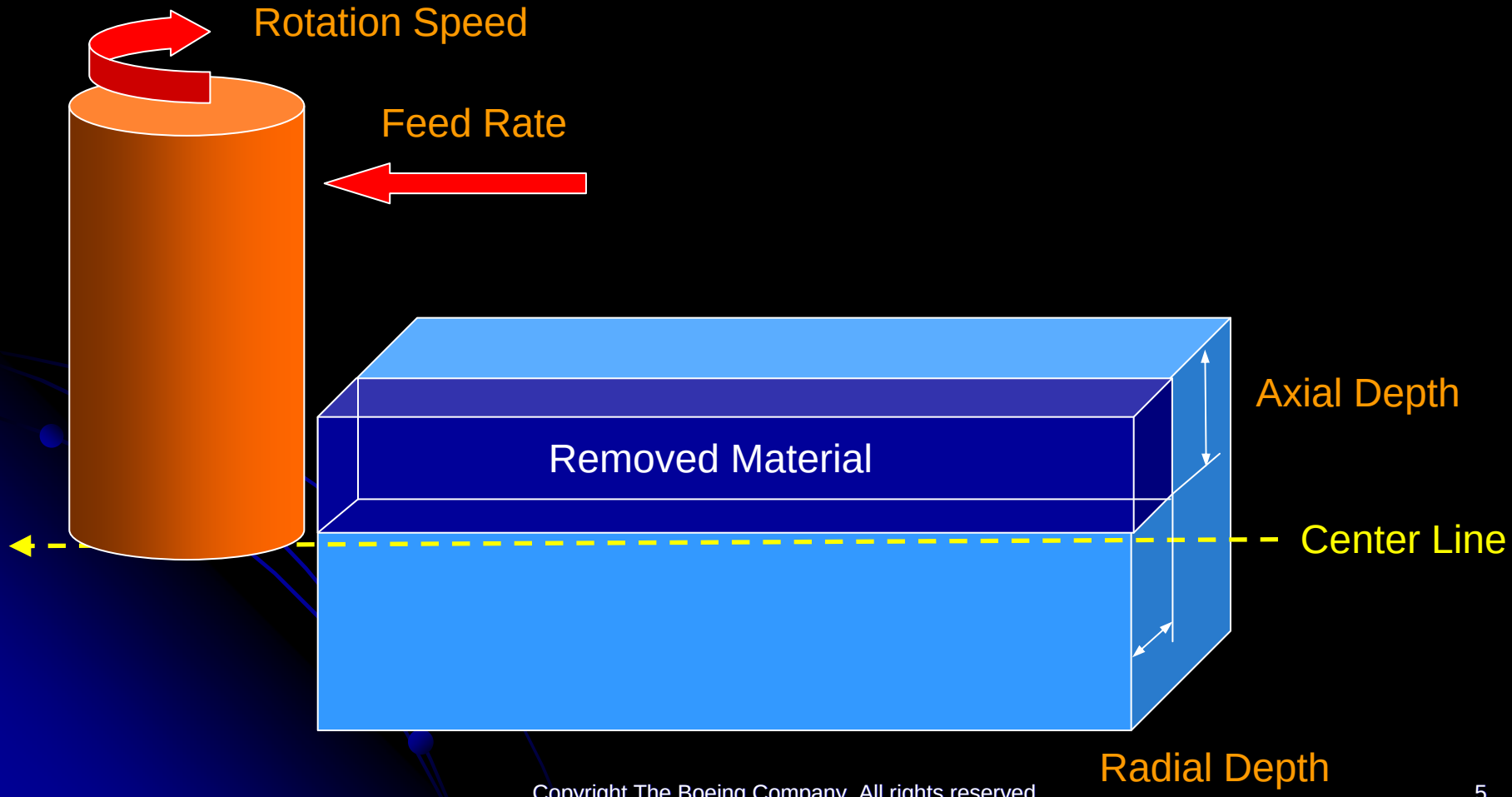


Material properties

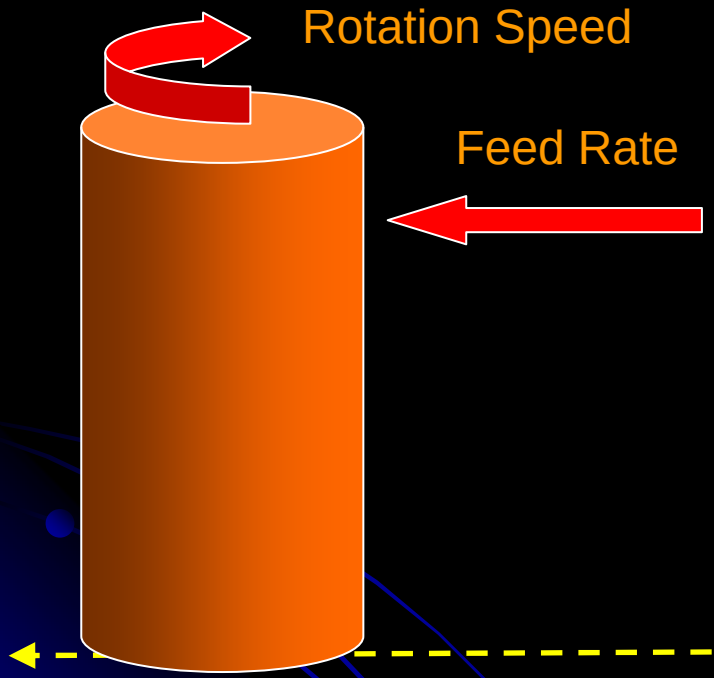


Machining parameters

Cutting Parameters and Path Geometry



Information in M-G Code (ISO 6983)

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N9 Z-2
N10 G1Z-4F8355.9
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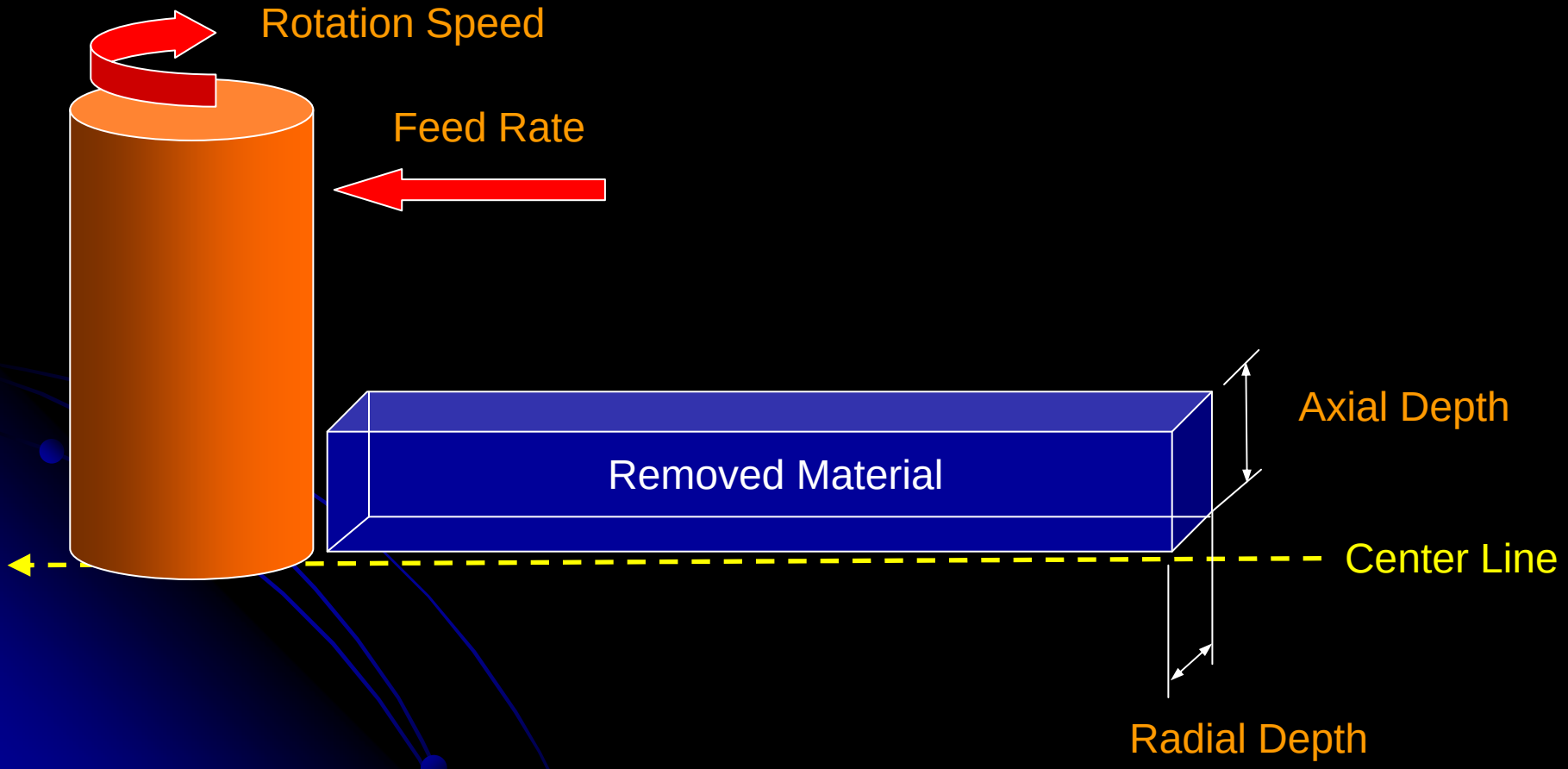
Information in ISO 10303-238



Cross-Sectional Area in ISO 10303-238

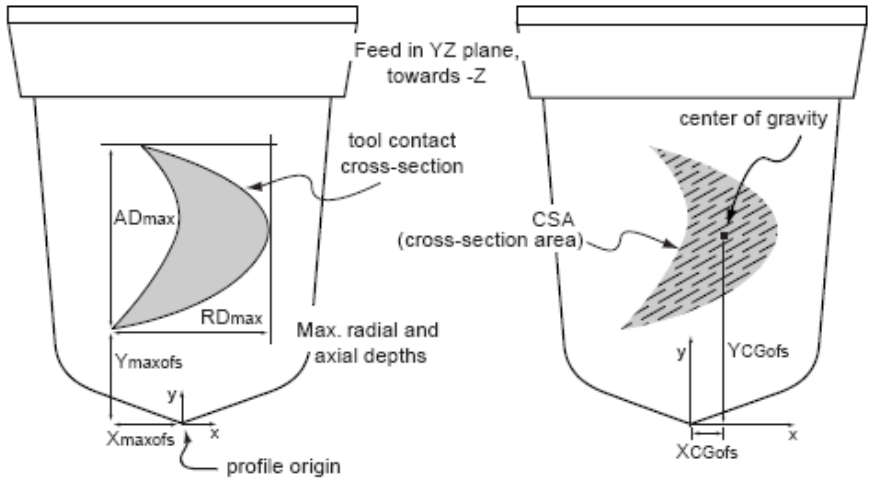


Figure 34 - Cross-section parameters for milling

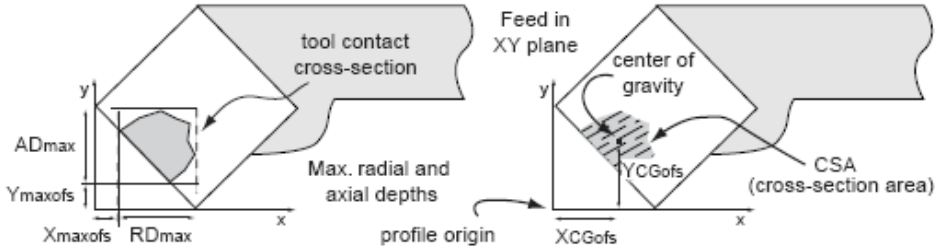
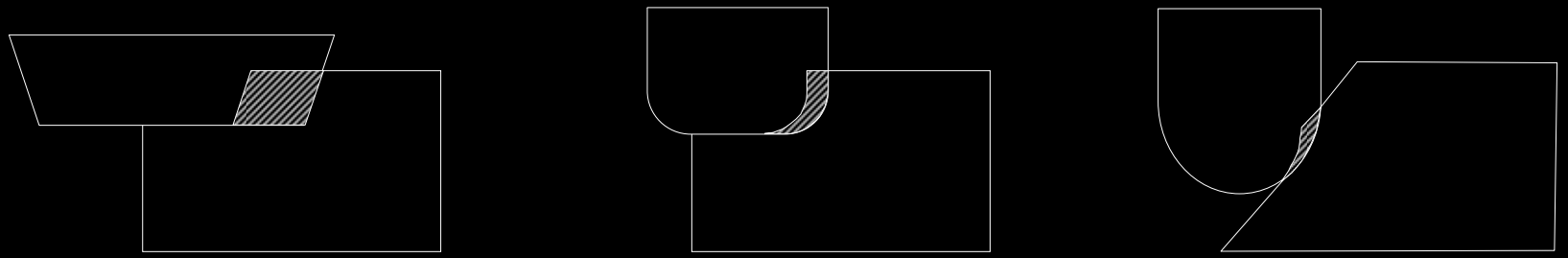
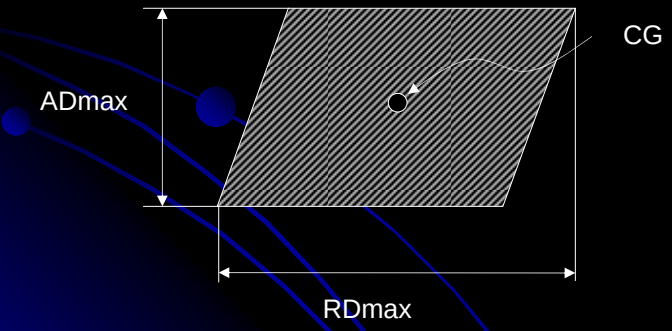


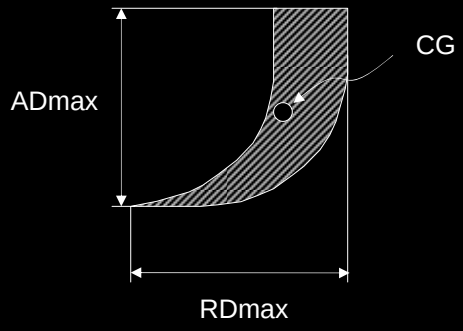
Figure 35 - Cross-section parameters for turning

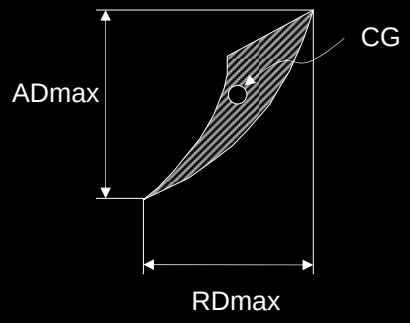
ISO 10303-238:2007 Technical Corrigendum 1

Examples of Cross-Sectional Area

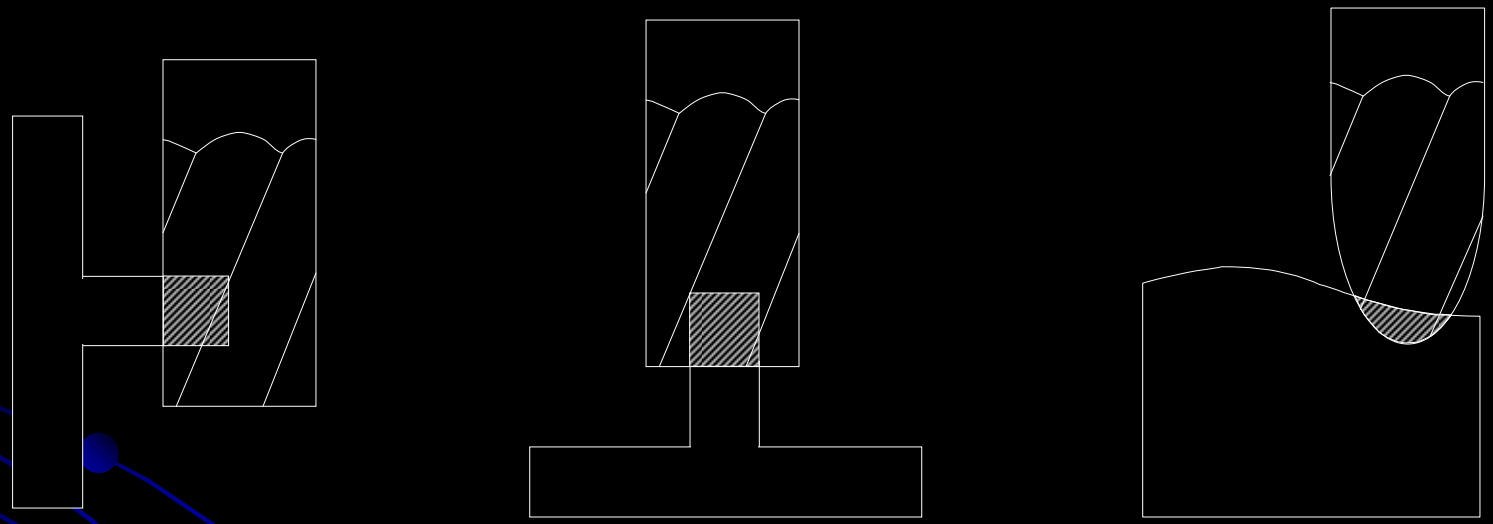




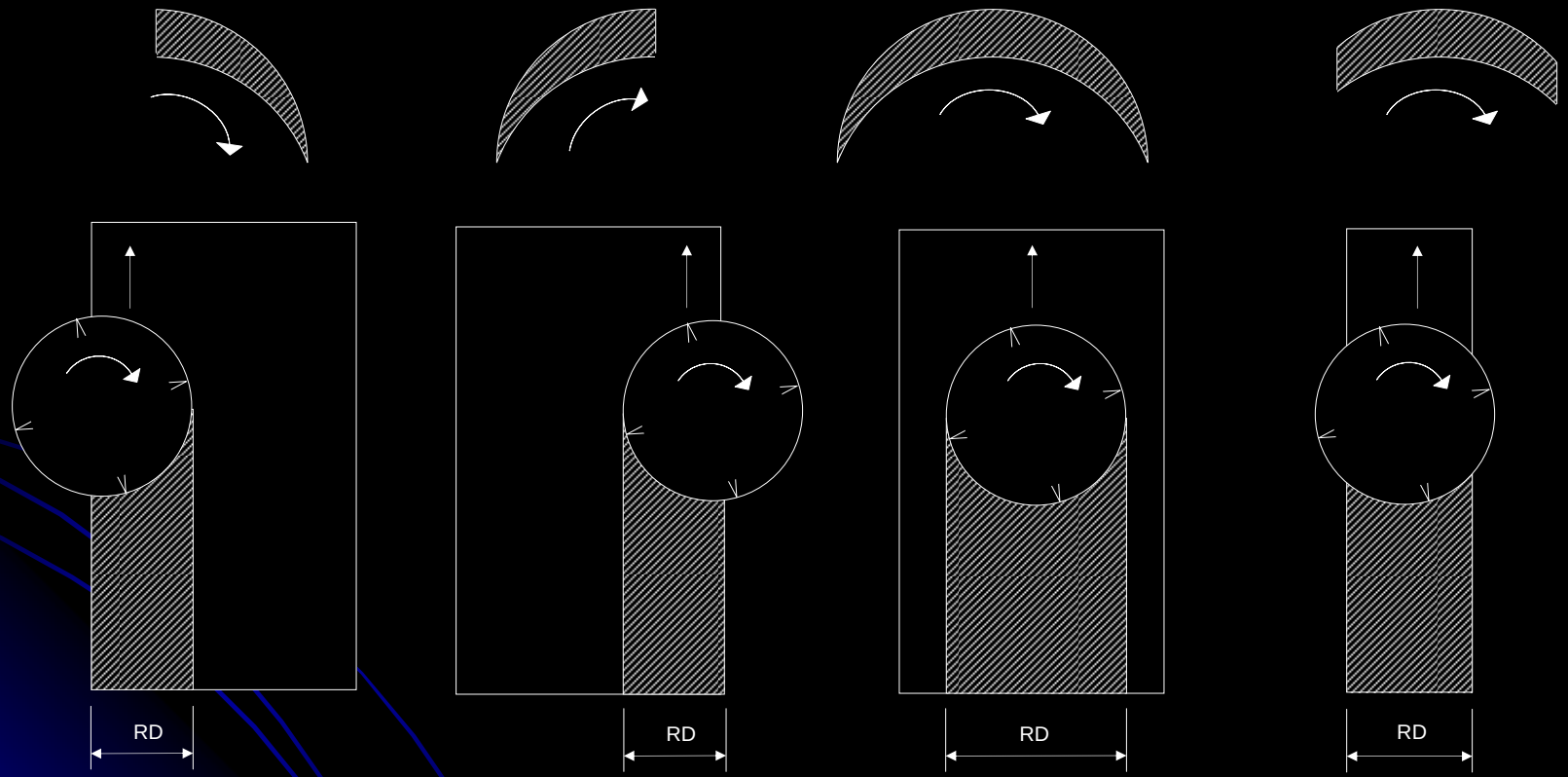




Engagement Locations

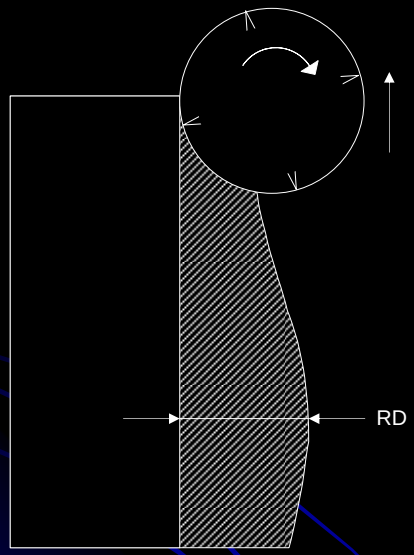


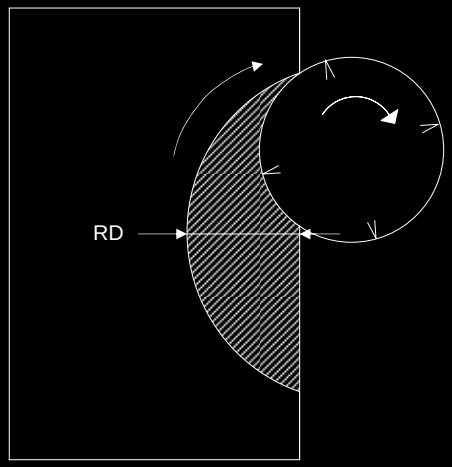
Engagement Start-End Conditions

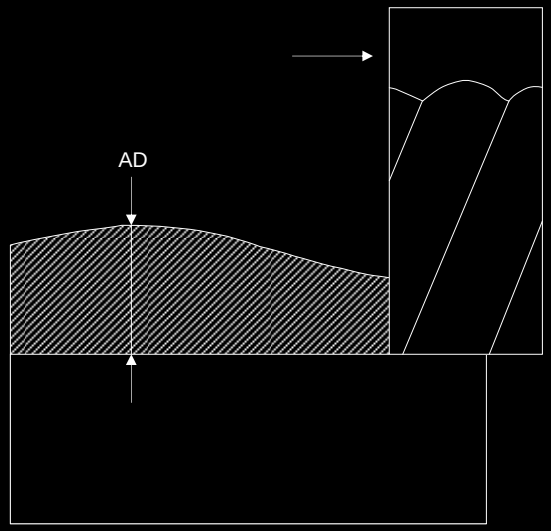


Climb Milling | Conventional Milling | Slotting (Channel Cutting) | Center Cutting

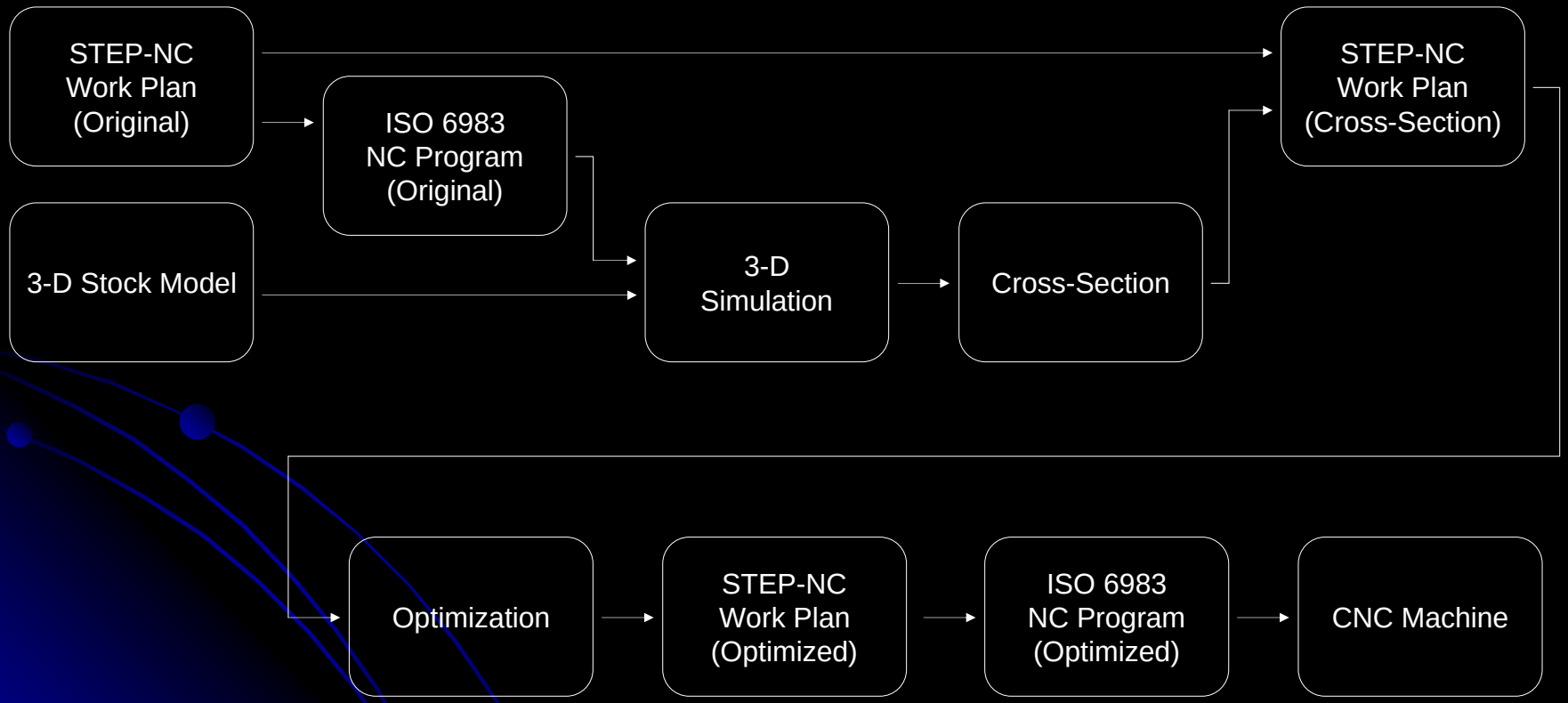
Maximum Engagement Conditions



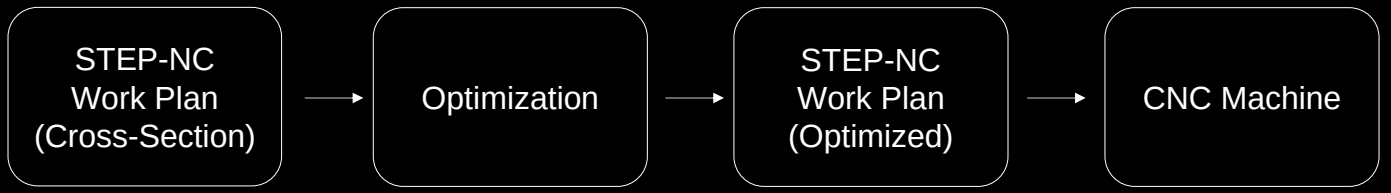




Current Optimization Process



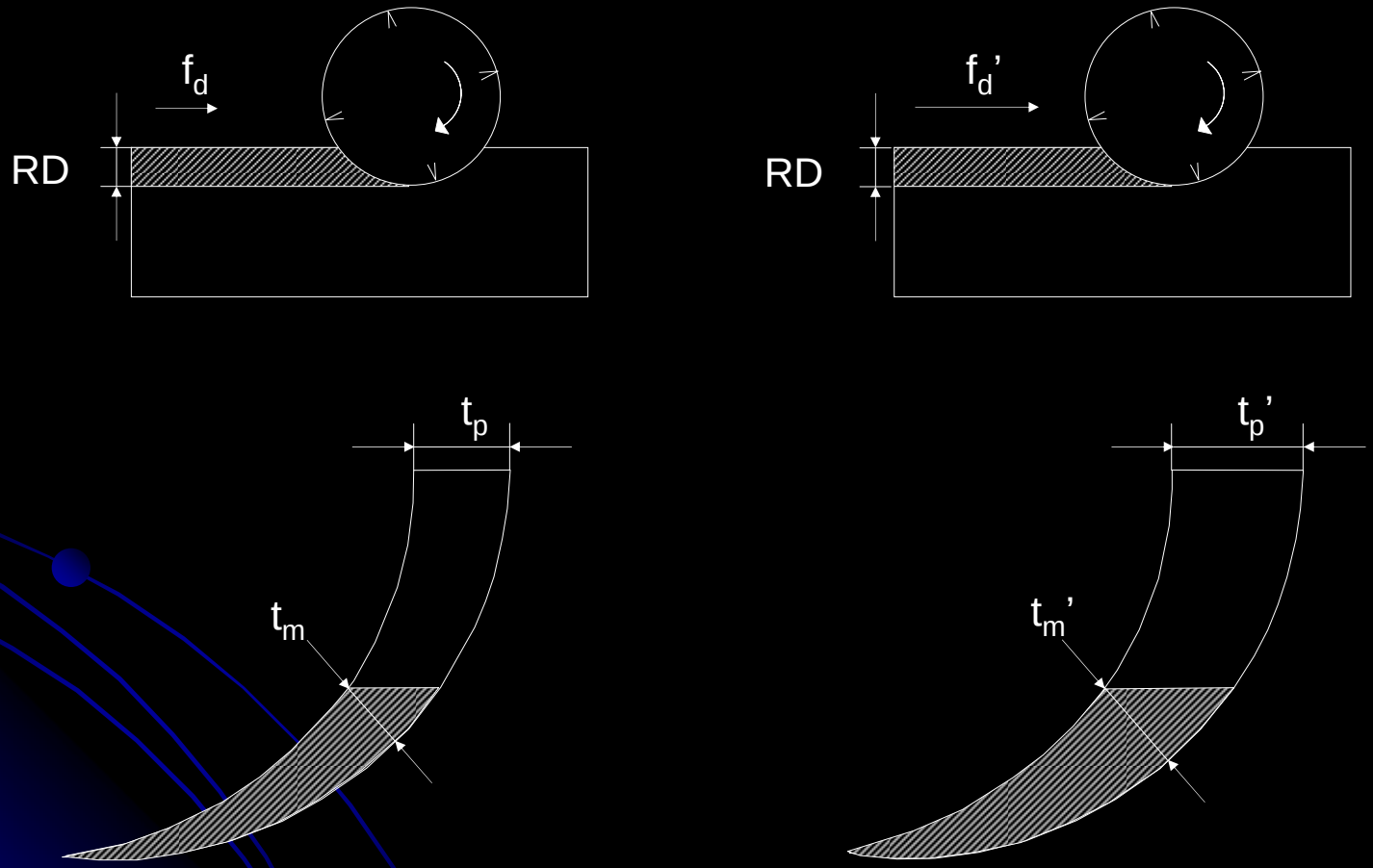
Future Optimization Process



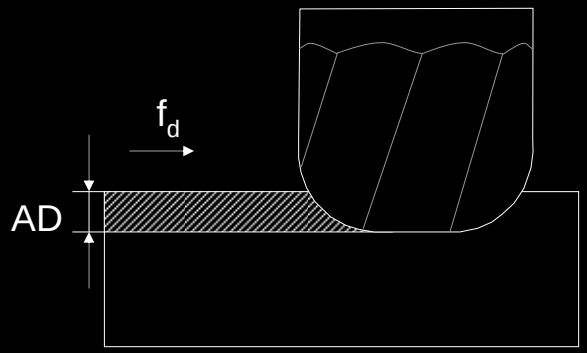
Optimization Methods

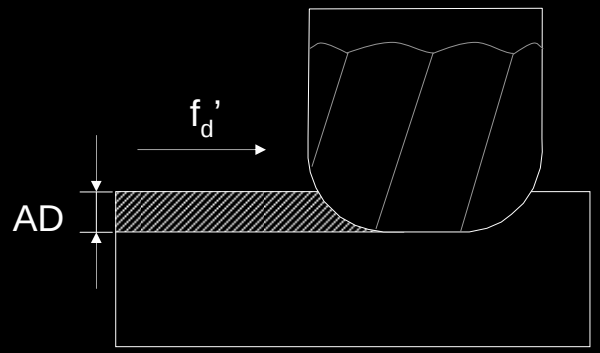
- Volume Based Optimization
- Force Based Optimization
- Tool Wear Optimization
- Constant Chip Optimization
- User-defined Optimization

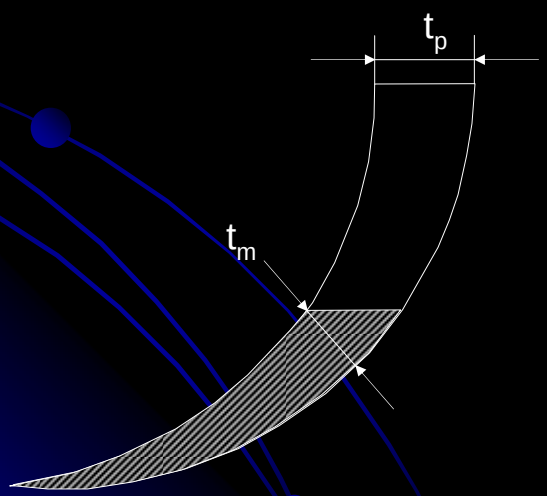
Radial Chip-Thinning Compensation

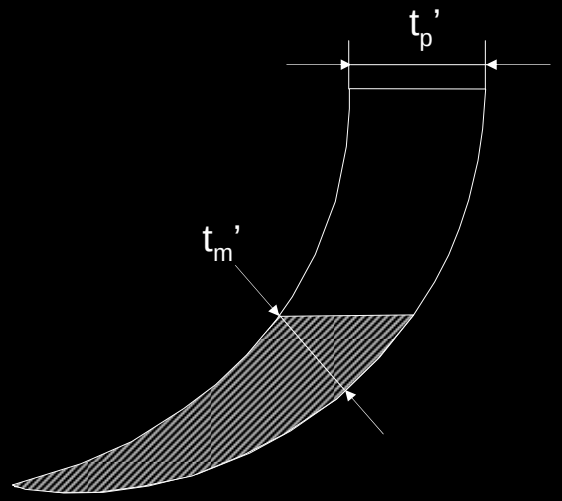


Axial Chip-Thinning Compensation

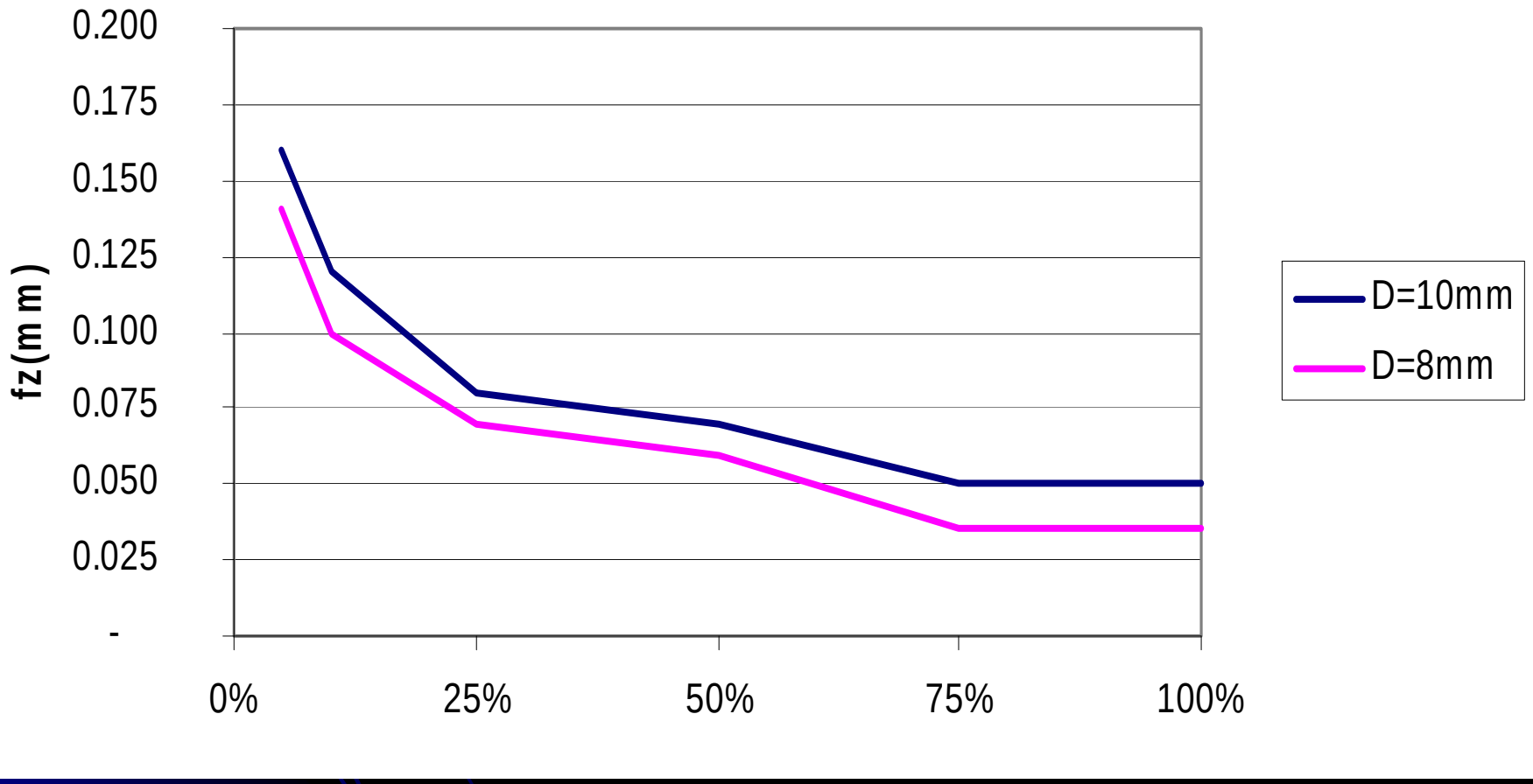




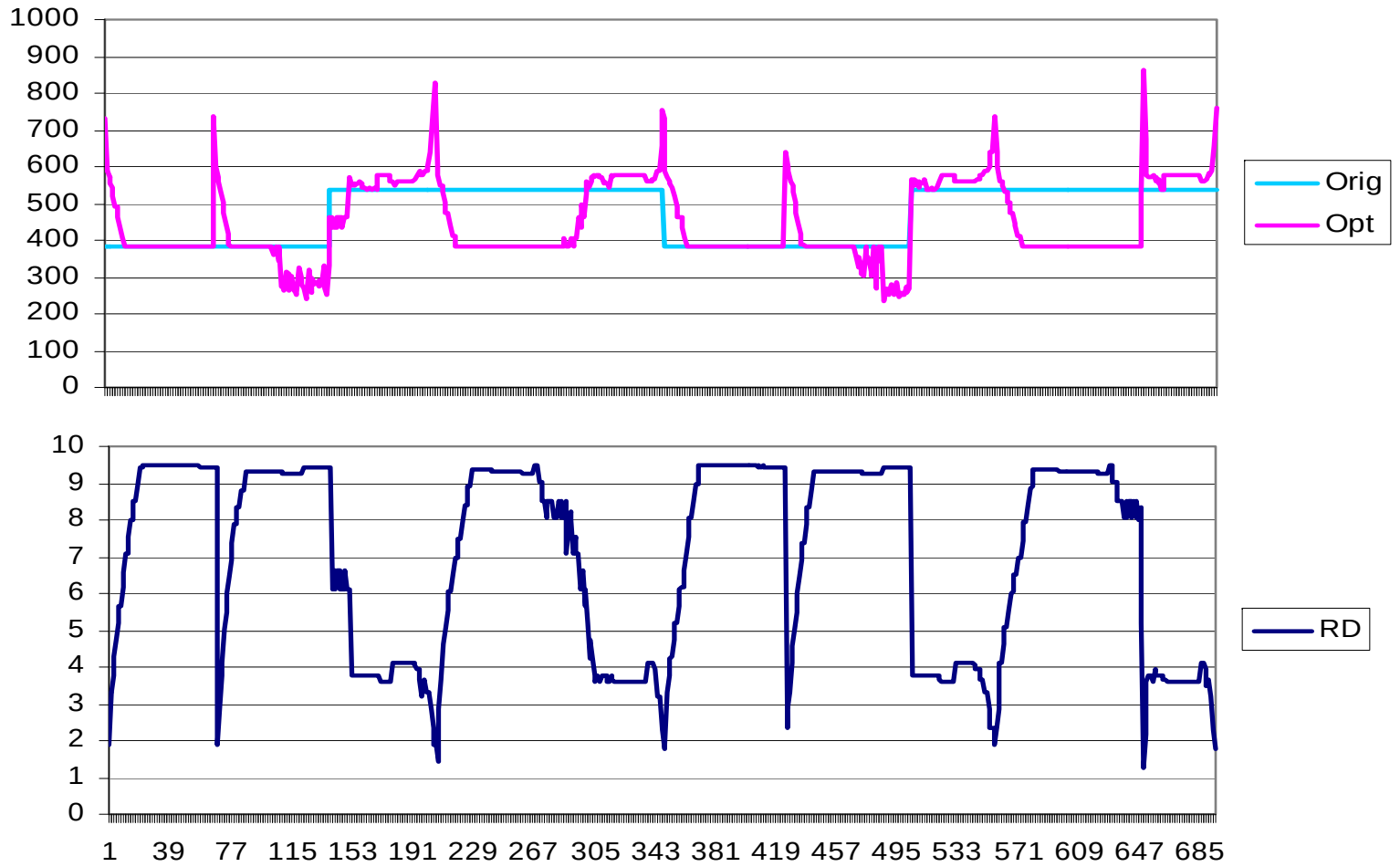




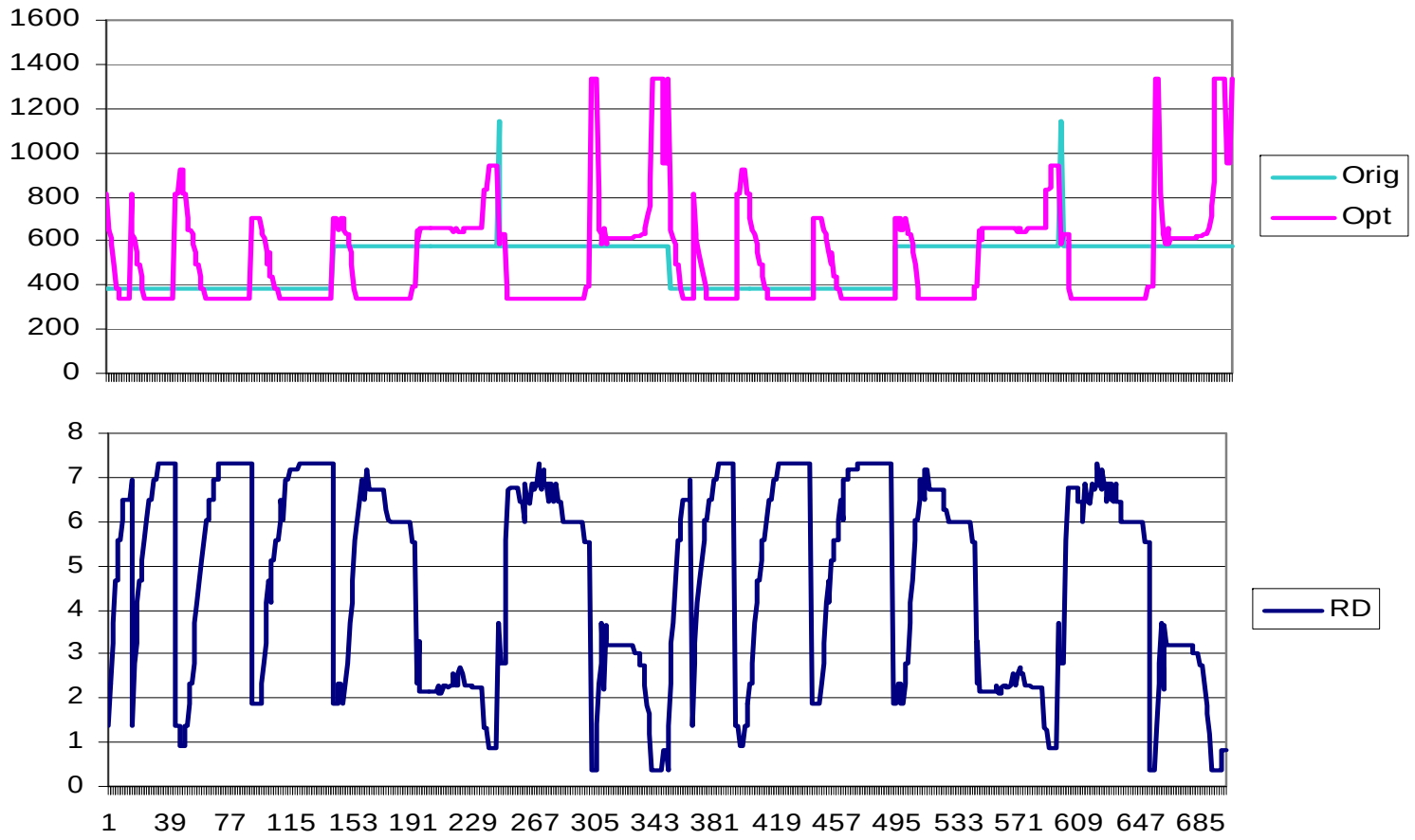
Feed/Tooth vs Radial Immersion



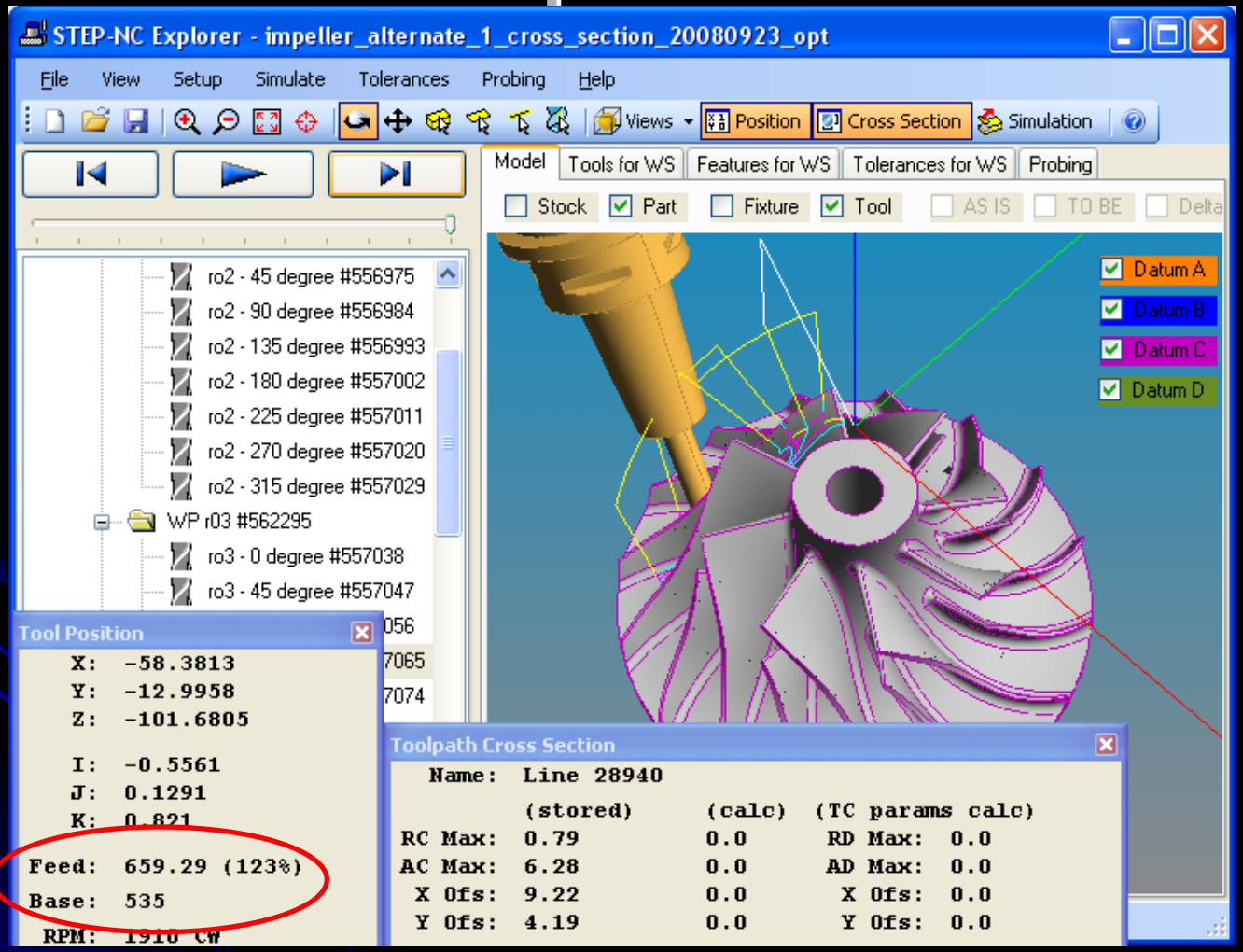
Feed and Radial Depth (T7)



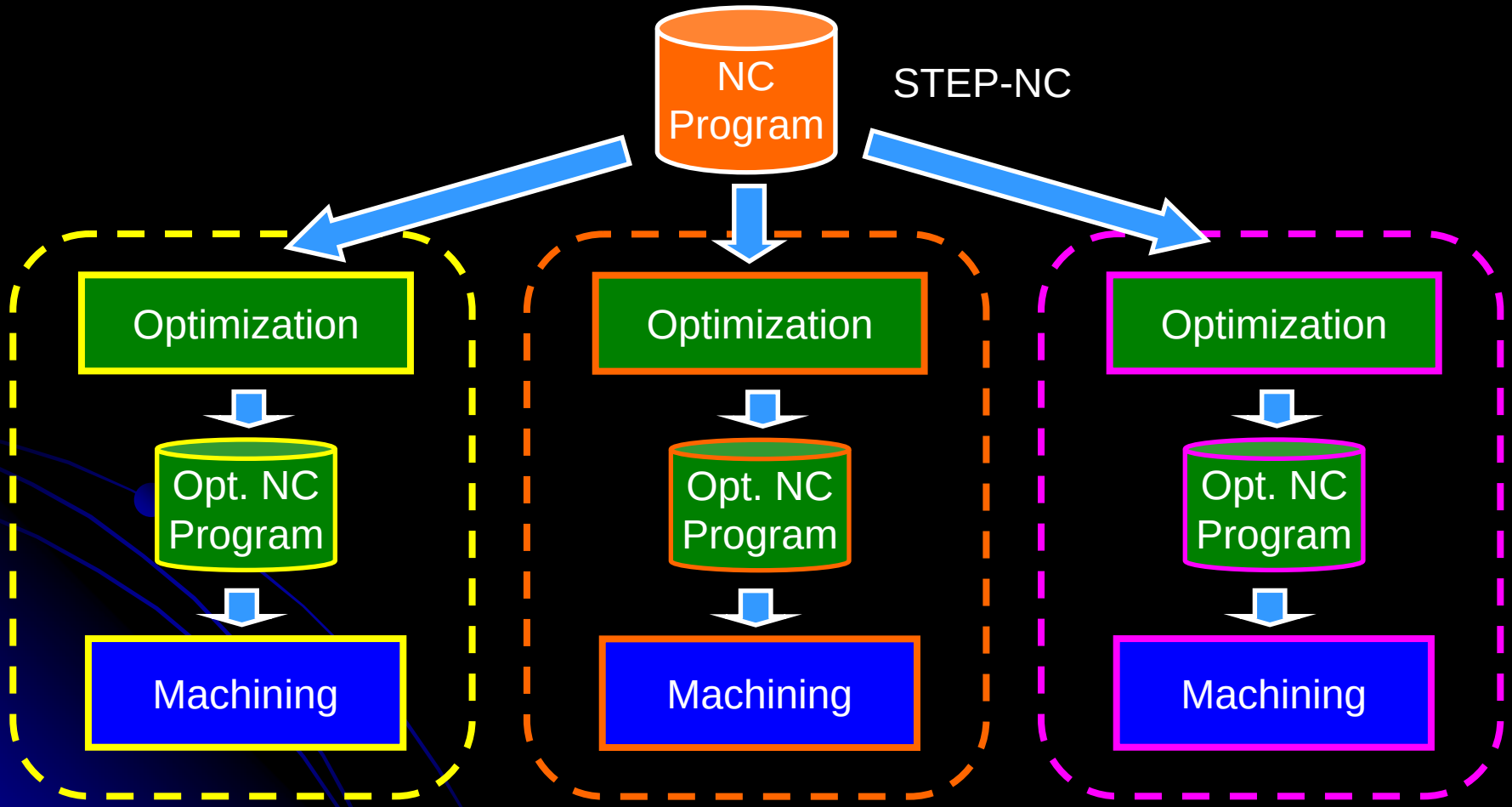
Feed and Radial Depth (T9)



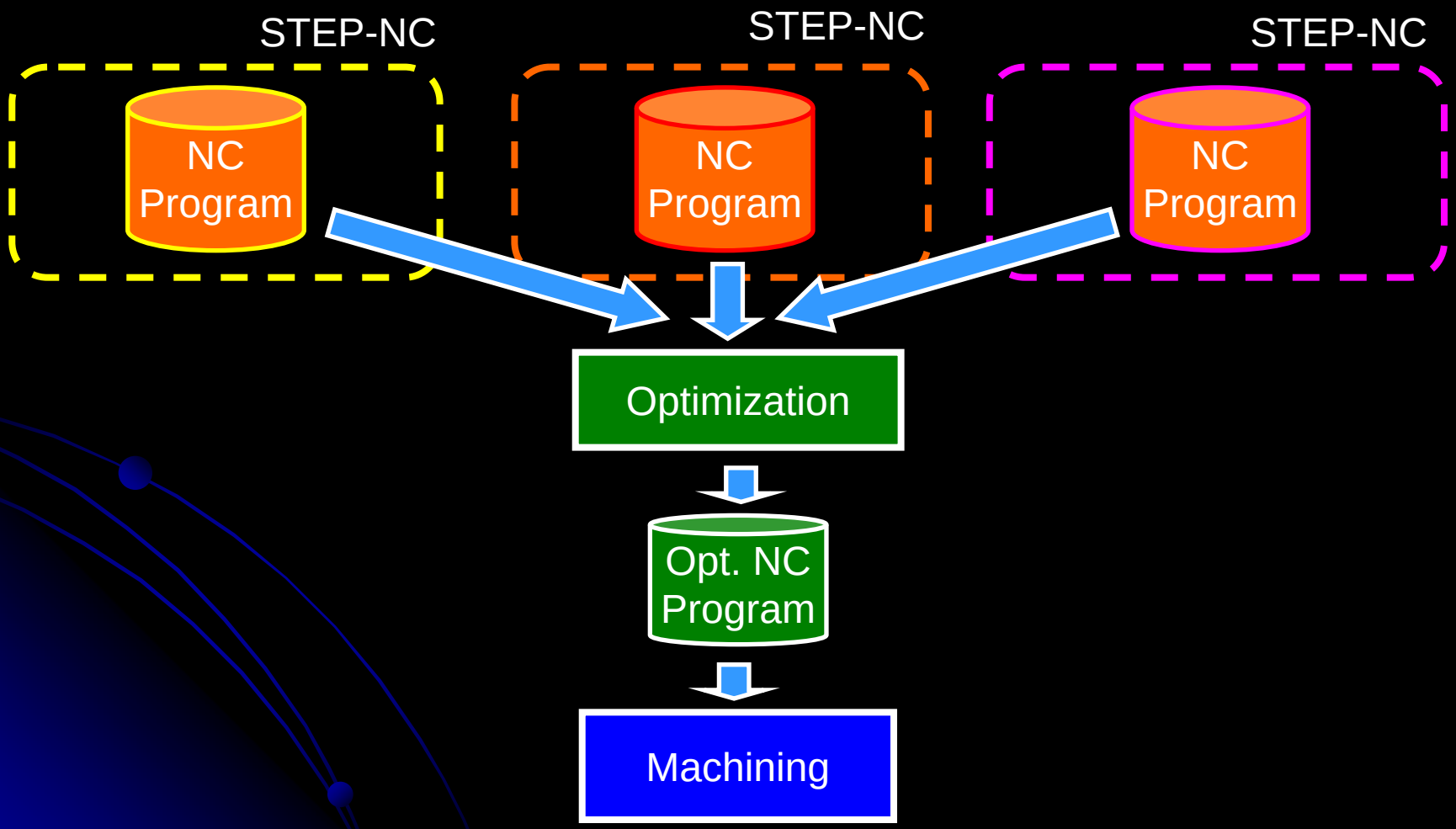
Feed Optimization



Optimization for Different Machines

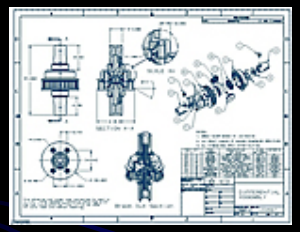


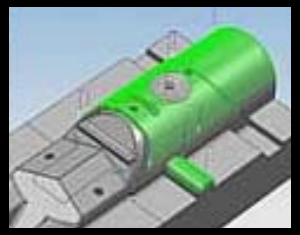
Optimization of Different Programs



Machining Process Optimization

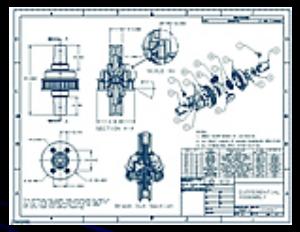
- Feed and speed

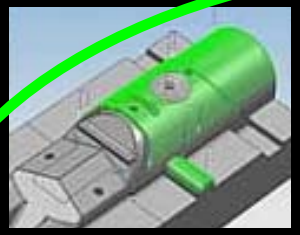


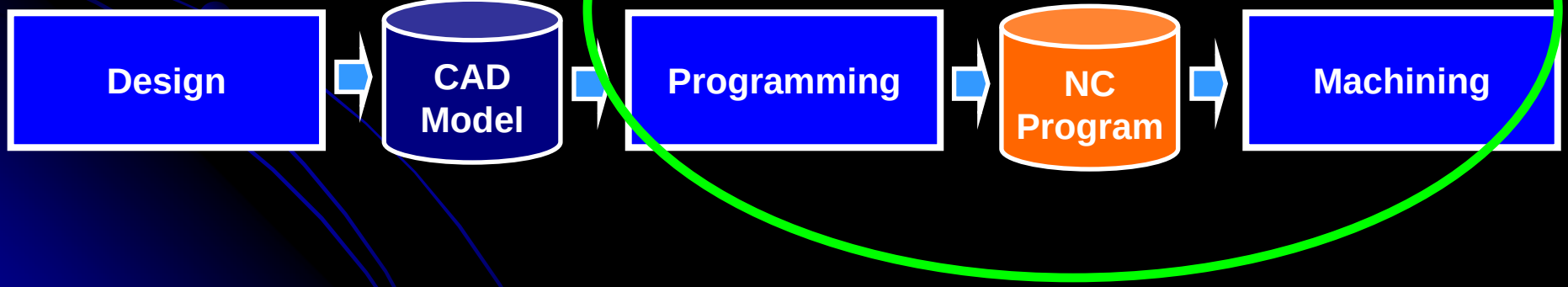


Machining Planning Optimization

- Feed and speed
- Path trajectory, radial and axial depths, number of passes…

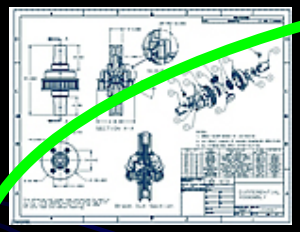


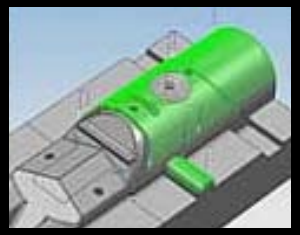


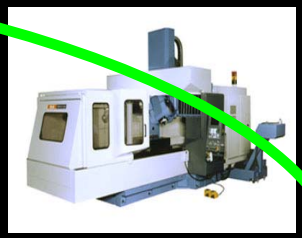


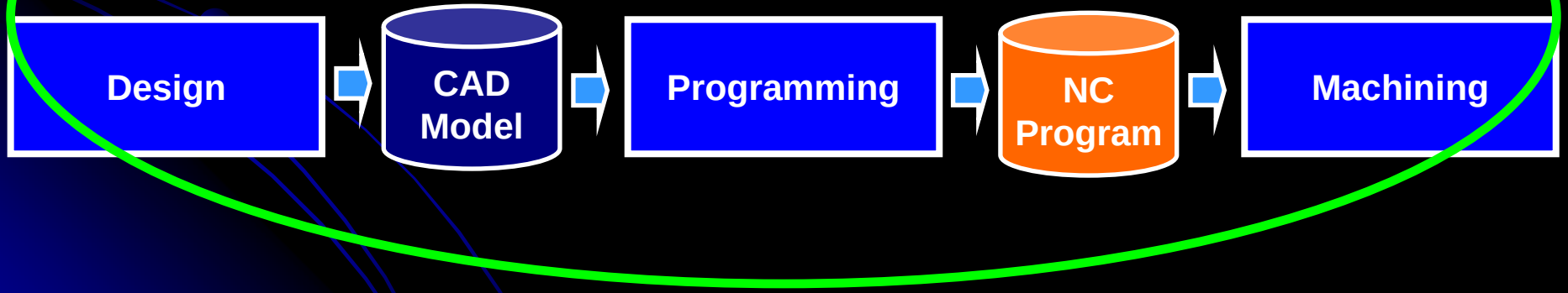
Machining Design Optimization

- “Machining friendly” feature design

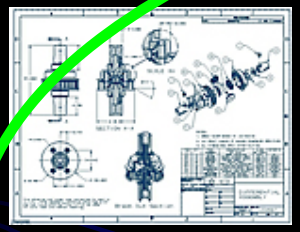


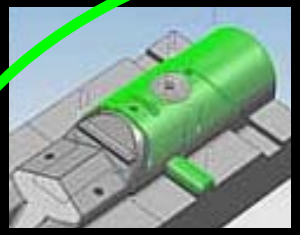






Total Manufacturing Optimization





Design → CAD Model → Programming → NC Program → Machining

Thank you!

ISO TC184/SC4 WG3/T24 STEP-Manufacturing, Spring 2008 Meeting

TRACEABILITY INTRODUCTION

Monday, 10 – Tuesday, 11, March at Sandviken, Sweden

Julio Garrido Campos & the ISO SC4/WG3/T24 group
jgarri@uvigo.es
University of Vigo (Spain)

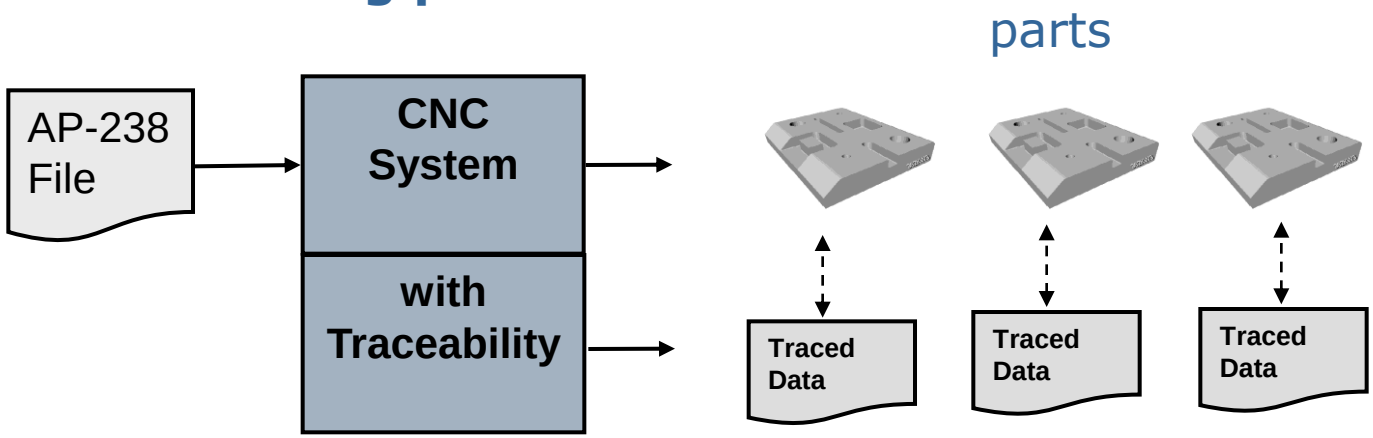
- **Traceability.**
  - What is Traceability?
  - For what is it implemented?
  - How is it performed (activities)?
  - How must be implemented (some implementation issues)?
  - Why Traceability in AP238?

- **Traceability requirements for AP-238 (some ones).**

- **Current status of the Traceability proposal for AP-238.**
  - Traceability nc_Functions as SC4 Dallas meeting.
    - The AP-238 executable Unit of Functionality and nc-functions.
    - Proposal: Traceability nc-functions.
    - How the Traceability nc-functions work: an example.
  - Some discussions & progress since SC4 Dallas meeting.
    - New data types for recorded data.
    - Redefinition of Block I functions.
    - Other comments.

1. Traceability.

- **What is Traceability?**
  - **The objective of Manufacturing Traceability is to provide all the relevant information about a manufacturing process.**

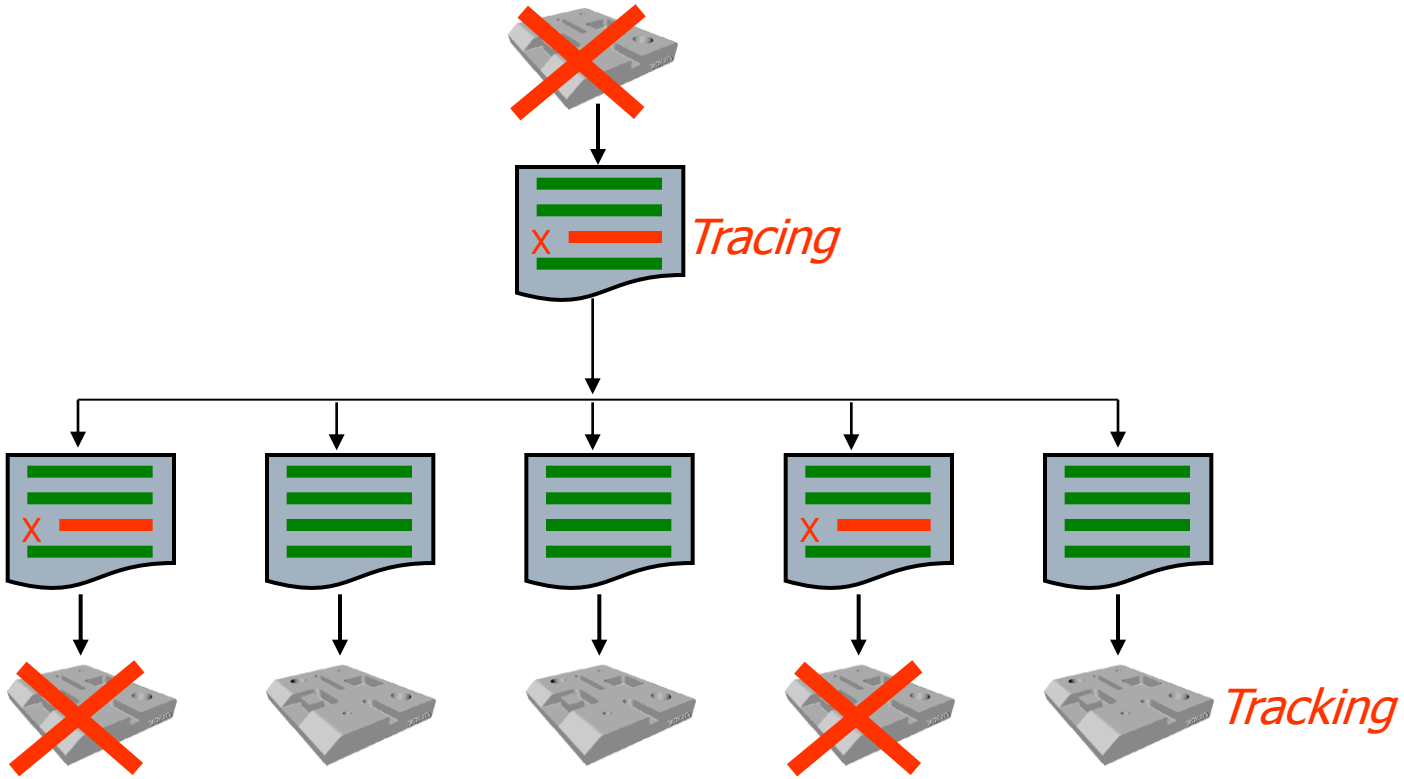


Which Data?

- **With what and where has been manufactured a piece?** raw material, coolant, tools, machine, software.
- **How/how well?** Tool paths, toll paths deviations, actual velocities, control events.
- **Who?** Operator
- **When?** manufacturing timings.

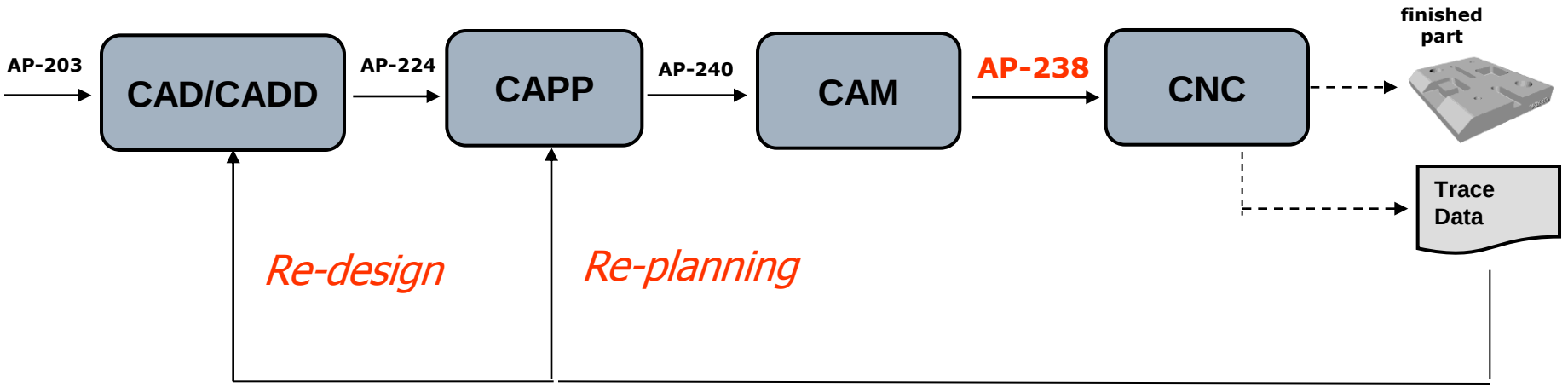
1. Traceability.

- **For What?**
  - For Quality analysis (and long term data analysis)
    - To be able to investigate the origin of a manufacturing default (***TRACE***). To answer questions like: **Why this feature is not ok?**
    - To be able to identify other pieces with the same fault (***TRACK***). To answer questions like: **Which other pieces may have also the same default and should be review?**



1. Traceability.

- **For What?**
  - For knowledge capture and optimization (for re-design and re-planning)
    - To answer questions like: **How log does it take to machine this feature?**



- **For What?**
  - To provide data for advanced "manufacturing" services.
    - Programmed Monitoring.
    - Intelligent manufacturing.

1. Traceability.

- **How is it performed (activities)?**
  - **Before manufacturing (Design phase).**
    - **Definition/Configuration of what to trace, where, how.**
  - **During Manufacturing (Shop floor phase).**
    - **Data recording process (shop floor).**
    - **establishment of the link between the traced data and the piece.**
  - **After Manufacturing (Quality and re-design phase)**
    - **Data communication.**
    - **Data storage**
    - **Data analysis, etc.**

1. Traceability.

- **Activity Model, 3 main activities:**

Before Manufacturing

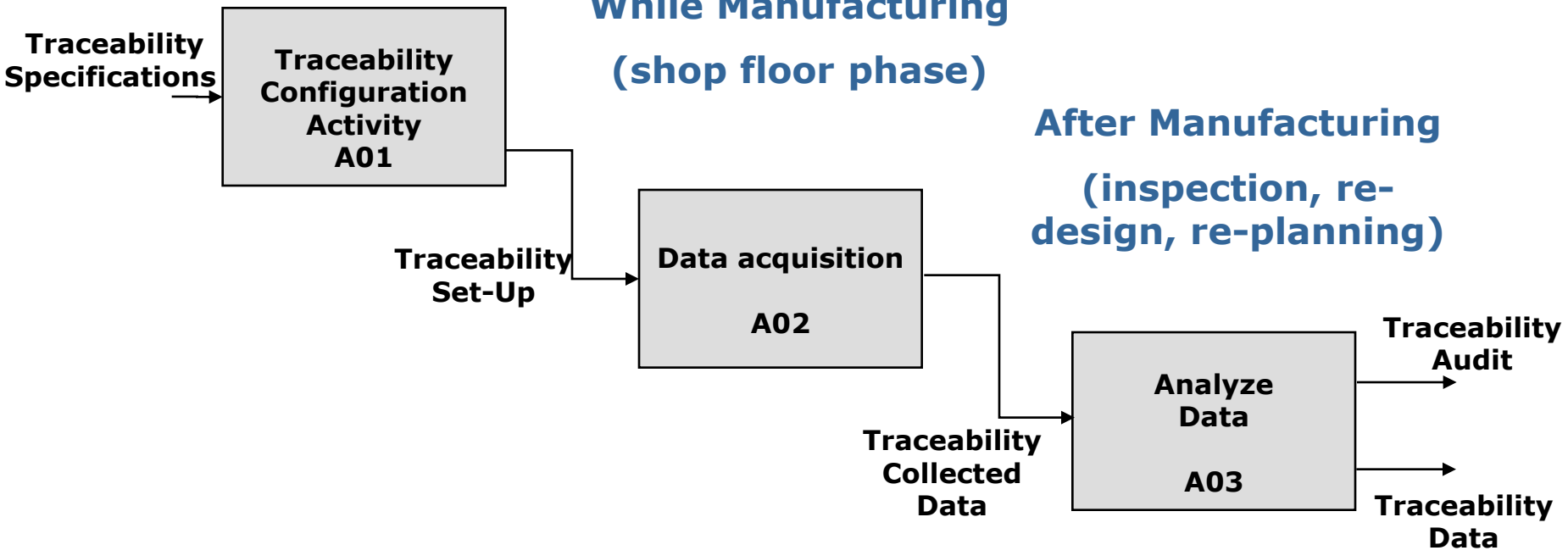
(design phase)

While Manufacturing

(shop floor phase)

After Manufacturing

(inspection, re-design, re-planning)



1. Traceability.

- **Why Traceability in AP-238?**

A- Many relevant data is just know by the process controller, so it has to provide this data.

The CNC controller knows much of this data. The HMI+CNC controller knows all the data.

B- In Client-supplier relationships, traceability data has to be understandable, trustable…

- **Understandable.** In terms of format and meaning.
  - The contractor has to understand the requirements with out doubts.
  - The client has to understand the data by its own.
- **Trustable**.
  - There shouldn't be doubts about the recording process.
  - Traceability activities must be performed as much automatically as possible (to guarantee there is no errors)

Traceability DATA (requirements & results) should be standard & automatically understood:

- **Automatically understood by controller.**
- **Understood by the analysis system (linked to an understandable specification of the machining process).**

1. Traceability.

"Some" Traceability requirements for AP-238.

- INPUTS
  - Based on STEP AP238
  - Machine independent
  - Based on customer requirements
  - Enable last minute adaptation
  - Done once

CNC Traceability

- OUTPUT is an extract from internally collected data according to requirements
  - As required by customer.
    - Probing
    - Quality insurance
  - As required for shop floor management: for scheduling, MES, maintenance, …
    - Scheduling, durations
    - Warnings and alarms,
    - Corrective actions,
  - Enables traceability, archiving and SPC.
    - Administrative data
    - On machine measurement data
    - Quality stamp
  - Enable knowledge capture and optimisation.
  - Format "standard".

1. Traceability.

"Some" Traceability requirements for AP-238: DATA.

- Data internally required (to be used on real-time):
  - For drive control
    - Data used to compute and monitor the tool path
  - For HMI
    - Data to be displayed on controller screen
    - According to mode: automatic, manual, maintenance,
    - Safety and environment security
    - Knowledge capture
  - For shop floor, workcell management and maintenance
    - Links with inventory, tools, pallets, calibration,
    - Tools wear
    - Resources and energy consumption

- Data to Trace (data commonly saved in log blocks)
  - Data for traceability is an extract of data collected during machining. Export is done after machining; this is to speed up the execution.
  - Trace of the program is saved for further execution including manual override and/or on line computations (for instance: F & S instead of input data AD, RD,….)
  - Specific data to be collected and conditions for capture are a global and/or default commands. This will decrease the size and improve readability.
    - data from the log books, workingstep data
  - Data locally collected during execution
    - Measures, Test condition true or false

2. Proposal: nc-functions as SC4 Dallas.

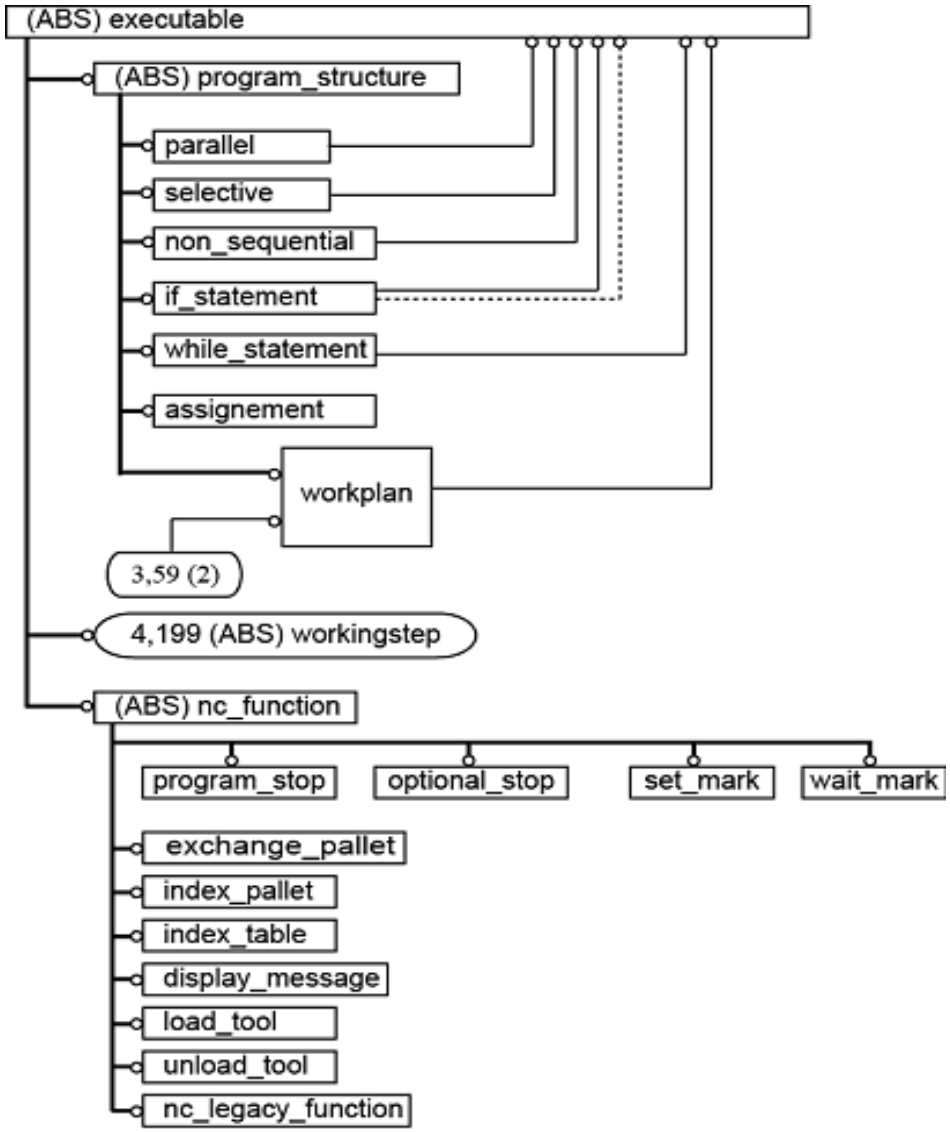
Current status of the Traceability proposal for AP-238.

- 2. Traceability NC-Functions as SC4 Dallas meeting (October 2007).
  - The AP-238 executable Unit of Functionality and nc-functions.
  - Proposal: Traceability nc-functions.
  - How the Traceability nc-functions work: an example.

- 3. Progress since SC4 Dallas meeting.
  - New data types for recorded data.
  - Redefinition of Block I functions.
  - NIST proposals.
  - Other comments.
  - Open issues.

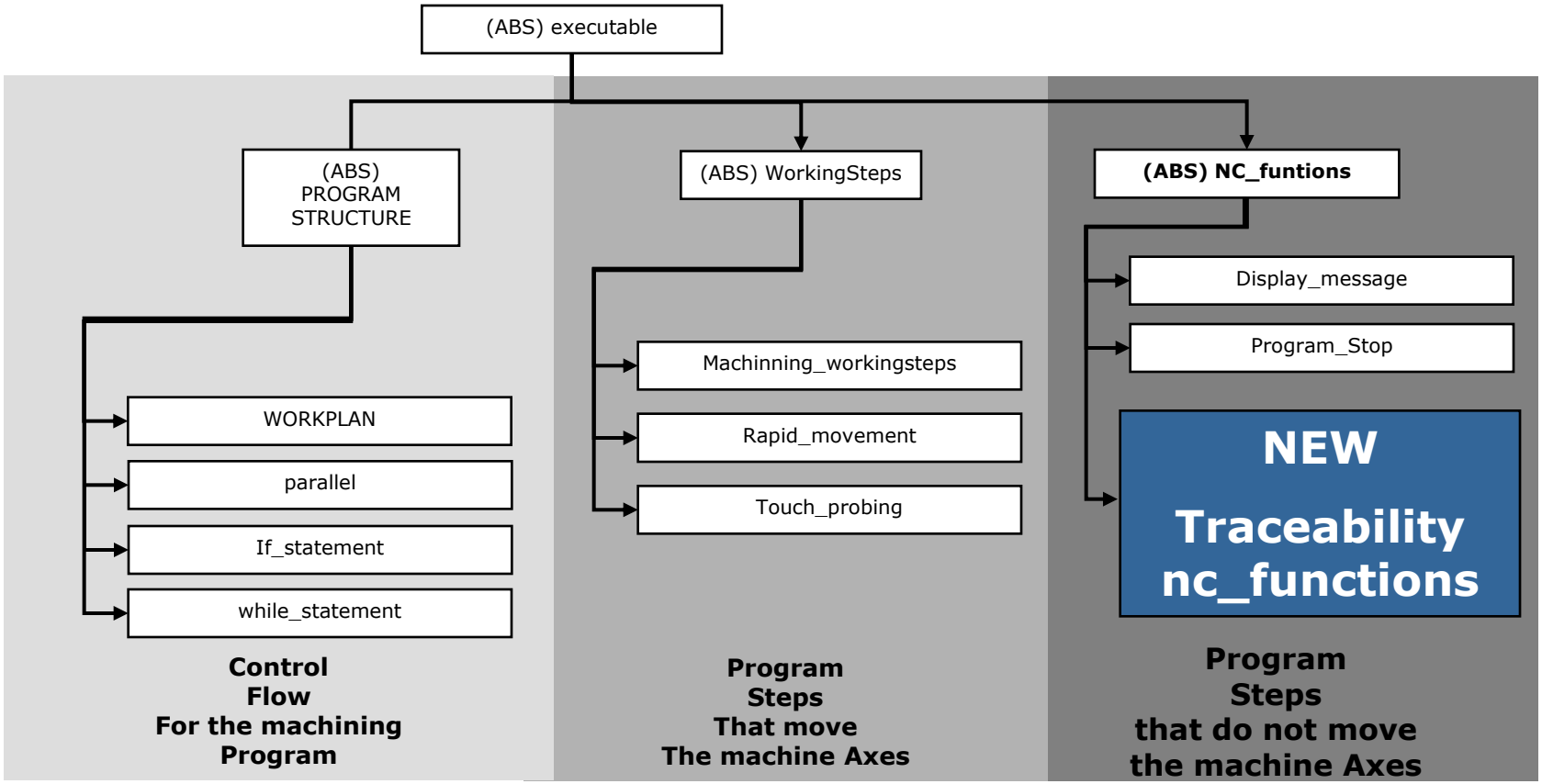
2. Proposal: nc-functions as SC4 Dallas.

- **Executable model (AP-238).**
- **(ABS) Program structure: Control flow for the machining program.**
- **(ABS) workingsteps: Program Steps that move the machine axes**
- **(ABS) nc_functions: Program steps that do not move the machine axes.**



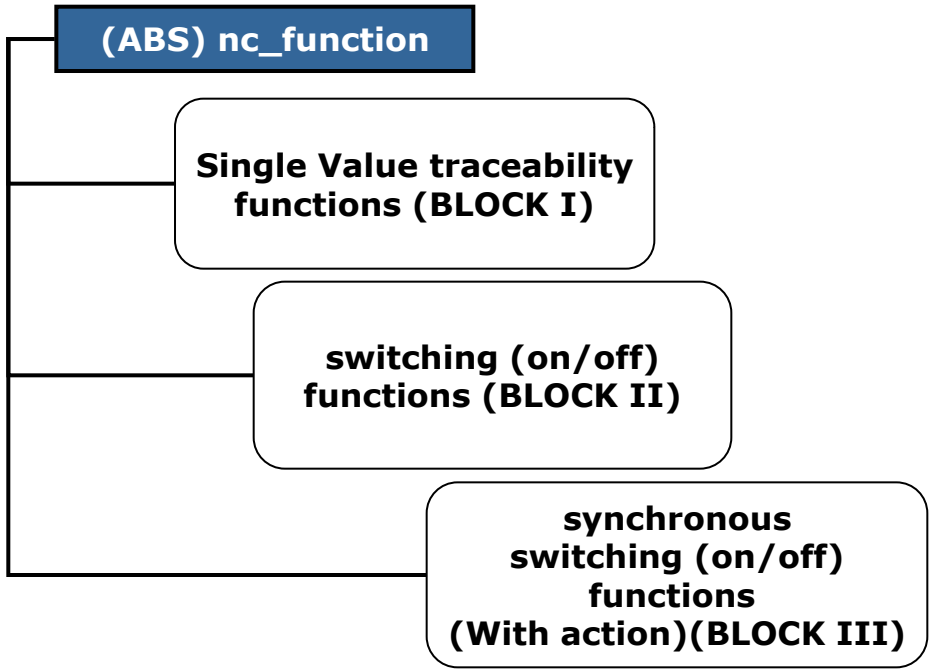
2. Proposal : nc-functions as SC4 Dallas.

- **AP 238: Adding Traceability NC-Functions**



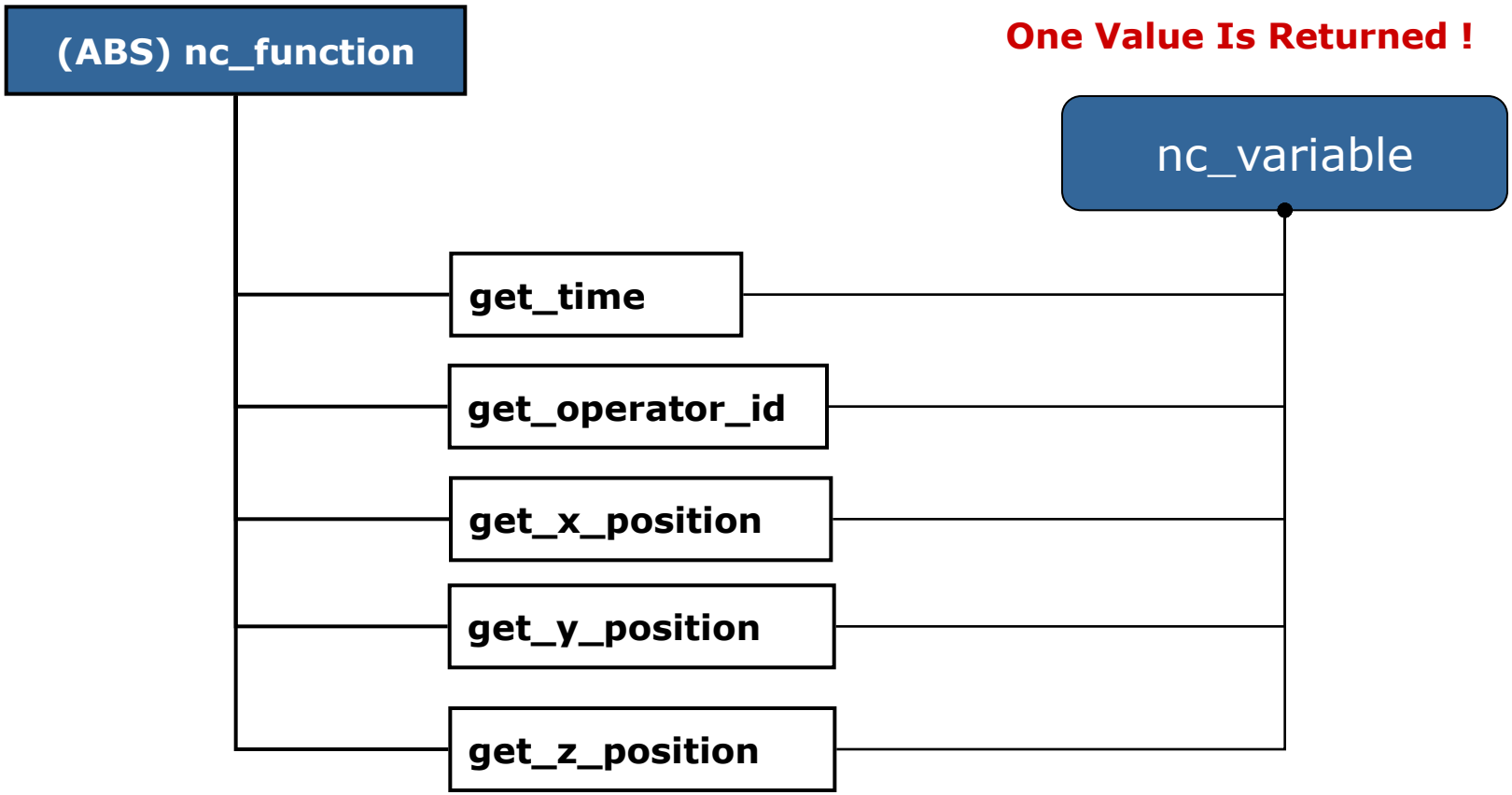
2. Proposal: nc-functions as SC4 Dallas.

- **Three Groups of Functions for data traceability:**
  - Group I:
    - **Blocking Functions**, take control of the program, collect a punctual or single value of data to be used in CNC calculations and return control to machining flow.
  - Group II:
    - **Switching Functions**, activate data collection or event information for a period of time. A **switching on** functions activates the data monitoring until the corresponding **switching off** functions id found in the program.
  - Group III:
    - **Synchronous Functions**, continuously monitor data to trigger if a condition is fulfilled a series of actions grouped as a workplan.

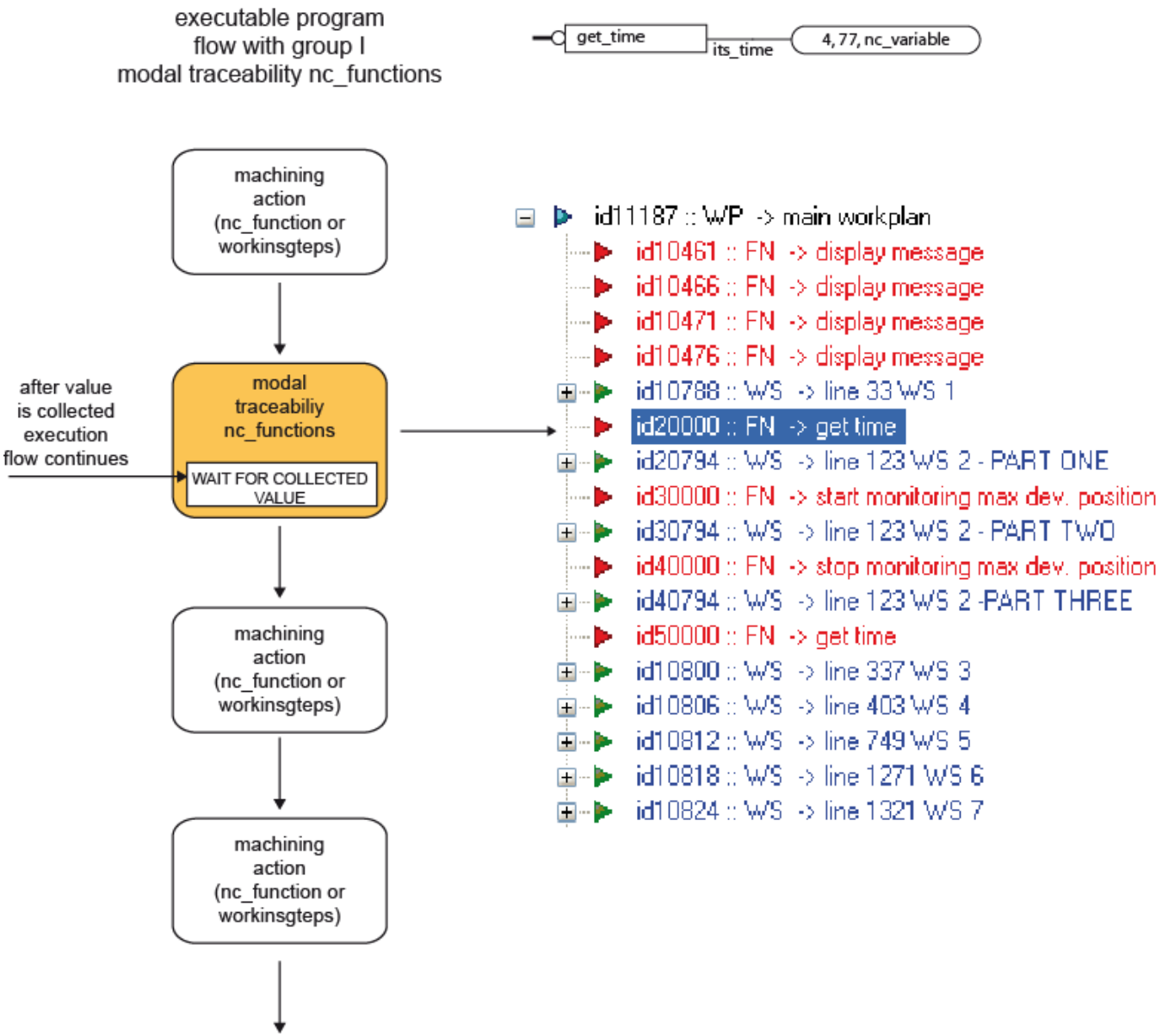


2. Proposal: nc-functions as SC4 Dallas.

- **Group I Functions.**



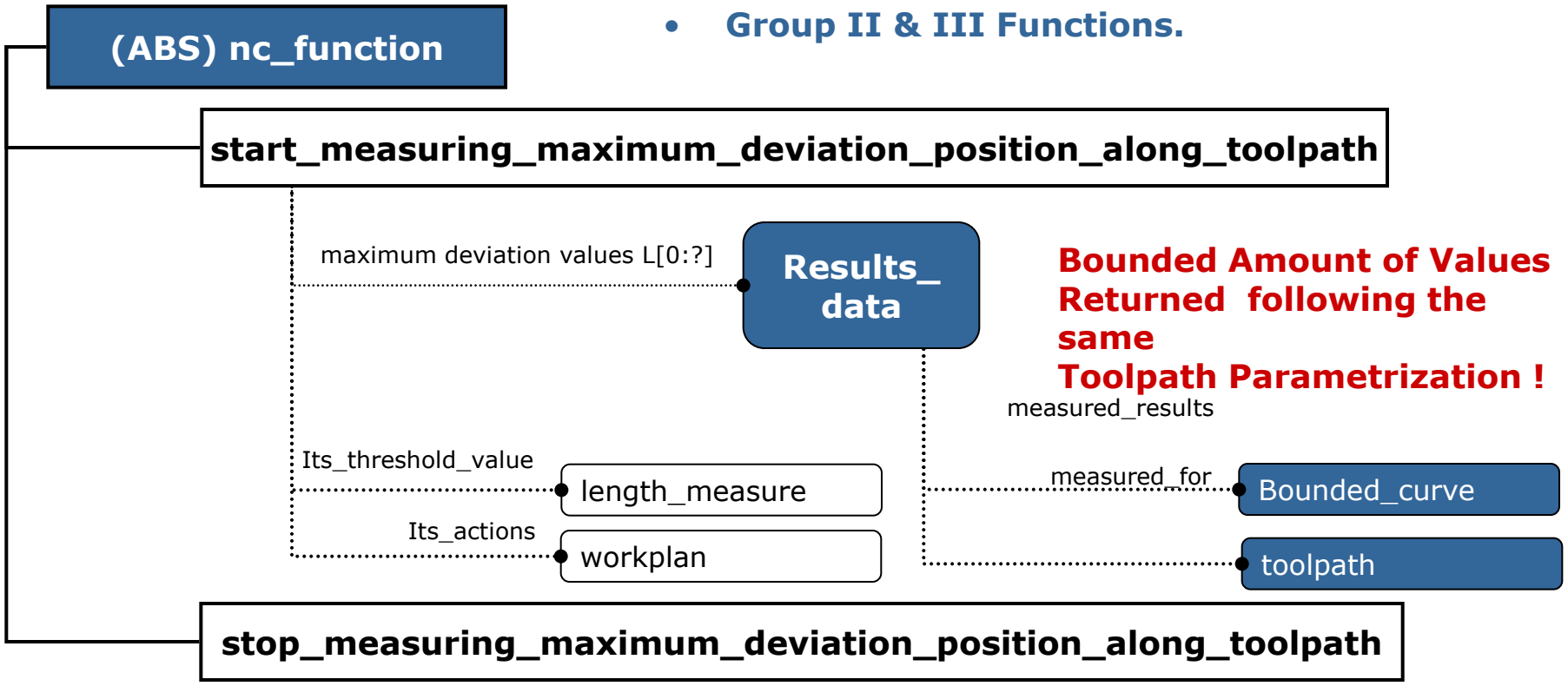
2. Proposal: nc-functions as SC4 Dallas.



Program Sample with Group I Functions.

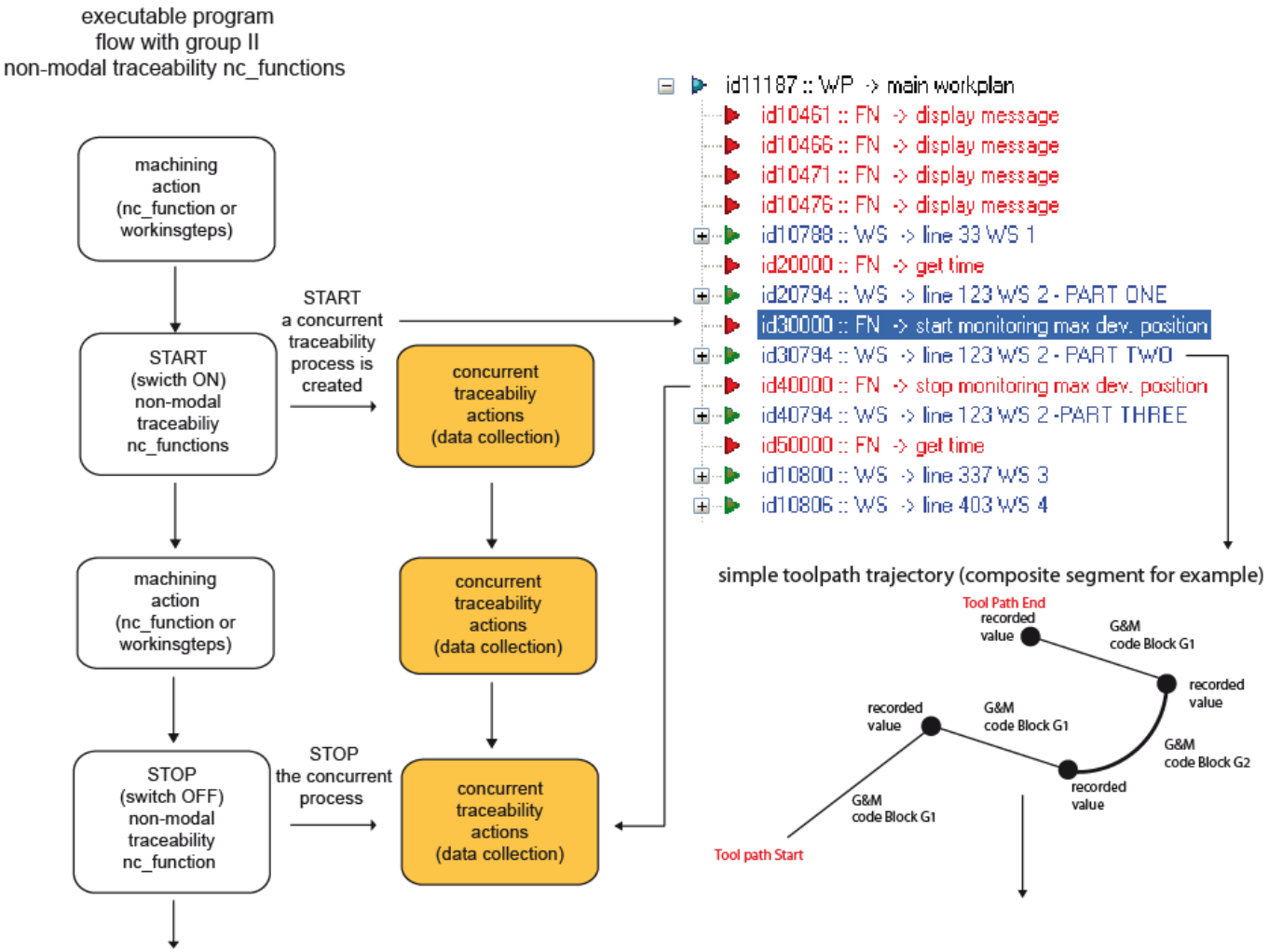
2. Proposal: nc-functions as SC4 Dallas.

- Group II & III Functions.



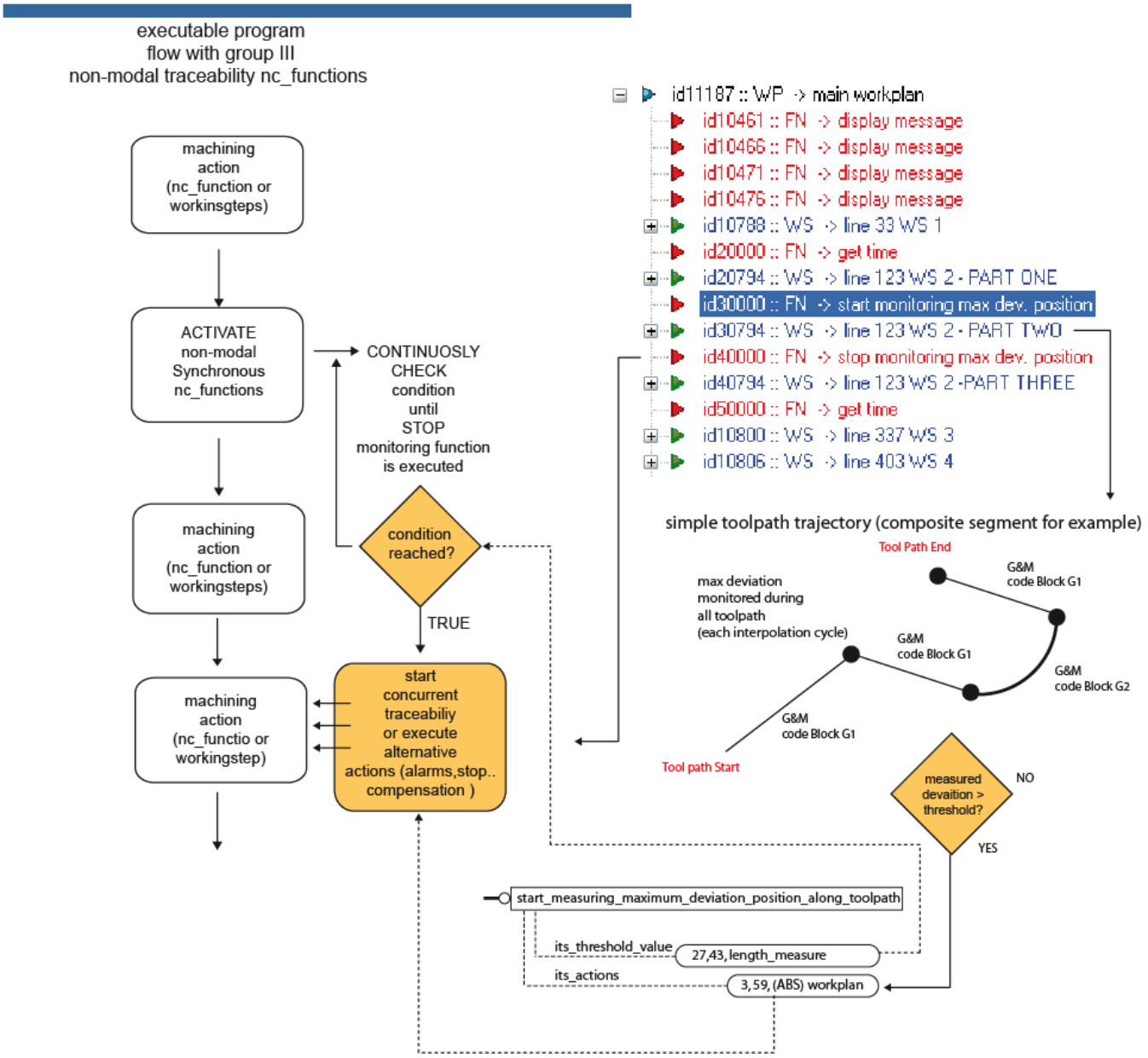
- maximum_deviation_values L[0:?] is used to store in AP-238 a bounded curve, series of collected values (per toolpath and following the same parametrization as the corresponding workingstep toolpath).
- its_threshold_value is used only if nc_function acts as a group III function to specify a threshold value for the comparing/triggering condition.
- its_actions is an alternative workplan (a series of actions) to be done in case the specified condition is fulfilled (just for group III).

2. Proposal: nc-functions as SC4 Dallas.



- **Program Sample with Group II.**

2. Proposal: nc-functions as SC4 Dallas.



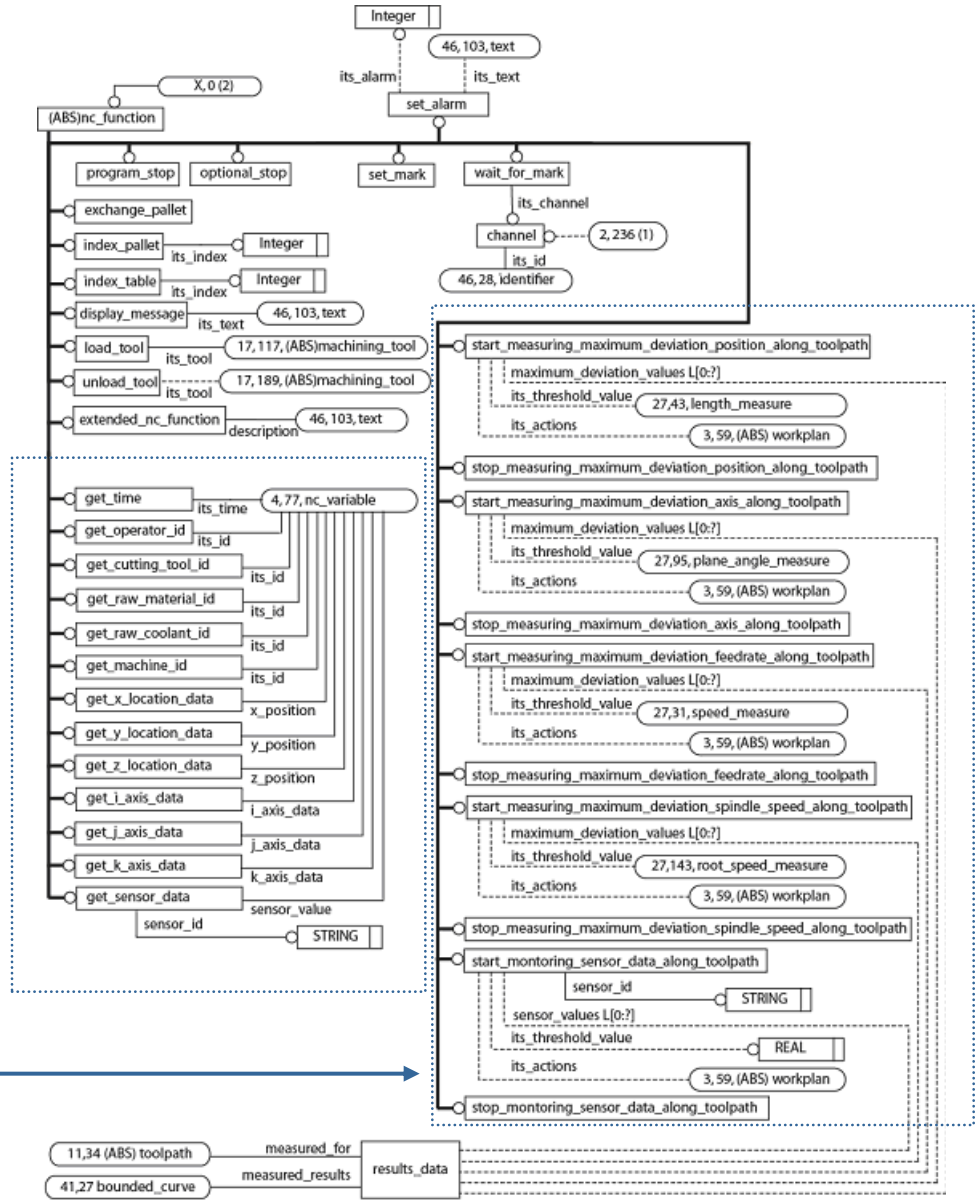
- **Program Sample with Group III Functions.**

2. Proposal: nc-functions as SC4 Dallas.

- **Complete Ap-238 nc-Functions Model.**

Group I
NC_Functions

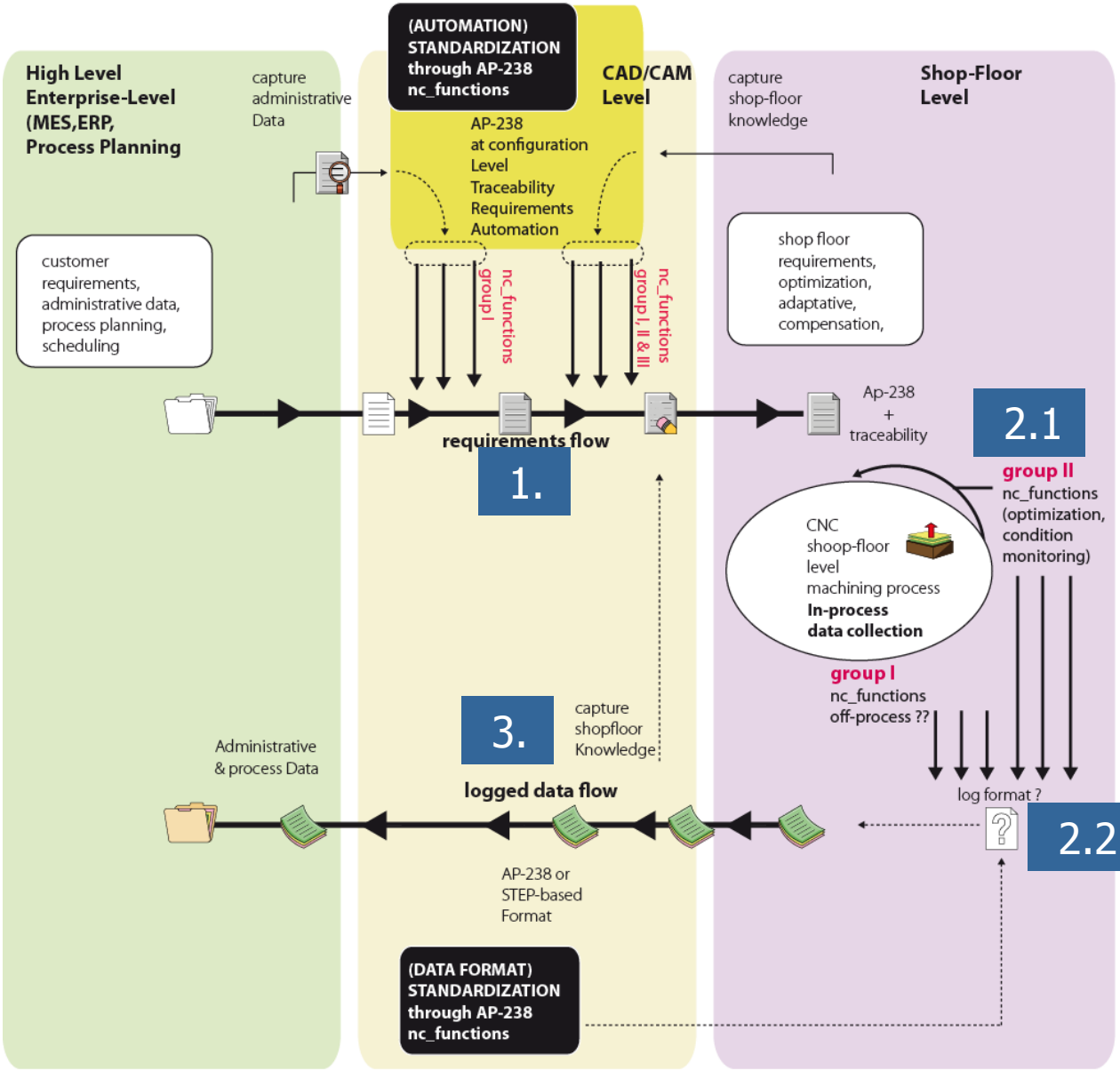
Group II & III
NC_Functions



2. Proposal: nc-functions as SC4 Dallas.

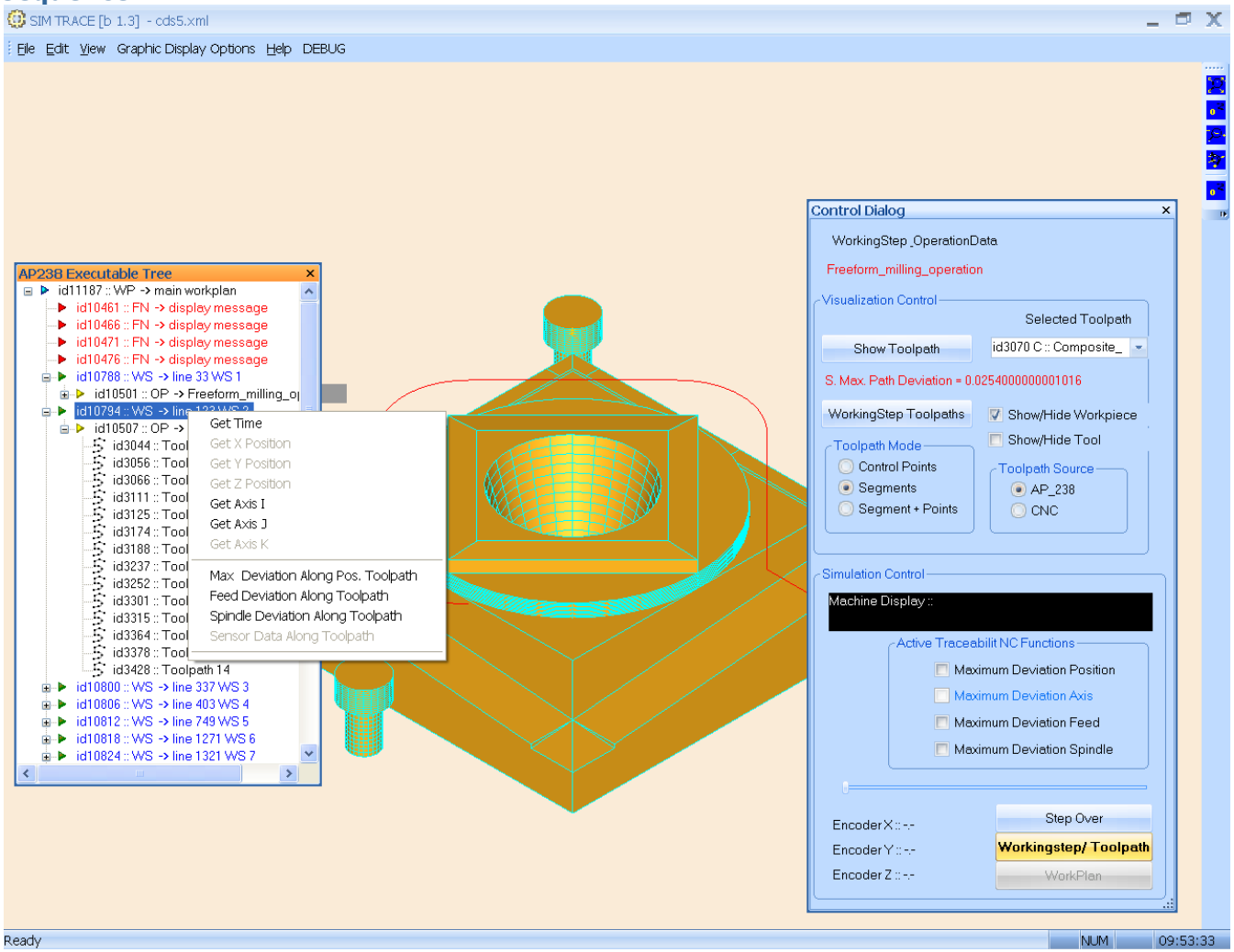
- **How nc_functions Work?**

1. **Configuration: requirements are translated into nc_functions in the AP238 executable.**
2. **nc_functions are automatically executed when they are found in the executable sequence.**
   - **2.1 Data can support run-time.**
   - **2.2 Data can be logged when machining finish**
3. **Logged data is used.**

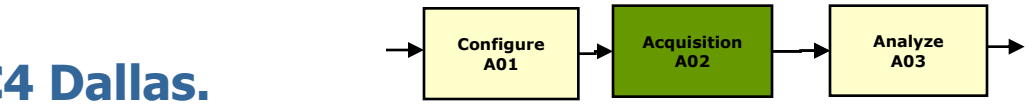


2. Proposal: nc-functions as SC4 Dallas.

- **How the Traceability nc_functions work: An example.**
  - **1. Traceability requirements are specified by inserting nc_functions in the executable sequence**



2. Proposal: nc-functions as SC4 Dallas.



- **How the Traceability nc_functions work: An example.**
- **2. Accessing the Data while machining:**
  - **2.1 With Current Technology:**
    - **nc_functions have to be translated to G&M codes. Limitations: current CNC resources (Memory, file access mechanism, etc).**

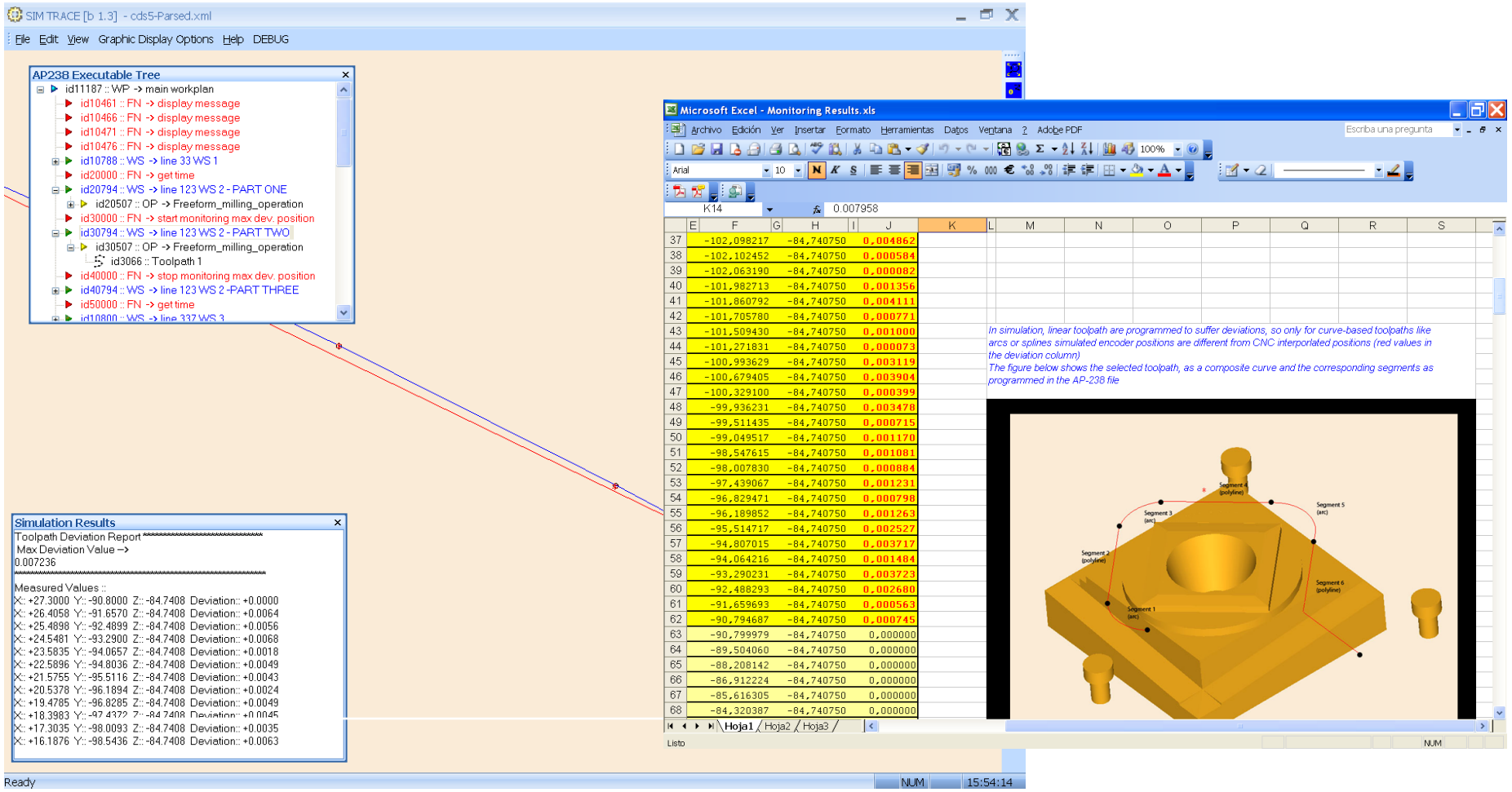
```
N100  $AC_TIMER[1] = 0 …
;RESET R[] variables
;R[1] WILL Hold the threshold value
……..
;START SINCHRONYZED ACTION threshold set for each segment
ID=1 WHEN $R[1] < $AC_TIMER[1] DO (ACTION: stop, alarm .. log data)
G1….
WRITE(“ERROR”,”LOGFILE”,”SEGMENT 1 TIME: “ << $AC_TIMER[1]);
$AC_TIMER[1]= 0 ;
G1…
WRITE(“ERROR”,”LOGFILE”,”SEGMENT 1 TIME: “ << $AC_TIMER[1]);
$AC_TIMER[1]= 0 ;
G1…
……..
CANCEL(1)
```

    - **Through the HMI interface (Accessing to the PLC internal variables with, for instance OPC communication) (Experiments at NIST)**

  - **2.2 With a AP-238 controller (TODAY, Simulation): The controller access its internal variables, computes the values, stores in memory. When mechanization ends (or when cycles ends), its writes the values to a file.**

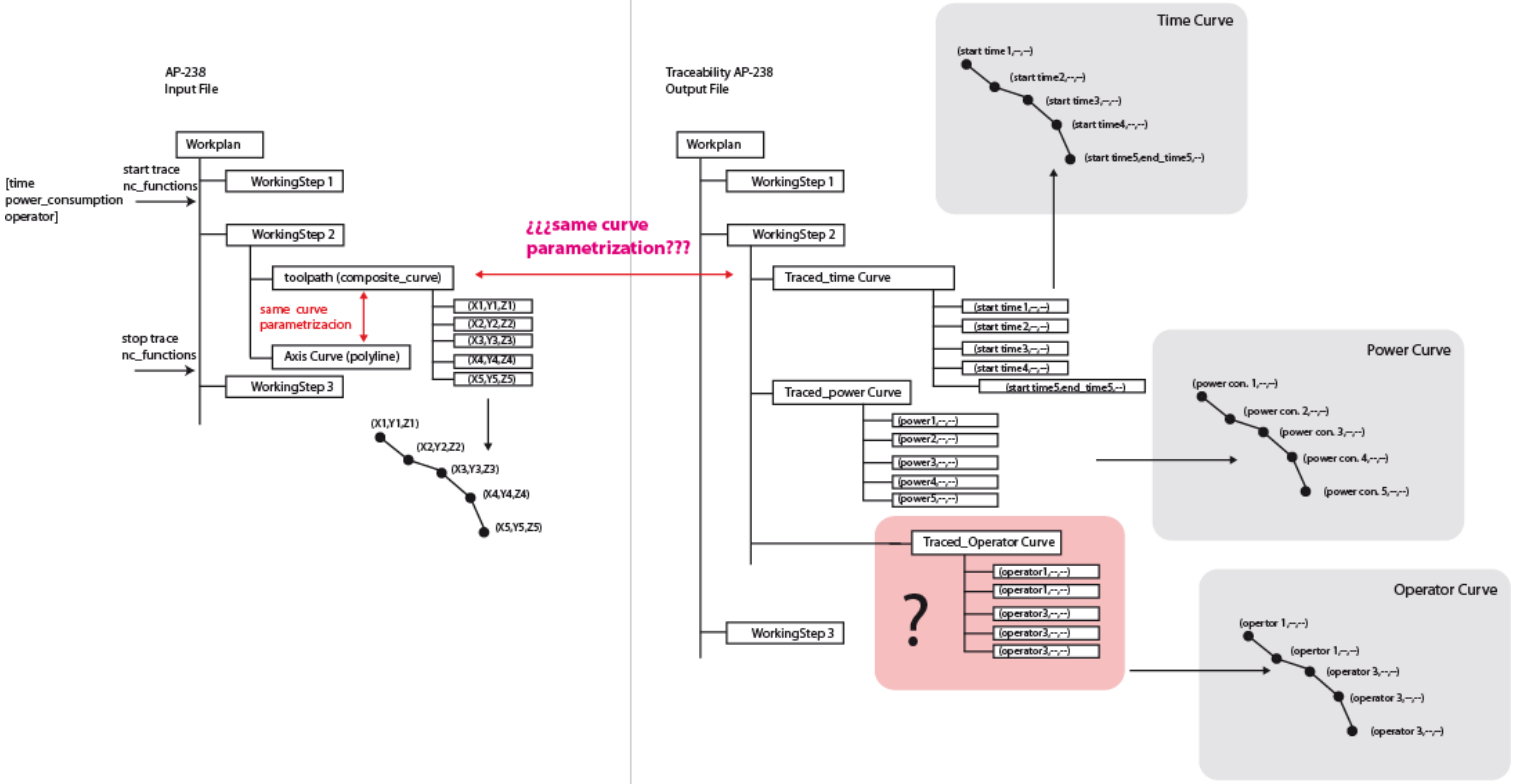
2. Proposal: nc-functions as SC4 Dallas.

- **How the Traceability nc_functions work: An example.**
- **3. Review of Logged Data.**



3. Proposal: Progress since SC4 Dallas meeting.

- **Logged Data FORMAT: a new conformance class to define the traceability data structure.**
  - **In this conformance class there will be workplans, workingsteps and tool paths. However, the toolpaths will trace the results of running the program. For example, there might be a curve describing the measured x, y z deviations, a curve describing the spindle power consumption, etc.**



3. Proposal: Progress since SC4 Dallas meeting.

- **Block I nc_functions:**
  - **Block I nf_functions more like Block II: Most Block I nc_function will become as block II to store data in the same way.**
    - **Nc_fucntion to star/stop getting execution times of toolpaths.**
    - **Nc_fucntion to star/stop getting (along toolpath): operators involved.**
    - **Nc_fucntion to star/stop getting (along toolpath): manual override intervention.**
    - **Nc_fucntion to star/stop getting (along toolpath):**
      - **Used tools Identification.**
      - **Used machines identification?.**
  - **Still, may be some Block I nc_functions returning single values. But nc_variables are too week. Need to define data types to hold the data values.**
      - **Administrative data? Machine software version? Etc…**

- **More Block II nc_functions needed for advanced services (speed control optimization, ….)**
- **An open mechanism to define new coming sensor/variables values as they will come in the future?**
  - Start_monitoring_sensor_data_along_toolpath…..IS IT OK?

4. End.

- **Conclusions.**
  - **NC-Functions seems to be a good mechanism.**
  - **To log data as standard format has to be defined a new Unit of functionality.**
  - **Implementation Issues:**
    - **Current technology is able to perform all proposed Nc-functions? some of them?**
    - **Are there enough data types? We need more?**

Thank you for your attention

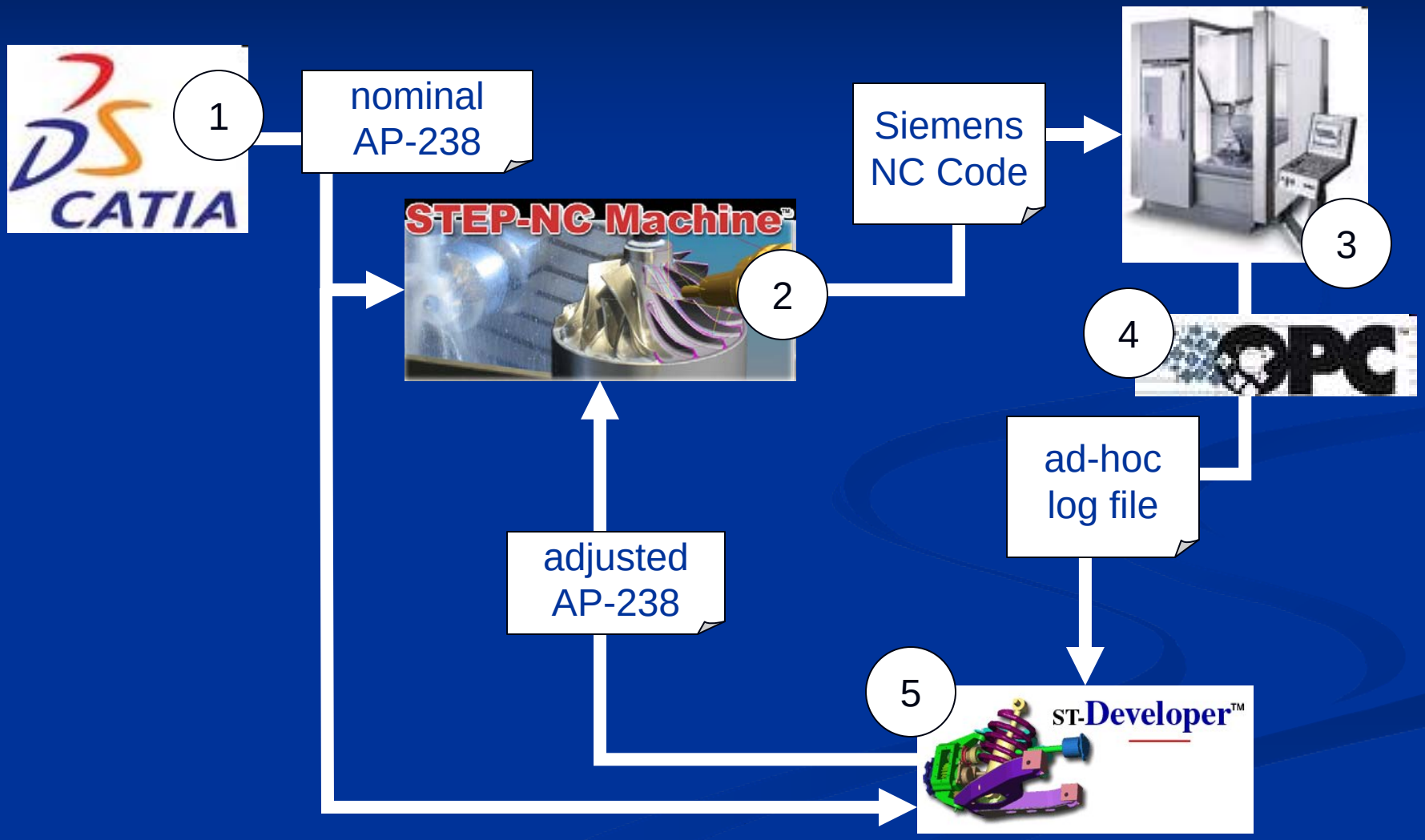
Speed and Feed Adjustment in STEP-NC

John Michaloski and Fred Proctor
NIST

Objective

- To record real-time operator adjustments to STEP-NC programmed spindle and feed rate overrides, and adjust the original STEP-NC file accordingly
- Scenarios where this might be useful:
  - manual optimization – the nominal speeds and feeds may be too conservative
  - to account for worn tools, or different tools
  - to compensate for chatter
  - to see the effect of speed and feed on surface finish

Overall Technique



Technique Details ...

1. Catia is used to generate an AP-238 process plan with nominal spindle speeds and axis feed rates
2. STEP-NC Machine is used to generate Siemens 840D NC code, with comments that indicate to which working step the following NC code lines are associated

Sample NC Code

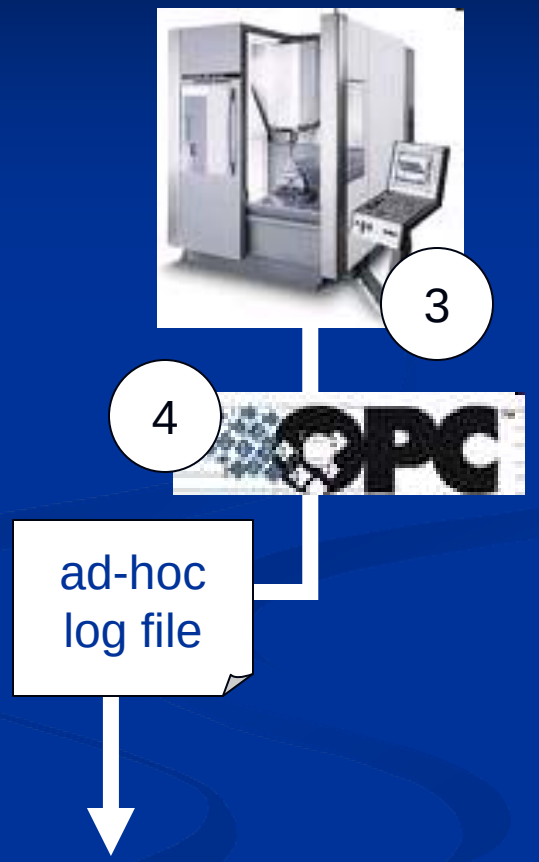
```
X5.58Y0.658Z0.875
X5.572Y0.654Z0.875
X5.562Y0.652Z0.875
G0Z2
; Workingstep: Island 3 #121939
G1X4.621Y4.635F80
Z0.9
X4.614Y4.614Z0.899
X4.646Y4.624Z0.898
X4.648Y4.625Z0.898
```

Comment text "Island 3 #121939" is the name of the AP-238 workingstep from which this NC code was generated

... Technique Details ...

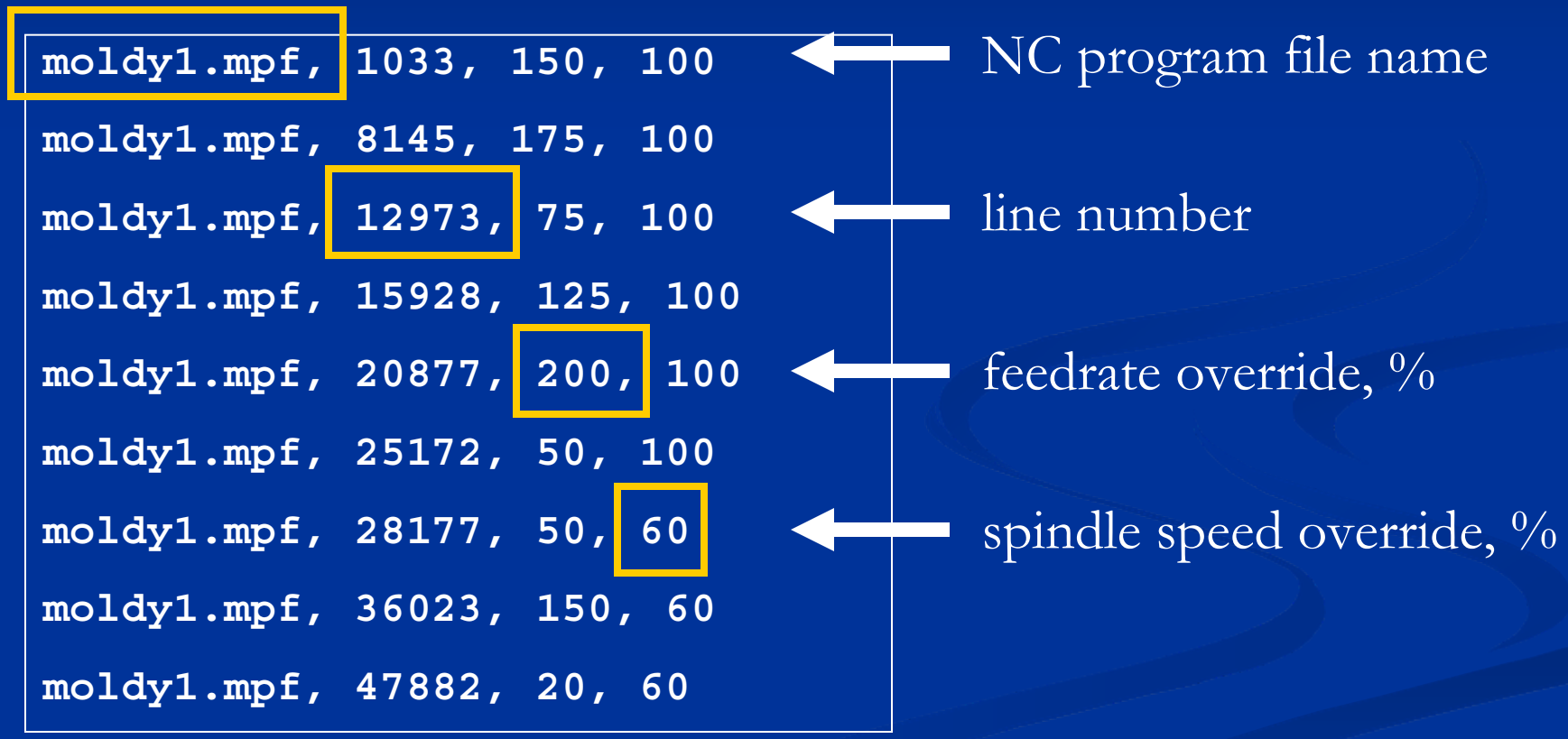
3 The NC code is run on the machine tool, and the operator adjusts speeds and feeds to improve machining conditions

4 A bespoke* OPC-based application reads out active NC code lines, speed and feed override settings and logs the data to a text file



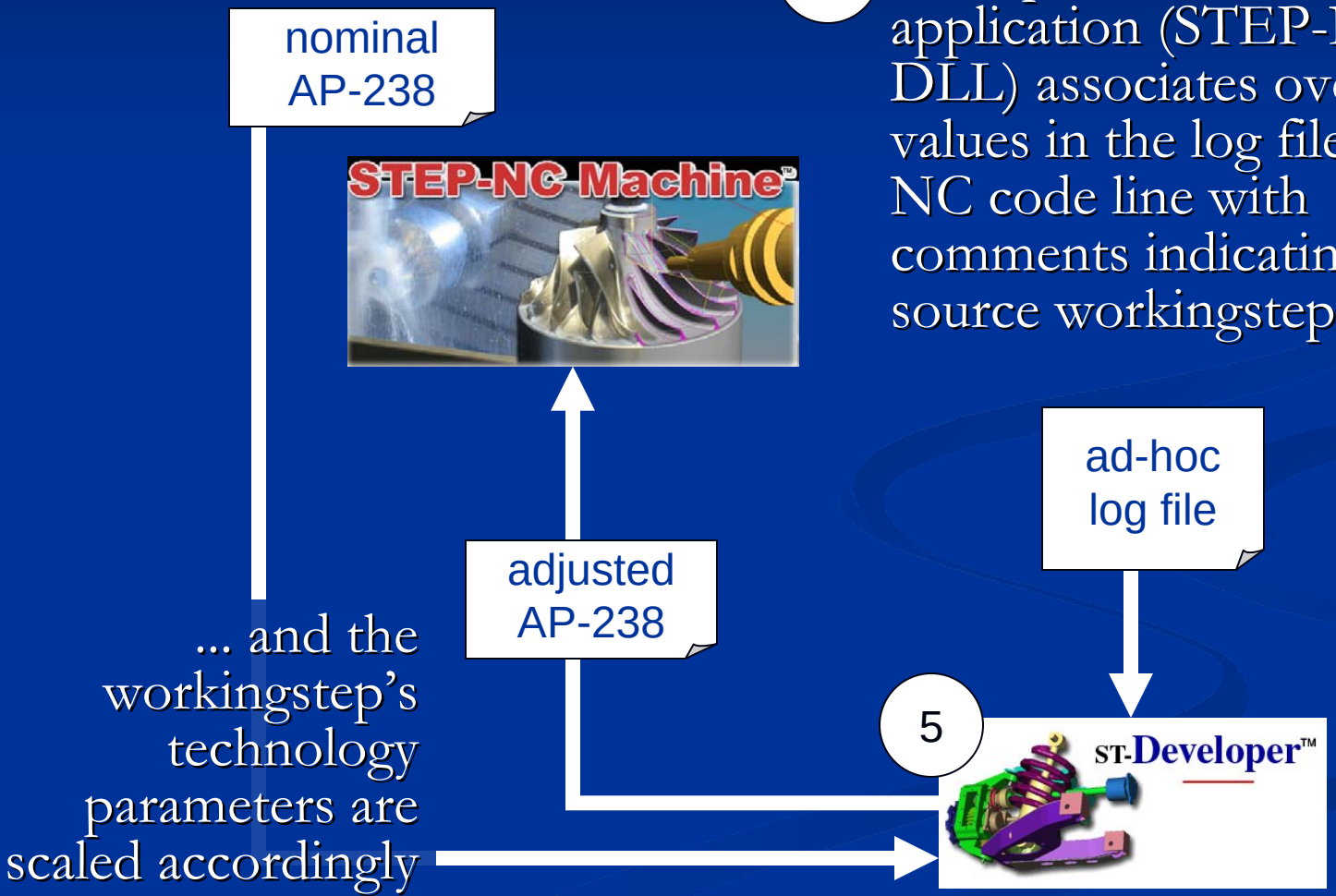
* "custom," for non-British English speakers

Sample Log File

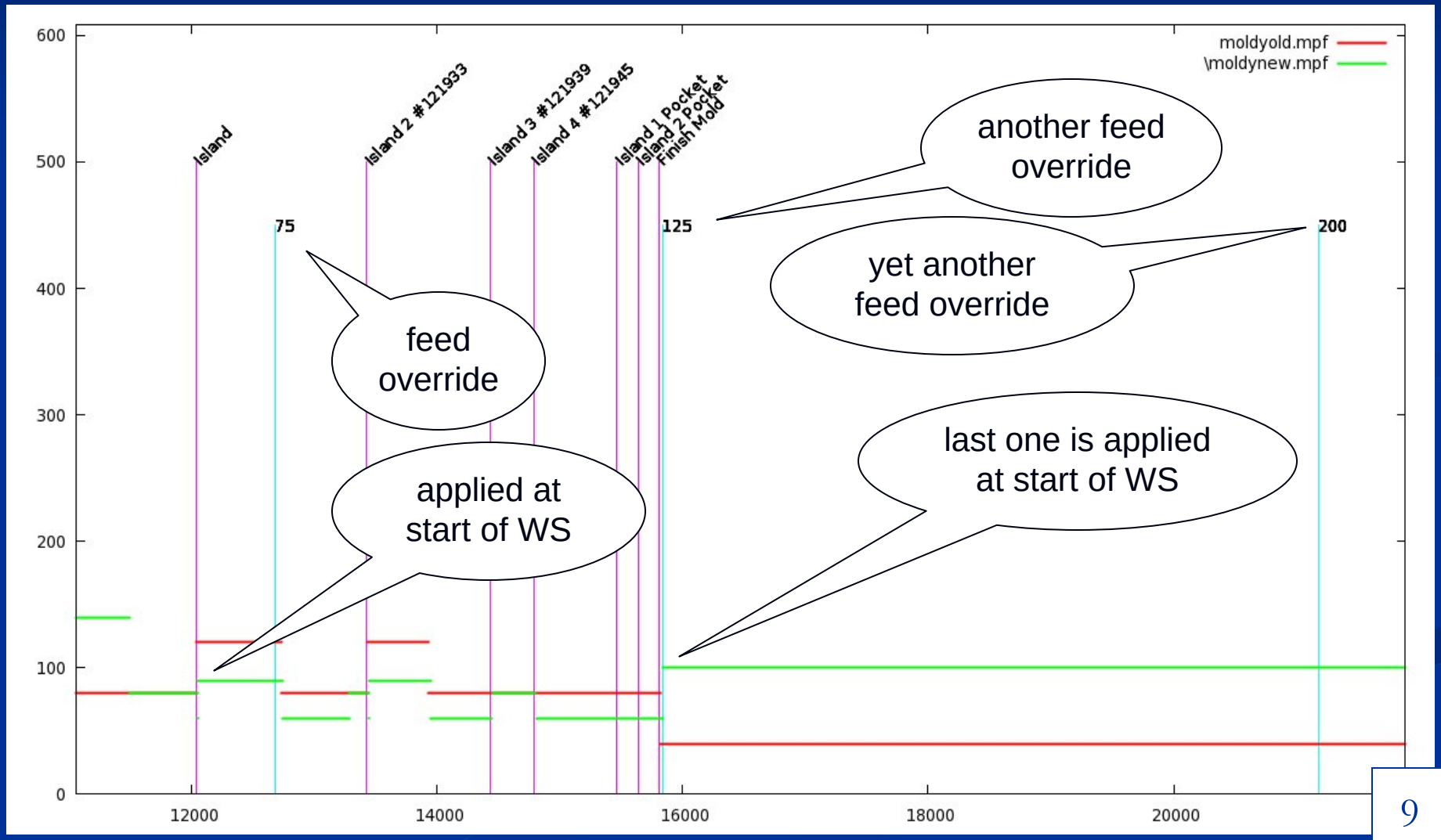


... Technique Details

5 A bespoke ST-Developer application (STEP-NC DLL) associates override values in the log file by NC code line with comments indicating the source workingstep ...



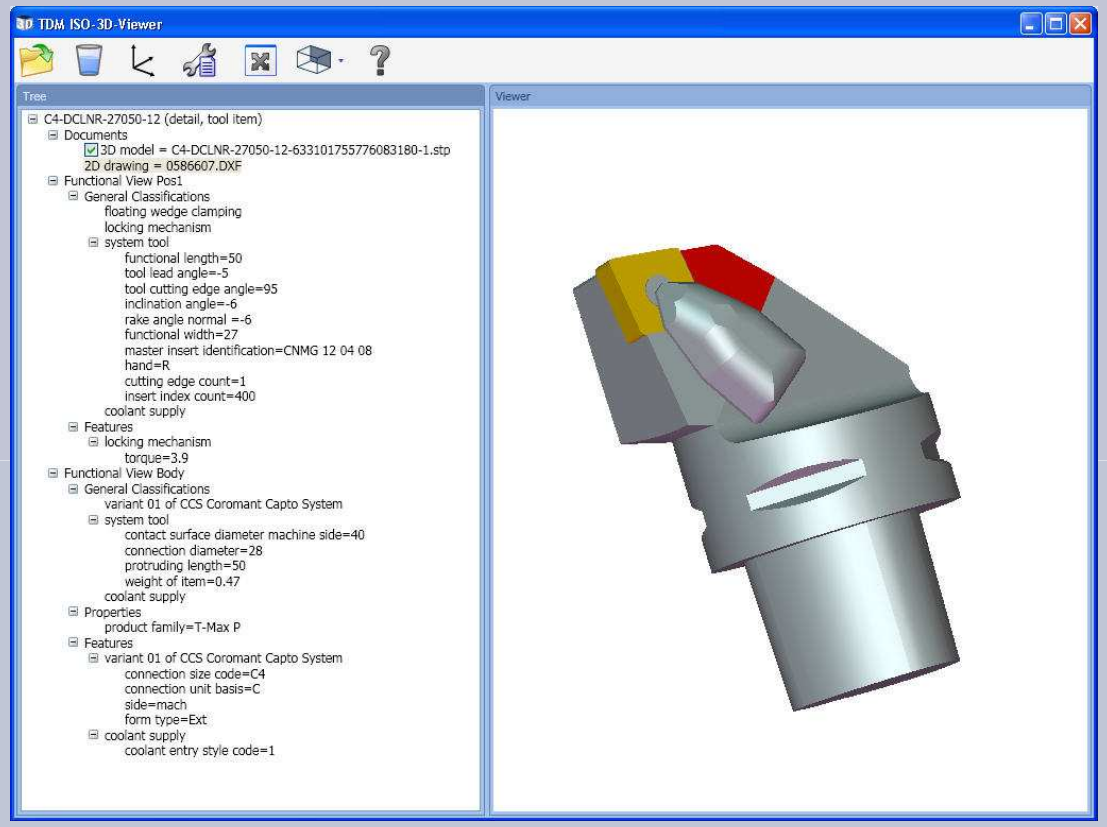
Sample Feed Results



Issues

- Fragile, comment-based association between AP-238 and NC code – better if AP-238 could be run natively on CNC, and OPC could log workingstep name directly
- Overrides may vary continually during a single workingstep – we apply last override to entire workingstep
  - could apply on a per-toolpath basis (still could vary continually during a toolpath) – better, not much work
  - could fit an override profile, and apply that – best, but more work

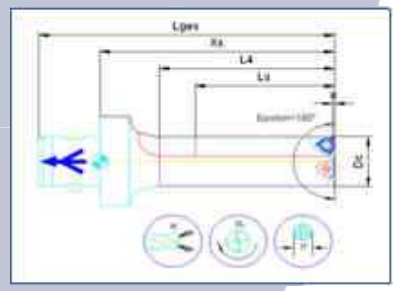
3D Viewer



T24 STEP-Manufacturing

September 24 – September 25, 2009

University of Bath, UK



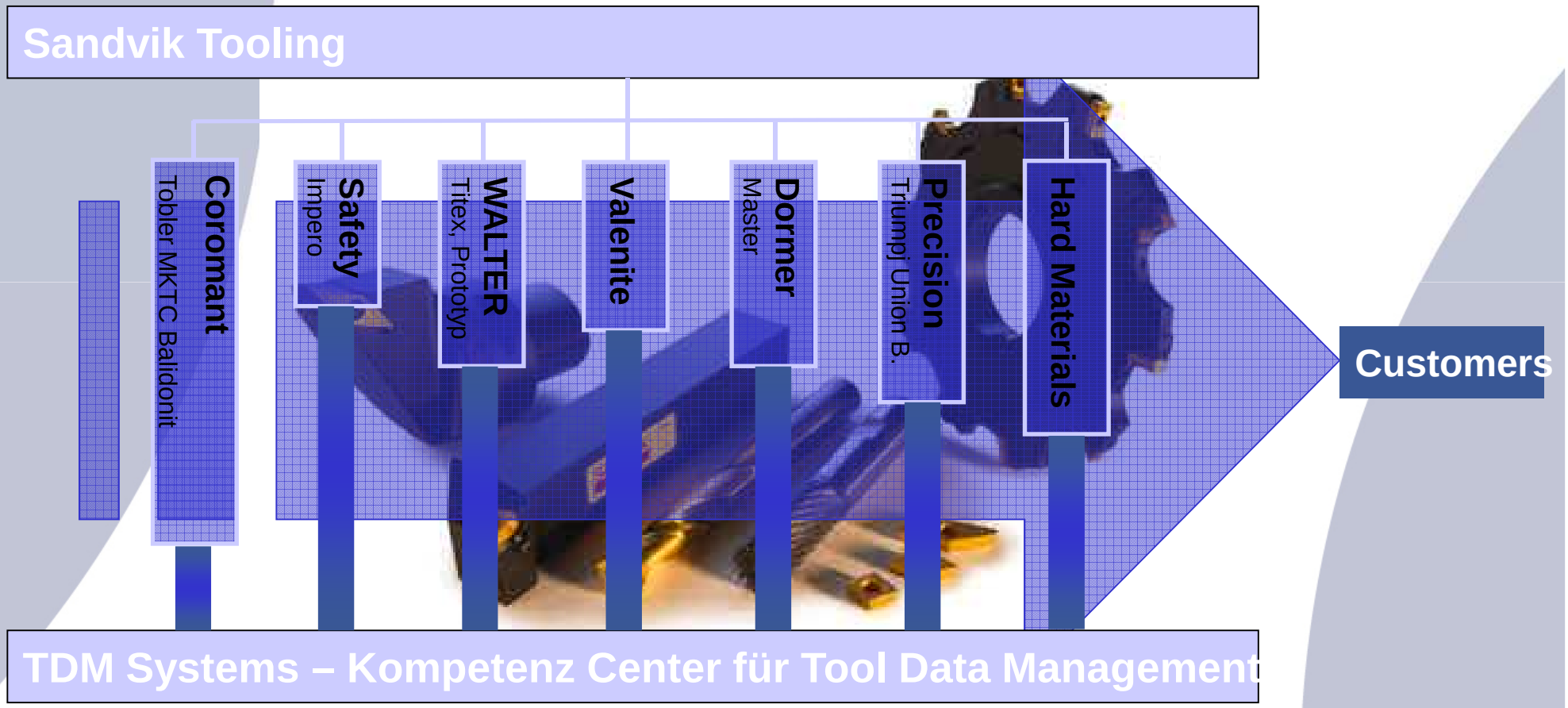
TDM Systems – your partner for Tool Data Management

- We supply software and data for organizing and managing tools, jigs and fixtures, inspection equipment, machine set-up and chucking devices as well as facilities and production equipment.
- We are the Sandvik Tooling Group's official Know-How Center for tool data management. Our unique pool of competence is reflected in our products. .

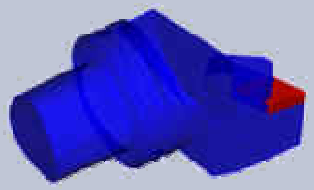
TDM Systems – specialists for increasing productivity

- Headquarter: Tübingen, Germany
- Foundation: 1993 as WALTER Informationssysteme GmbH
- Employees 2009: 52 (plus 9 apprentices)
- Products: TDM V4, myTDM.com, MPO, TDM 3D, FMM
- Customers: approx. 650 worldwide
- User: 7.500 worldwide
- Markets: Europe, North- and South America, Asia

TDM Systems within the Sandvik Tooling Group



History - Milestones in the progress of TDM



1987
- Start of development of the first TDM system

1989
- Presentation of Version TDM V1

1991
- Development of the Module for Tool Crib Management

1992
- Release of MPO: Measurement, Products Organizat.

1996
- Product launch TDMeasy

999
- Release TDM V2 with a standard link to SAP

2002
- Release myTDM.com

2003
- Product launch TDMprocess software for process planning

2004
- Release TDM V4: new software generation

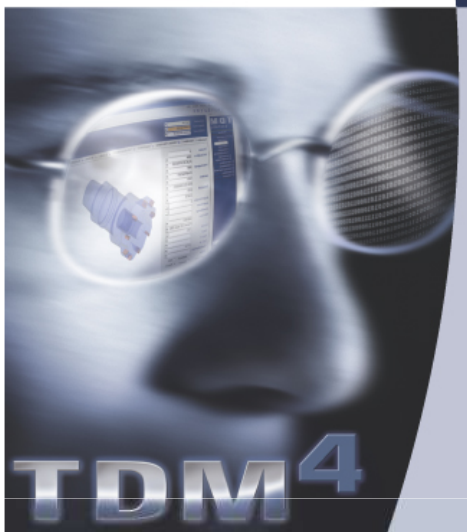
2005
- Product launch TDM Data & Graphic Generator

2006
- TDM FMM Facility & Maintenance Management

2007
- Release TDM Import-assistent

2008
- Release TDMstoreasy Controlling Software for automatic Crib Systems

TDM systems



Products & Services

TDM Products – Software Program

The software program which leads to higher transparency and increasing productivity

TDM V4
Modular system for Tool Data Management

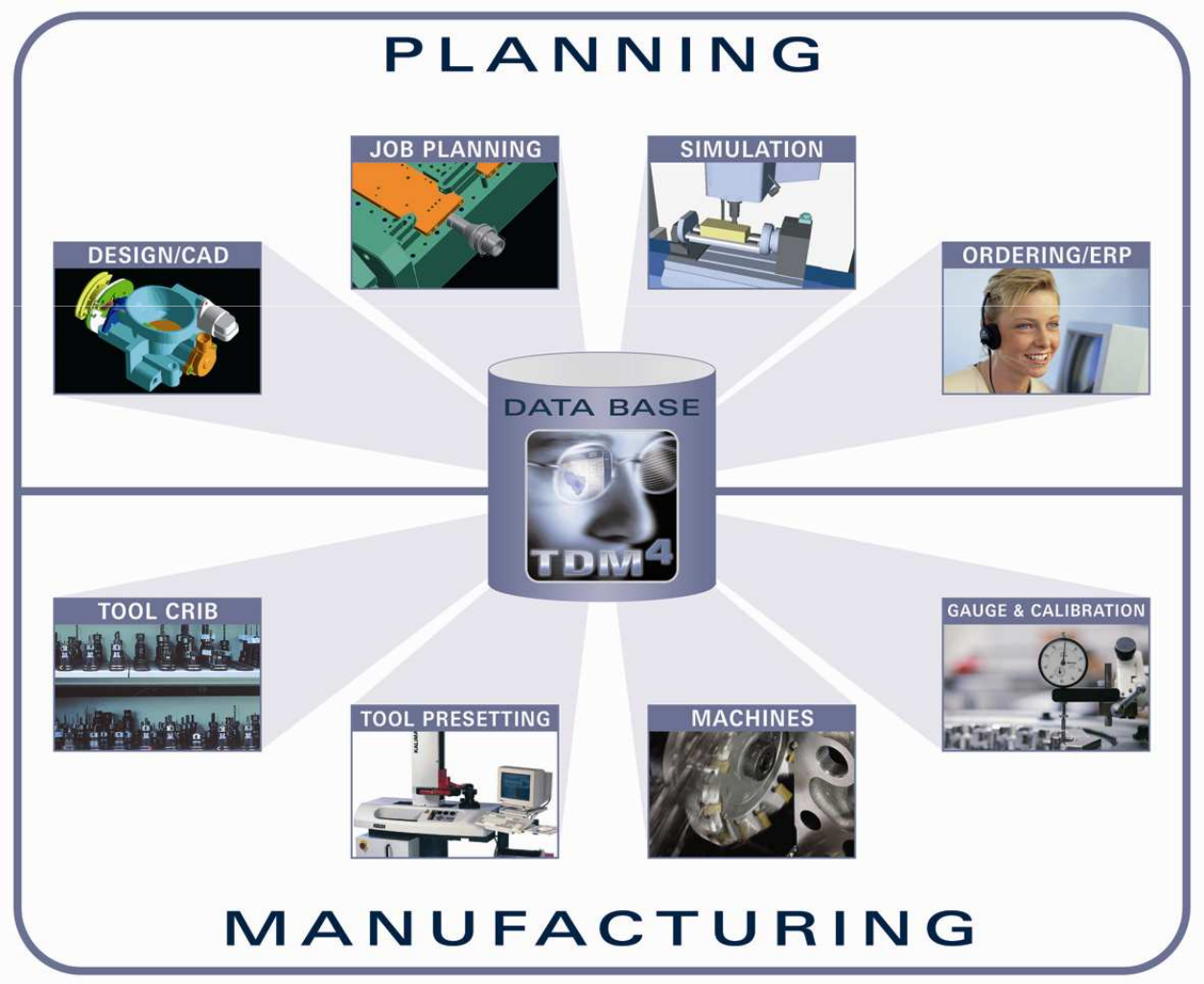
MPO
Management of Measurement Products

myTDM.com
Internet based tool management system

TDM Facility and Maintenance Management
Data Base which creates tool data,
2D and 3D graphics for over 40.000 tools

TDM Data and Graphic Generator
Data Base which creates tool data,
2D and 3D graphics for over 40.000 tools

- **Multiple possibilities for Integration**



We guide you through all project phases

- Pre Sales Services of TDM Systems
  - Consulting
  - Specifications
  - Engineering
  - Cost Benefit Analysis
  - Project Management
- After Sales Services of TDM Systems
  - Software Training
  - Online Support
  - Technical Hotline
  - System Maintenance

The TDM User Groups

Experience exchange and exclusive product information

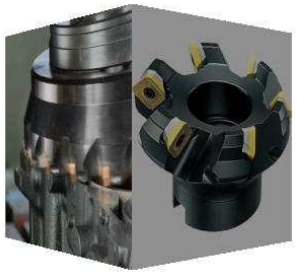
- TDM Interessenverband: User group for German speaking TDM user (Germany, Austria, Switzerland)
- TDMclub: User group for European customers
- NAUG: North American User Group
- Exclusive communication of news about the TDM software and the company
- Experience and information exchange
- Club members can influence the further development of TDM with their ideas
- Annual user group meeting

How can ISO 13399 improve the production process?

- **Exchange of tool information between different partners (tool manufacturers, machine / control suppliers, CAD-/CAM suppliers, simulation systems, end users, …) will be much easier, as it is the case now.**

- **<u>Expense:</u>**
  One common format and accepted standard will reduce the expenses for data exchange.

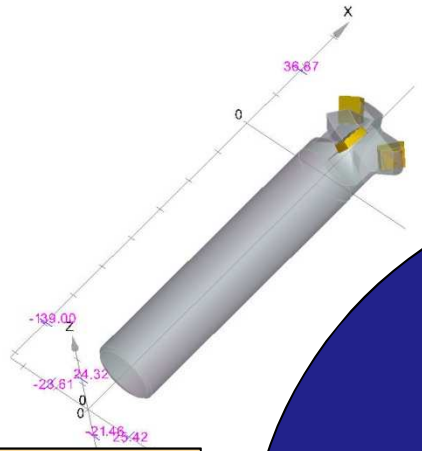
- **<u>Quality:</u>**
  One common format and accepted standard will make sure, that no information is lost, when data are exchanged between different systems.



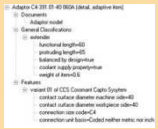
3D Viewer

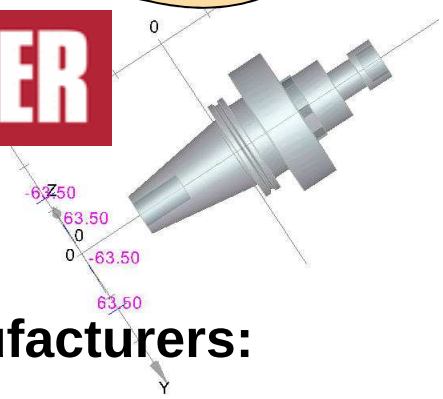
Customers and suppliers

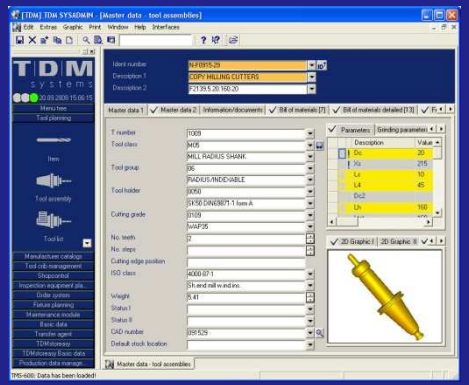
Tool manufacturers: Items



ISO 13399

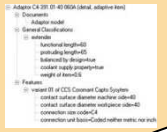






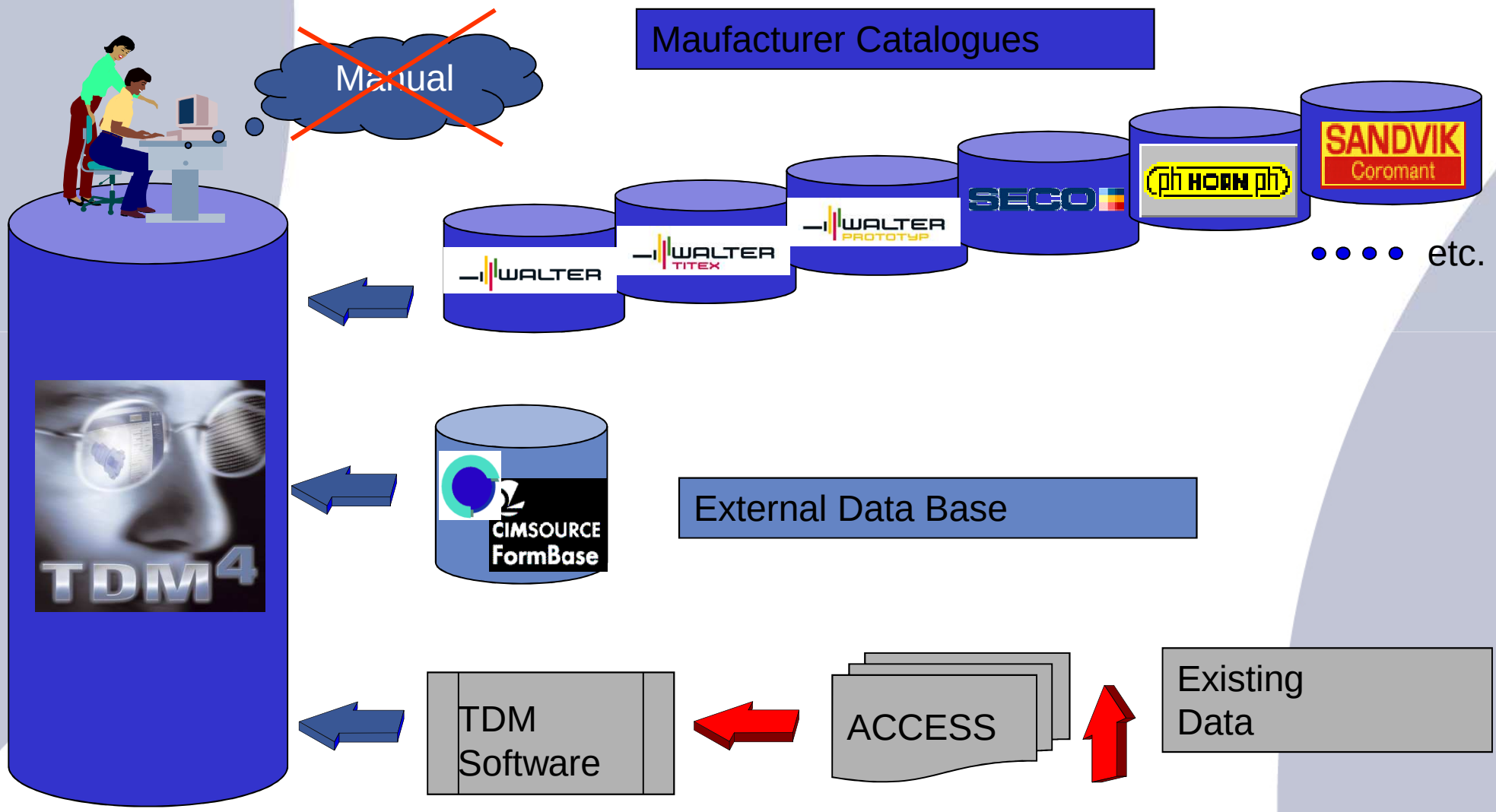
TDM Tool Data Management and related products

ISO 13399



Customer:
Assemblies, rotated

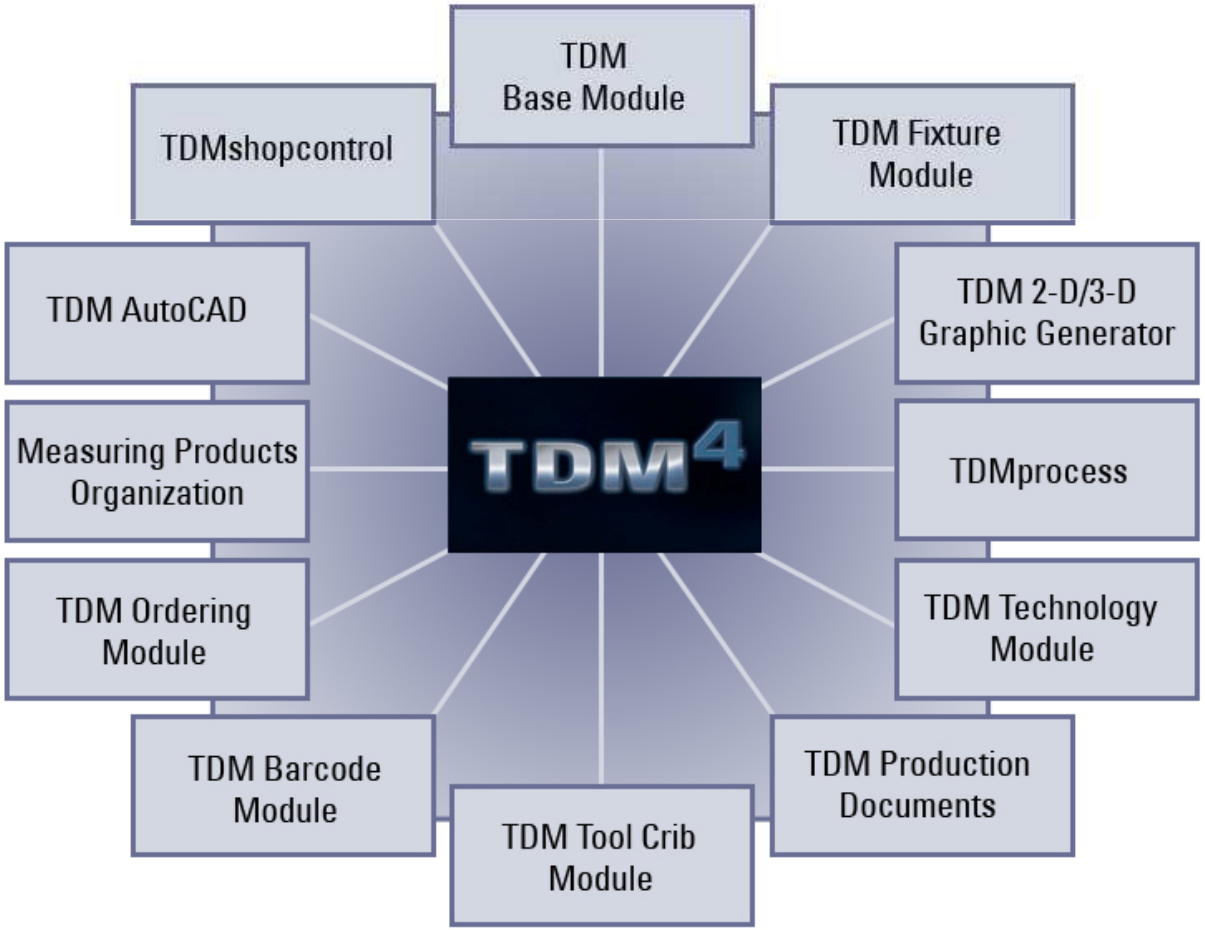
Different possibilities for Data Input



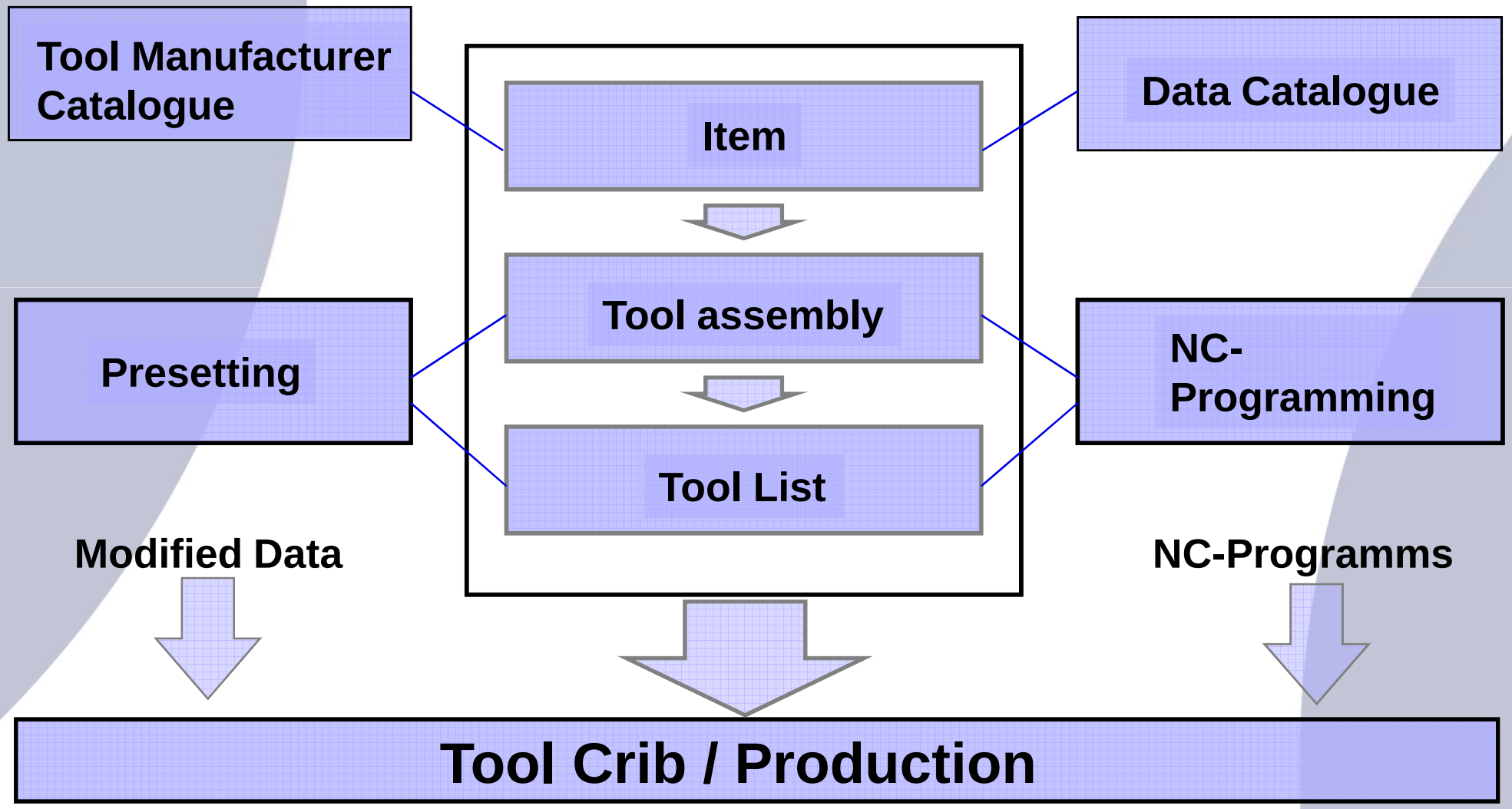
TDM – Module Concept

TDM V4

- is an innovate system for manufacturing resources
- simplifies organization
- makes operating processes more efficient as well as in a better quality

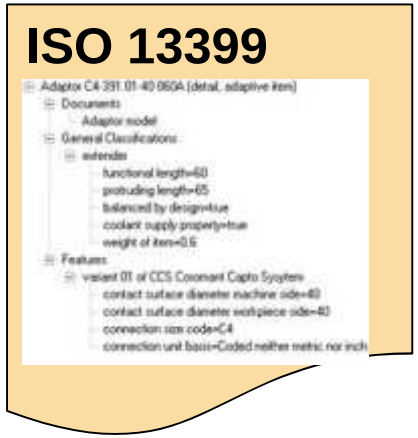


TDM – Flow of Data



Product example: TDM 3D Viewer

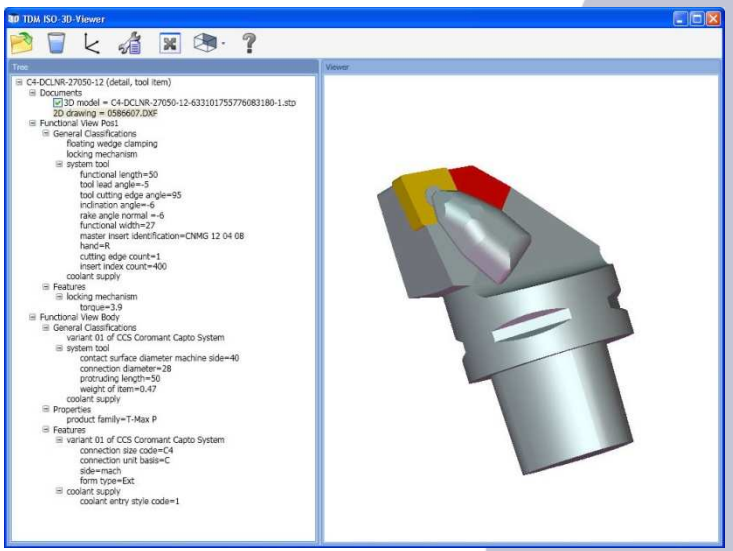
ISO 13399



One common standard!

Different systems who support it.

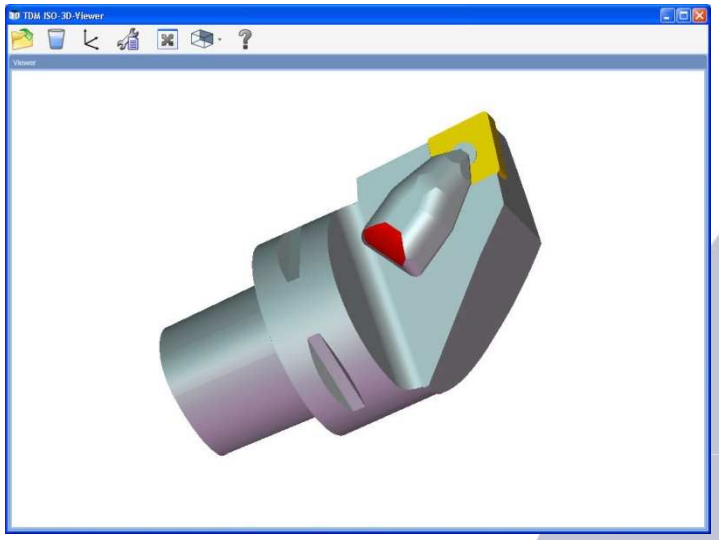
<u>Example:</u>
TDM 3D Viewer



Functionality overview

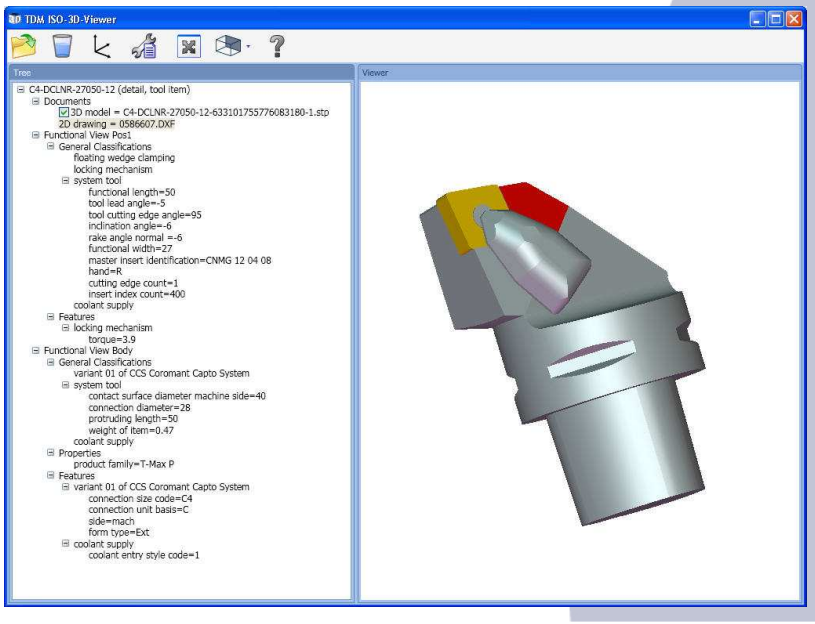
Basic solid viewer

Open and view ISO10303-203 p21 file (stationary view for tool maintenance/information purpose).



Extended solid viewer

- **Possibility to open an ISO13399 p21 files of an item and view ISO13399 to the left and 3D view of referenced ISO10303-203 p21 file to the right.**
- **Possibility to view the 3D model or the information tree only or both.**



Functionality overview

Assembly solid viewer

- **Possibility to open an ISO13399 p21 file of an assembly and view the step geometries of the items which are part of the assembly and are stored in the file. The step file contains also the position of the items and their orientation according to ISO.**
- **The possibility to fade in or out single items of the components list exists as well.**
- **The creation of the assembly can be done for example via an external software system like TDM.**

Profile solid viewer

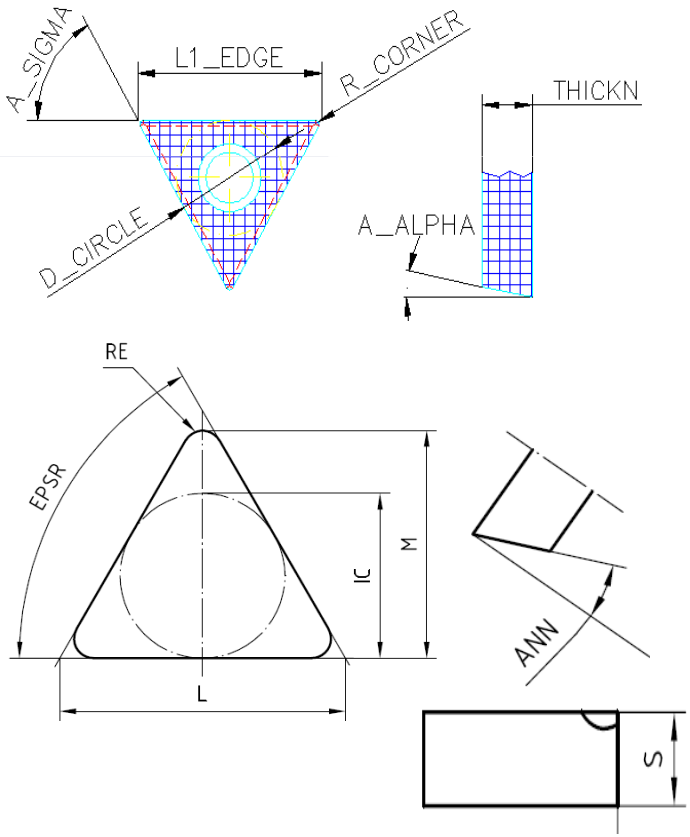
Possibility to build the rotated model of a stationary one.

Translation solid viewer

Possibility to open sat, IGES and STL based 3D components for items and assemblies and save it as an ISO 10303-203 p21 file.

Creation of a cut profile from the ISO data

Example:
Cutting area; tool with inserts

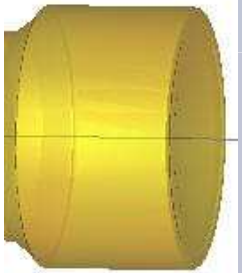


ISO-File

ISO-Parameters:

IC
L
EPSR
RE
ANN
S
SC (Insert shape code)

TDM 3D Engines



Rotated 3D model

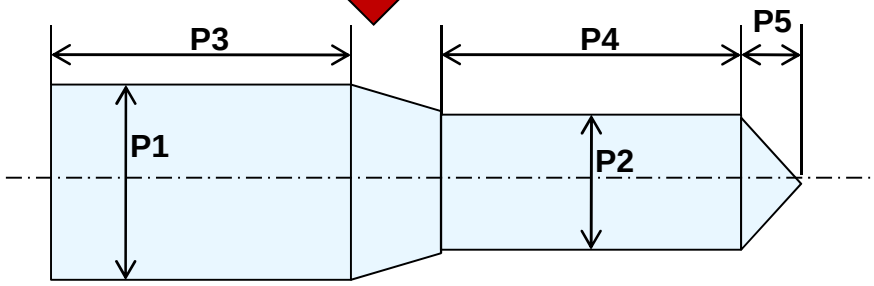
Creation of a cut profile from the ISO data

ISO-File

P1
P2
P3
P4
P5
Object type, for example step drill

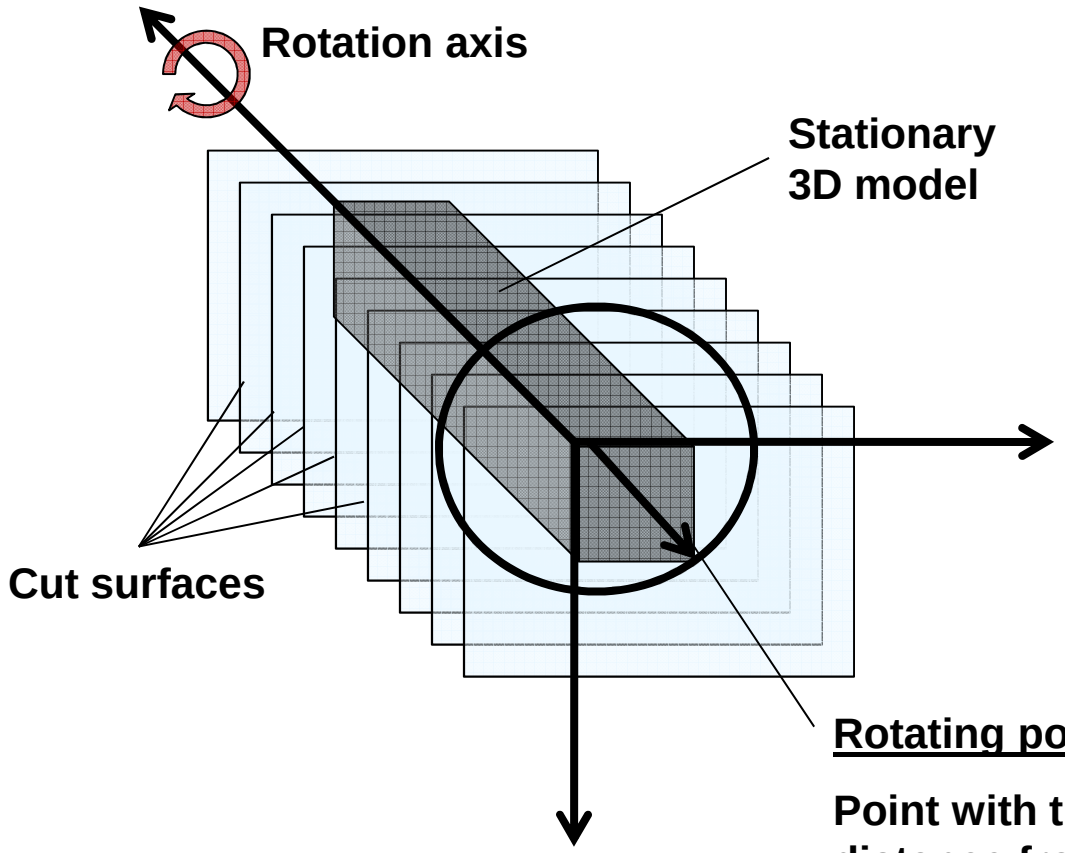
Example:
Cutting area; tool without inserts

TDM 3D Engines



Rotated 3D model

Creation of a cut profile from the ISO data



Rotating point:

Point with the biggest distance from the rotation axis in the respective cut surface.

CHAMADA PÚBLICA MCT/FINEP/CT-AERO – TECSA - 1/2010

SELEÇÃO PÚBLICA DE PROPOSTAS PARA APOIO A PROJETOS DE PESQUISA, DESENVOLVIMENTO E INOVAÇÃO NO SETOR AERONÁUTICO

1. OBJETIVO

Selecionar, para apoio financeiro, propostas de projetos de pesquisa, desenvolvimento científico, tecnológico e de inovação em áreas de interesse do setor aeronáutico visando garantir a competitividade nos mercados interno e externo, a capacitação nacional em tecnologia aeronáutica, o aumento da parceria entre Instituições de Pesquisa Científica e Tecnológica (ICT) e Empresas, o desenvolvimento de novos produtos para o setor aeronáutico, a difusão de novas tecnologias, a atualização tecnológica da indústria brasileira.

- **SEGMENTOS APOIADOS**

Serão apoiados projetos cooperativos de pesquisa, desenvolvimento e inovação entre Instituições de Pesquisa Científica e Tecnológica e Empresas do setor aeronáutico direcionados a:

- Propulsão aeronáutica e combustíveis alternativos
- Materiais compósitos
- Estruturas leves e eficientes
- Processos de manufatura avançada
- Sensoriamento para integridade de aeronaves
- Aeroacústica
- Tecnologias para minimizar riscos e impactos de acidentes
- Integração de sistemas e softwares embarcados
- Integração para tecnologias embarcadas para CNS/ATM
- Comunicação, radar e ótica.

2. ELEGIBILIDADE DAS INSTITUIÇÕES PARTICIPANTES

Instituição Proponente/Convenente: Órgão ou entidade da Administração Pública direta ou indireta de qualquer esfera de governo, ou Instituição de Pesquisa Científica e Tecnológica, pública ou privada sem fins lucrativos. A Instituição Proponente/Convenente será responsável pela execução gerencial e financeira do projeto. As instituições acima poderão ser representadas por Fundações/ Instituições de Apoio.

Instituição Executora: Universidade(s) ou Instituições de Ensino e Pesquisa, Centros ou Institutos de pesquisa científica e/ou tecnológica, públicos ou privados sem fins lucrativos, atuando individualmente ou em grupo.

Instituição Interveniente Cofinanciadora: Empresa brasileira de qualquer porte, grupos de empresas brasileiras ou consórcio de empresas brasileiras formalmente constituído,

interessadas nos resultados do projeto, que dele participem com aporte de recursos financeiros e que apresentem experiência no setor aeronáutico ou que, comprovadamente, sejam fornecedoras deste setor .

As instituições privadas sem fins lucrativos somente poderão participar da presente Chamada Pública se tiverem no mínimo 03 (três) anos completos de existência, em observância ao disposto no art. 36, inciso VII, alínea b, da Lei 12.017/09 - LDO 2010.

3. CARACTERÍSTICAS DA PROPOSTA

Todas as propostas deverão:

- Identificar, **no objetivo geral**, o produto, processo ou serviço que se pretende desenvolver ou aprimorar e o enquadramento do projeto nos segmentos/sistemas abrangidos por esta Chamada Pública, conforme item 1.1;
- explicitar, na **justificativa do projeto**, a relevância da proposta e seu enquadramento nas prioridades estabelecidas no item 1.1 indicando seu caráter incremental sob o ponto de vista de inovação tecnológica no mercado em que se insere;
- caracterizar a efetividade da cooperação entre as empresas demandantes de inovação, e os grupos de pesquisas envolvidos;
- detalhar, se houver, ações de cooperação técnica das Instituições Intervenientes Cofinanciadoras direcionadas ao projeto, citando as instituições envolvidas, o nível de cooperação e o campo de atuação;
- descrever e qualificar a equipe de P,D&I existente nas Instituições Intervenientes Executoras e nas Instituições Intervenientes Cofinanciadoras envolvidas e as suas experiências/capacitações relacionadas ao objetivo do projeto;
- ter os currículos do coordenador do projeto e dos pesquisadores que compõem a equipe executora atualizados na Plataforma LATTES (www.lattes.cnpq.br);
- ter cadastradas as Instituições Intervenientes Executoras e as Instituições Intervenientes Cofinanciadoras no sítio www.portalinovação.mct.gov.br.
- apresentar valor total solicitado ao FNDCT de no mínimo R$ 1.000.000,00 (um milhão de reais);
- solicitar ao FNDCT no máximo R$ 4.000.000,00 (quatro milhões de reais), incluindo o valor das bolsas.
- apresentar, com relação ao orçamento proposto, especificação de equipamentos, serviços e consultoria, incluindo as qualificações necessárias e apresentando cotação de referência para os equipamentos cujo valor unitário seja superior a R$ 20.000,00; relacionar cada item com as metas físicas e a metodologia do projeto.
- explicitar os mecanismos gerenciais das empresas cofinanciadoras , detalhando os instrumentos de monitoramento e análise das execuções física e financeira do projeto.

- o aporte de recursos financeiros da(s) empresa(s) interveniente(s) cofinanciadora(s) é obrigatório, nos percentuais estabelecidos na tabela constante do item 5. O aporte de recursos financeiros acima do mínimo exigido será considerado nos critérios de avaliação das propostas.
- apresentar, em documento anexo à proposta, os seguintes históricos (considerando-se os últimos 3 (três) anos):

Para as Instituições Executoras:

- projetos de pesquisa, desenvolvimento e inovação direcionados ao setor de equipamentos e materiais aeronáuticos, sobretudo de caráter cooperativo com empresas;
- patentes depositadas e concedidas para tecnologias, materiais e equipamentos aeronáuticos;

Para as Instituições Intervenientes Cofinanciadoras:

- atuação no mercado de equipamentos e materiais de uso aeronáutico;
- projetos de Pesquisa, Desenvolvimento e Inovação (P,D&I) na empresa
- montante de investimentos em P,D&I na empresa;
- relação de patentes depositadas e concedidas para tecnologias, materiais e equipamentos de uso aeronáutico;

4. RECURSOS FINANCEIROS A SEREM CONCEDIDOS

No âmbito desta Chamada Pública, serão comprometidos recursos não-reembolsáveis no valor de R$ 23.000.000,00 (vinte e três milhões de reais) originários do FNDCT/CT – AERO.

Dos recursos financeiros a serem concedidos ao proponente, 30% deverão ser aplicados nas regiões Norte (N), Nordeste (NE) e Centro-Oeste (CO). Caso o valor total das propostas selecionadas, oriundas dessas regiões, seja inferior a este percentual, os recursos não aplicados serão automaticamente transferidos às propostas com melhor classificação de outras regiões.

A liberação dos recursos somente ocorrerá em conformidade com a disponibilidade orçamentária e financeira do FNDCT/ CT – AERO.

5. APORTES DE RECURSOS DAS INSTITUIÇÕES INTERVENIENTES

No âmbito desta Chamada Pública, o aporte de recursos financeiros por parte das Instituições Intervenientes Cofinanciadoras **é obrigatório** e deve obedecer aos percentuais abaixo definidos, de acordo com o porte da empresa, que deverá ser comprovado através dos documentos exigidos no item 3. Os percentuais incidem sobre os valores solicitados ao FNDCT (incluindo aqueles voltados ao custeio de bolsas do CNPq).

PORTE EMPRESA	FATURAMENTO ANUAL	APORTE MÍNIMO
Micro e pequeno porte	Até R$ 2.400.000,00	5%
Pequena	De R$ 2.400.000,01 a R$ 16.000.000,00	10%
Média	De R$16.000.000,01 a R$ 90.000.000,00	50%
Média-grande e Grande	Maior de R$ 90.000.000,00	100%

No caso de grupo ou consórcio de empresas será considerado o faturamento da empresa de maior porte.

Para definição do porte econômico da empresa, deve ser considerado o faturamento global do grupo econômico ao qual pertence.

A FINEP poderá financiar o aporte de recursos da empresa, desde que os recursos solicitados sejam destinados exclusivamente ao projeto, e que o valor não seja inferior a R$ 1.000.000,00 (um milhão de reais). Para esse fim poderão ser utilizados os mecanismos de financiamento reembolsável da FINEP, previstos no âmbito do Programa Inova Brasil.

6. CONTRAPARTIDA

De acordo com o disposto no artigo 39, §1º da Lei 12.017, de 12 de agosto de 2009 - Lei de Diretrizes Orçamentárias - LDO, será exigida a apresentação de contrapartida, nos convênios que vierem a ser firmados com Instituições Estaduais, Municipais e do Distrito Federal, nos percentuais mínimos e máximos sobre o valor total concedido, indicados no item 6.1, abaixo.

Entende-se por contrapartida não-financeira recursos humanos (horas de trabalho), insumos necessários ao desenvolvimento de protótipos, horas de máquinas, material de consumo, hospedagem e transporte dos envolvidos no projeto. A proposta deverá detalhar as bases de mensuração desta contrapartida.

6.1. INSTITUIÇÕES ESTADUAIS, MUNICIPAIS E DISTRITO FEDERAL.

Municípios:

- Municípios com até 50.000 habitantes .....2 - 4%
- Municípios acima de 50.000 habitantes localizados nas áreas prioritárias definidas no âmbito da Política Nacional de Desenvolvimento Regional - PNDR, nas áreas da Superintendência do Desenvolvimento do Nordeste - SUDENE e da Superintendência do Desenvolvimento da Amazônia - SUDAM e na Região Centro Oeste - SUDECO..... 4 - 8%
- Demais Municípios .....8 - 40%

Estados e Distrito Federal:

- Estados e Distrito Federal, localizados nas áreas prioritárias definidas no âmbito da Política Nacional de Desenvolvimento Regional - PNDR, nas áreas da SUDENE e da SUDAM e na Região Centro-Oeste - SUDECO.....10 -20%

- Demais Estados .....20 - 40%
- No caso de consórcios públicos constituídos por Estados, Distrito Federal e Municípios .....2 - 4%

6.2. INSTITUIÇÕES ISENTAS DE CONTRAPARTIDA

Não é exigida contrapartida de órgão ou entidade da Administração Pública Federal, direta ou indireta e das Instituições privadas sem fins lucrativos.

7. PRAZOS

Lançamento da Chamada pública	09/07/2010
Disponibilização do Formulário - FAP	23/07/2010
Data final para envio eletrônico da proposta	08/09/2010
Data final para o envio das cópias impressas	09/09/2010
Divulgação Resultados	A partir de 5/11/2010

7.1. PRAZO DE VALIDADE DA CHAMADA PÚBLICA

Essa Chamada Pública tem validade de 12 (doze) meses.

7.2. PRAZO DE EXECUÇÃO DO PROJETO

O prazo de execução do projeto deverá ser de até 24 (vinte e quatro) meses.

8. DESPESAS APOIÁVEIS

Em observância à legislação em vigor à época da aprovação do projeto, poderão ser apoiadas as seguintes despesas:

a) **Despesas Correntes**: Passagens, diárias, material de consumo, *softwares*, serviços de instalação, recuperação e manutenção de equipamentos, despesas acessórias com importação, serviços de terceiros (pessoa física ou jurídica), e despesas referentes à proteção da propriedade intelectual.

b) **Despesas de Capital**: Equipamento, material permanente e material bibliográfico, obras, instalações civis e reformas em geral, necessárias ao desenvolvimento do projeto.

c) **Despesas Operacionais e Administrativas:** Poderá ser solicitada a cobertura de despesas operacionais e administrativas, de caráter indivisível, respaldadas na Lei nº 10.973/04, denominada “Lei da Inovação”, até o limite de 5% do valor dos recursos federais solicitados, excluindo o valor de bolsas.

d) **Bolsas:** O projeto poderá prever, em até 20% do valor total solicitado ao FNDCT/Fundos Setoriais, as seguintes bolsas do CNPq:

- Desenvolvimento Tecnológico e Industrial (DTI)
- Iniciação Tecnológica e Industrial (ITI)

- Especialista Visitante (EV)

As bolsas serão implementadas pelo CNPq de acordo com as características de cada uma e segundo as normas e procedimentos daquela agência, que podem ser consultadas no endereço http://www.cnpq.br/normas/rn_06_019.htm.

9. PROCEDIMENTOS

9.1. APRESENTAÇÃO DAS PROPOSTAS

A proposta deverá ser enviada à FINEP através da Internet, até a data limite estabelecida no item 7, por meio do Formulário de Apresentação de Propostas – FAP-específico para essa Chamada Pública, disponível no sítio da FINEP (www.finep.gov.br). O preenchimento deverá ser realizado de acordo com as instruções contidas no Manual que acompanha o Formulário.

O horário para envio da versão eletrônica na data limite para apresentação das propostas é até às 18h (horário de Brasília).

Adicionalmente é **obrigatório** o envio à FINEP de 2 (duas) cópias impressas da proposta, devidamente assinadas pelos dirigentes máximos das instituições e empresas envolvidas ou seus representantes legais (com delegação formal anexada) e pelo coordenador do projeto, para comprovação dos compromissos estabelecidos.

As propostas deverão ser impressas em papel A4, e apresentadas sem nenhum tipo de encadernação ou grampeamento. Exige-se que a proposta seja impressa **após** o envio eletrônico, juntamente com a capa. É vedada qualquer alteração na proposta, posterior ao envio eletrônico dos dados.

Às cópias impressas poderão ser anexados outros documentos e informações consideradas relevantes para análise do projeto, até um limite total de 50 (cinqüenta) folhas. Documentos solicitados nessa Chamada não serão contabilizados nesse limite.

A documentação poderá ser entregue diretamente ao Departamento de Apoio Logístico aos Programas Integradores (DALP), na FINEP/RJ, no endereço abaixo indicado, ou remetida pelo correio, mediante registro postal ou equivalente, com comprovante da postagem até a data limite para envio da cópia impressa estabelecida no item 7 desta Chamada Pública, devendo constar no envelope a seguinte identificação:

CHAMADA PÚBLICA/ MCT/FINEP/CT-AERO - 1/2010

(sigla convenente)/(sigla executor)/ (sigla projeto)
FINEP – Financiadora de Estudos e Projetos
Praia do Flamengo, 200, 9 º andar - DALP
22.210-030 – Rio de Janeiro – RJ

Após o prazo limite para apresentação das propostas, nenhuma outra será recebida, assim como não serão aceitos adendos ou esclarecimentos que não forem explícita e formalmente solicitados pela FINEP.

9.2. PROCESSO DE SELEÇÃO

9.2.1. Avaliação de Mérito

Os projetos que atenderem às exigências formais da presente Chamada Pública serão submetidos a um Comitê de Avaliação que analisará o mérito das propostas de acordo com os critérios abaixo.

CRITÉRIOS	Δ NOTAS	PESO
Aderência da proposta aos objetivos, adequação da metodologia e sua compatibilidade com o cronograma físico.	1 - 5	3
Qualificação técnica da equipe executora da ICT e sua adequação às necessidades da proposta.	1 - 5	4
Capacitação técnica da equipe da Instituição Interveniente Cofinanciadora.	1 - 5	4
Adequação do orçamento e cronograma de desembolso aos objetivos da proposta.	1 - 5	3
Aporte de recursos financeiros da Instituição Interveniente Cofinanciadora, em relação aos recursos globais do projeto.	1 - 5	5
Adequação da infraestrutura das instituições executora e cofinanciadoras para o desenvolvimento do projeto.	1 - 5	5
Incorporação dos resultados esperados do projeto proposto para os setores produtivos considerando o impacto do produto ou sistema no mercado e sua importância estratégica para a sociedade.	1 - 5	5

Serão recomendadas as propostas que obtiverem média ponderada igual ou superior a 3,0 (três).

As propostas recomendadas no mérito serão ordenadas de forma decrescente até o limite dos recursos disponíveis e, a seguir, submetidas a uma análise técnico-jurídica.

9.2.2. Análise Técnico-jurídica

As propostas classificadas na forma do item 9.2.1 serão submetidas a uma análise quanto a aspectos técnicos, tais como a adequação do cronograma físico (metas, atividades, indicadores de progresso, prazos), orçamento e cronograma.

Durante a análise técnica do projeto, poderá ser comunicada ao convenente qualquer irregularidade ou imprecisão no Plano de Trabalho, que deverá ser sanada

no prazo de 15 (quinze) dias corridos, sob pena de desistência no prosseguimento do processo.

No tocante à análise jurídica serão verificadas a elegibilidade das instituições partícipes, a documentação necessária à contratação e a adequação à legislação vigente.

Caso algum dos aspectos analisados nessa etapa não atenda às disposições da Chamada ou à legislação vigente, a proposta será eliminada.

Durante a análise jurídica, caso necessário, serão solicitados documentos institucionais, que poderão ser fornecidos através de inserção no Arquivo de Documentos Institucionais – ADI, constante no sítio da FINEP: http://www.finep.gov.br/formularios_manuais/adi.asp .

9.3. DELIBERAÇÃO

As propostas recomendadas na forma do item 9.2.2 serão submetidas à apreciação da Diretoria Executiva da FINEP para decisão final.

Caso haja uma maior disponibilidade de recursos orçamentários e financeiros do Governo Federal, outras propostas aprovadas no mérito poderão ser contempladas.

9.4. CONTRATAÇÃO

As condições para a contratação de cada projeto serão definidas na Decisão da Diretoria Executiva da FINEP.

A minuta de convênio assinada pelos representantes legais das Instituições participantes, exceto a Concedente, deverá ser entregue à FINEP no prazo máximo de 15 dias a contar do seu recebimento. O não cumprimento do prazo poderá acarretar o arquivamento da proposta.

9.5. ACOMPANHAMENTO E AVALIAÇÃO

O acompanhamento técnico e financeiro dos projetos apoiados será feito pela FINEP ou por entidade designada, através da visitas de acompanhamento, reuniões técnicas ou outros mecanismos de avaliação, a critério da FINEP.

10. DISPOSIÇÕES GERAIS

10.1. BASE LEGAL: Termo de Referência assinado em 07/05/2009, Instrução Normativa nº 01/2010 de 25/06/2010, do Conselho Diretor do FNDCT, publicada no DOU em 28/06/2010.

10.2. INTERPOSIÇÃO DE RECURSOS: Com base na Lei nº 9784/99, a instituição candidata poderá apresentar recursos às decisões da FINEP, através de correspondência formal, dirigida ao Presidente da FINEP, até 10 dias úteis após a divulgação do resultado.

10.3. REVOGAÇÃO OU ANULAÇÃO DA CHAMADA PÚBLICA: A qualquer tempo, a presente Chamada Pública poderá ser revogada ou anulada, no todo ou em parte, por motivo de interesse público ou exigência legal, sem que isso implique em direito a indenização ou reclamação de qualquer natureza.

A FINEP reserva-se o direito de resolver os casos omissos e as situações não previstas na presente Chamada Pública.

11. CONCEITOS

Para fins desta Chamada:

- Instituição de Pesquisa Científica e Tecnológica – ICT - Instituição Pública ou privada sem fins lucrativos que tenha por missão institucional, dentre outras, executar atividades de pesquisa básica ou aplicada de caráter científico ou tecnológico.
- Empresa – Organização econômica, instituída para a produção ou a circulação de bens ou de serviços, com finalidade lucrativa, devidamente registrada na Junta Comercial.
    - Empresa brasileira – Empresa constituída sob as leis brasileiras e que tenha a sede de sua administração no país.
- Inovação – Introdução de novidade ou aperfeiçoamento no ambiente produtivo ou social que resulte em novos produtos, processos ou serviços (Lei de Inovação – Lei 10.973/2004).
- Consórcio de Empresas – Modalidade de cooperação econômica que decorre de um contrato entre sociedades independentes, restringindo-se à conjugação de empresas para a execução de um determinado empreendimento.
- Recursos Financeiros – Recursos em espécie, depositados na conta bancária específica do convênio, destinados exclusivamente ao desenvolvimento do projeto.
- Contrapartida – recursos financeiros e/ou não financeiros aportados ao projeto pelo convenente e/ou executor, a serem aplicados exclusivamente na Instituição Científica e Tecnológica para o desenvolvimento do projeto.
- Valor Total do Projeto – Valor Solicitado ao FNDCT (despesas de custeio, despesas de capital e bolsas) + Valor do Aporte de Recursos Financeiros da Empresa.

12. CONSIDERAÇÕES FINAIS

Os resultados finais serão divulgados no sítio da FINEP (www.finep.gov.br), informado através de carta aos proponentes e publicado no Diário Oficial da União.

Esclarecimentos acerca do conteúdo desta Chamada Pública poderão ser obtidos através do Serviço de Atendimento ao Cliente FINEP – SEAC – por e-mail - seac@finep.gov.br, ou telefone: (21) 2555-0555.

Rio de Janeiro, 9 de julho de 2010.

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EUGENIUS KASZKUREWICZ

Presidente em exercício

Financiadora de Estudos e Projetos – FINEP