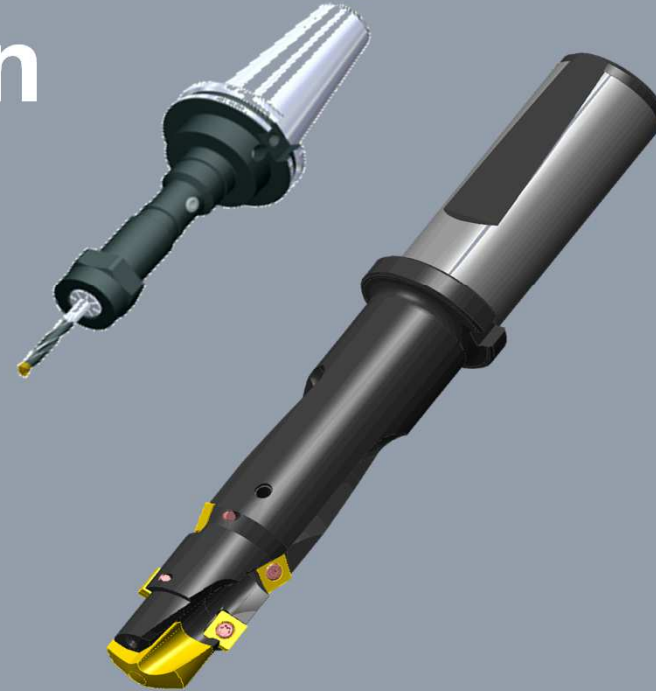


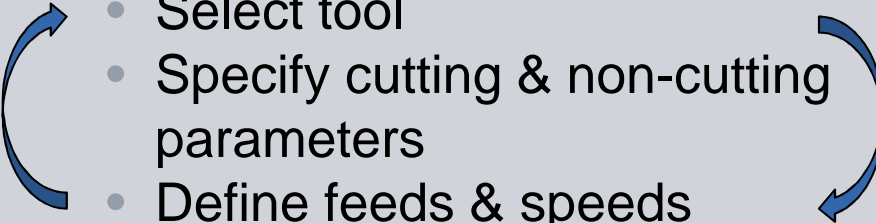
NX CAM Feature-Based Machining (FBM) Introduction

Tom van 't Erve
NX CAM Development



What is Feature-based Machining (FBM)?

Traditional Manual CAM steps

- Define Workpiece
 - Create operation 1
 - Select geometry
 - Select tool
 - Specify cutting & non-cutting parameters
 - Define feeds & speeds
 - Add UDE's
 - Generate tool path
 - Create operation 2, 3, 4, 5, ... n
 - Simulation & Verification
 - Post processing
- 

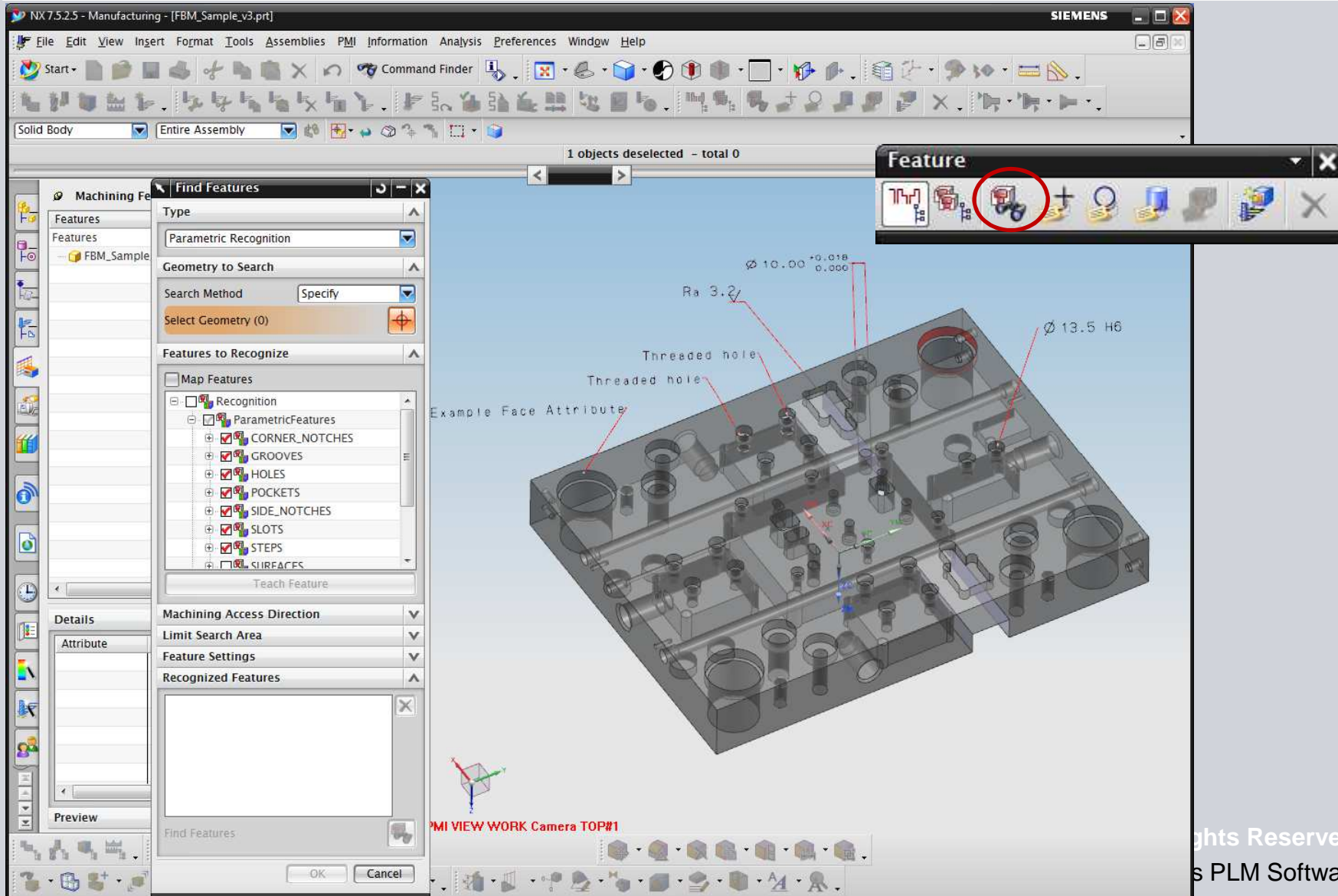
Automatic FBM steps

- Define Workpiece
- Automatically Find Features
- Automatically Create Operations
- Generate tool paths
- Make changes as needed
- Simulation & Verification
- Post processing

Example User Workflow

Find Features - Start

SIEMENS

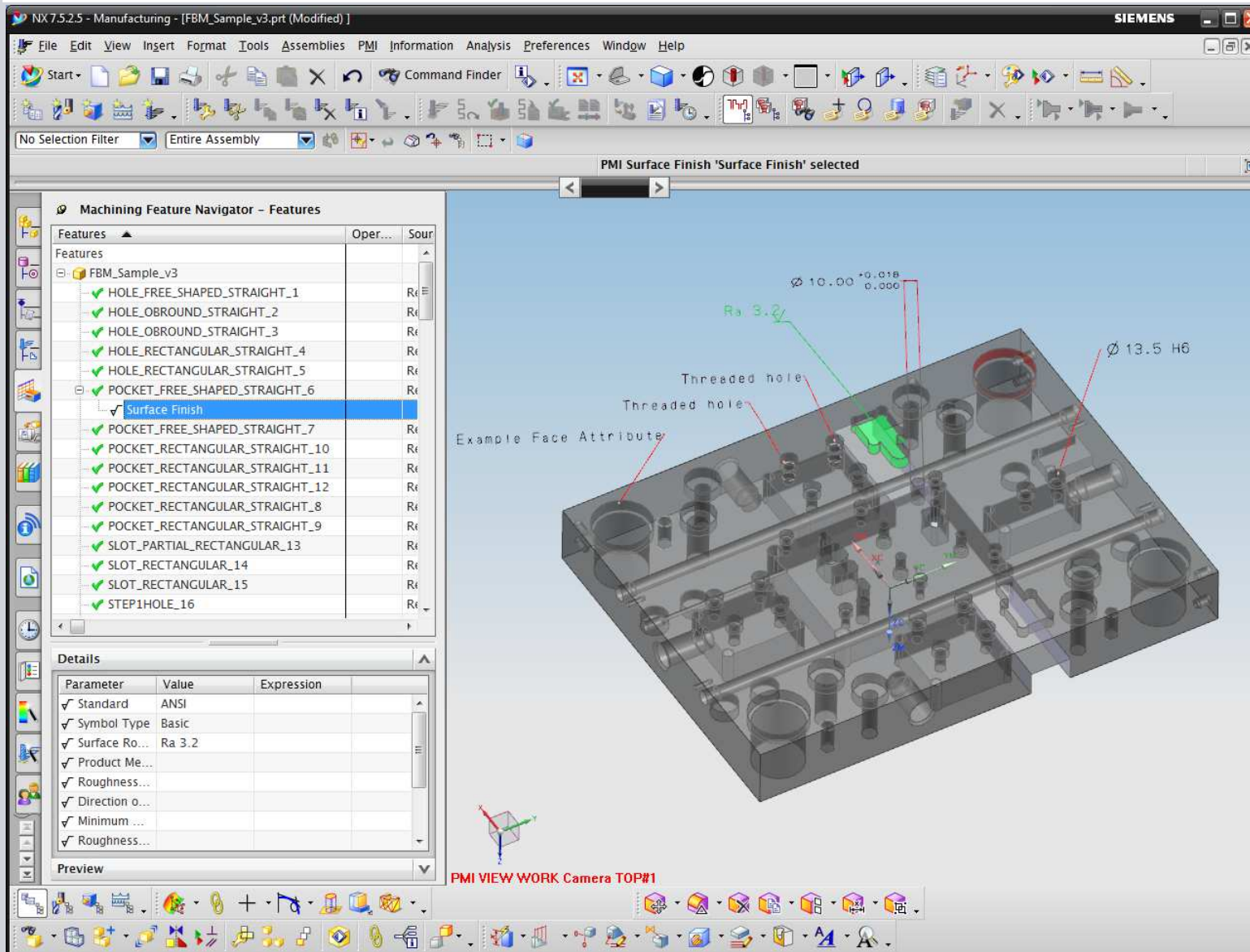


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Example User Workflow

Find Features – Automatically finds 105 features

SIEMENS



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Example User Workflow

Create Feature Process - Start

SIEMENS

The screenshot displays the Siemens NX 7.5.2.5 Manufacturing interface. The main window shows a 3D model of a complex mechanical part with various features and dimensions. A 'Feature' toolbar is visible at the top right, with a red circle highlighting the 'Create Feature Process' icon. The 'Create Feature Process' dialog is open, showing the following settings:

- Type: Rule Based
- Knowledge Libraries: Machining Knowledge, MillDrill, Turning, WireEDM, XampleMillColors
- Location: Geometry (Automatic)
- Settings: Groups (Use Existing)

The 'Machining Feature Navigator - Features' panel on the left lists the following features:

- FBM_Sample_v3
 - HOLE_FREE_SHAPED_STRAIGHT_1
 - POCKET_FREE_SHAPED_STRAIGHT_6
 - POCKET_FREE_SHAPED_STRAIGHT_7
 - STEP1POCKET_THREAD_50
 - STEP1POCKET_THREAD_51
 - STEP1POCKET_THREAD_52
 - STEP1POCKET_THREAD_53
 - STEP2HOLE_54
 - STEP2HOLE_55
 - STEP2HOLE_56
 - STEP2HOLE_57
 - STEP2HOLE_58
 - STEP2HOLE_59
 - STEP2HOLE_60
 - STEP2HOLE_61
 - STEP2HOLE_62
 - STEP2HOLE_63

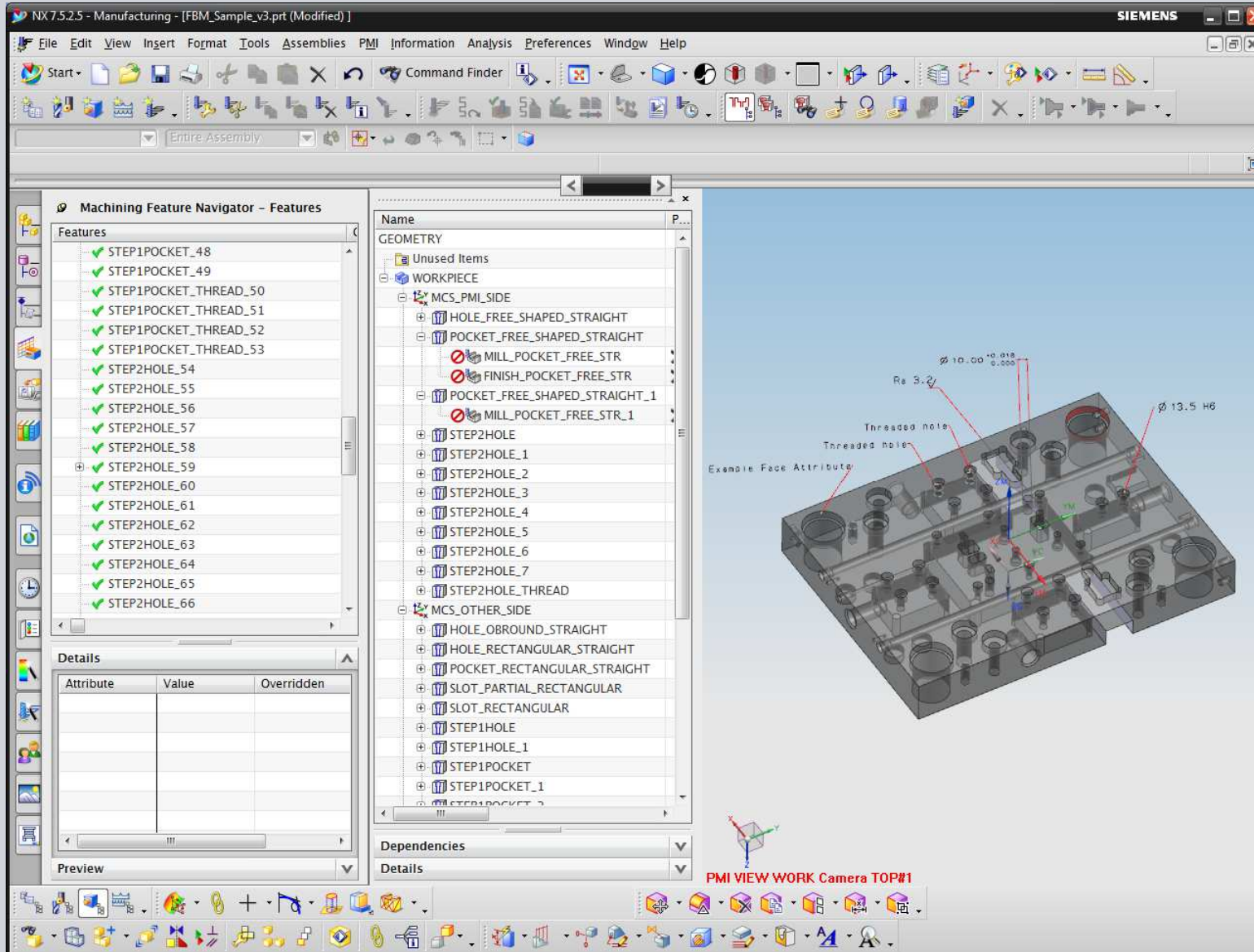
The 3D model shows dimensions such as $\phi 10.00^{+0.018}_{0.000}$, $\text{Re } 3.2$, $\phi 13.5 \text{ H6}$, and 'Threaded hole'. A 'PMI VIEW WORK Camera TOP#1' is visible at the bottom of the model.

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Example User Workflow

Create Feature Process - Creates 84 operations

SIEMENS

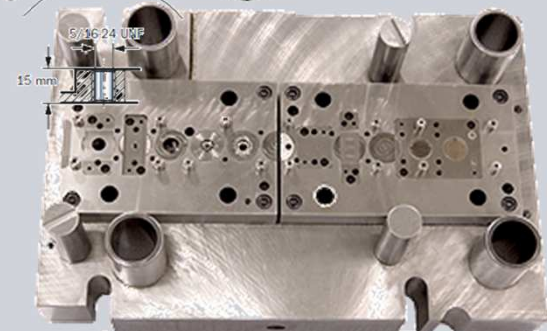
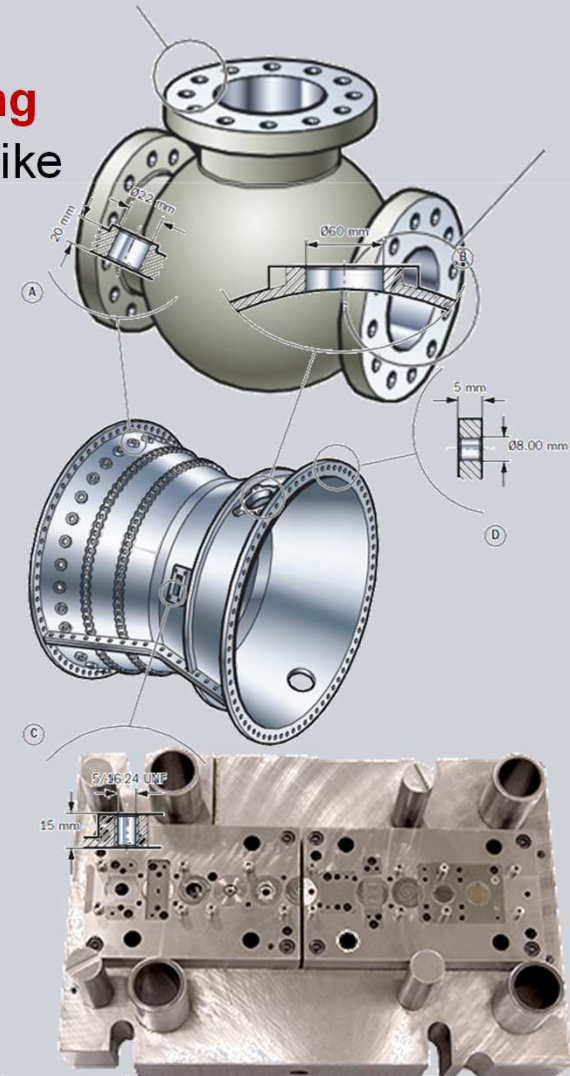
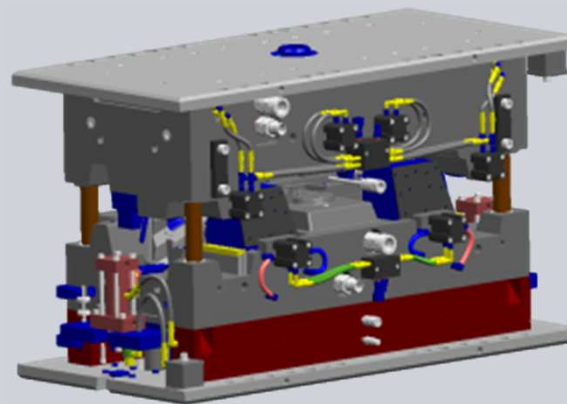
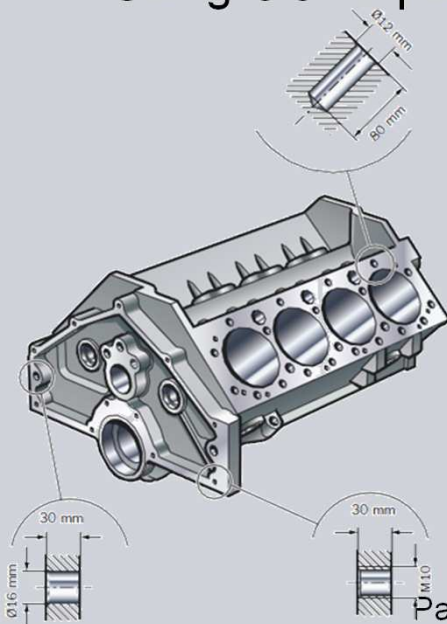


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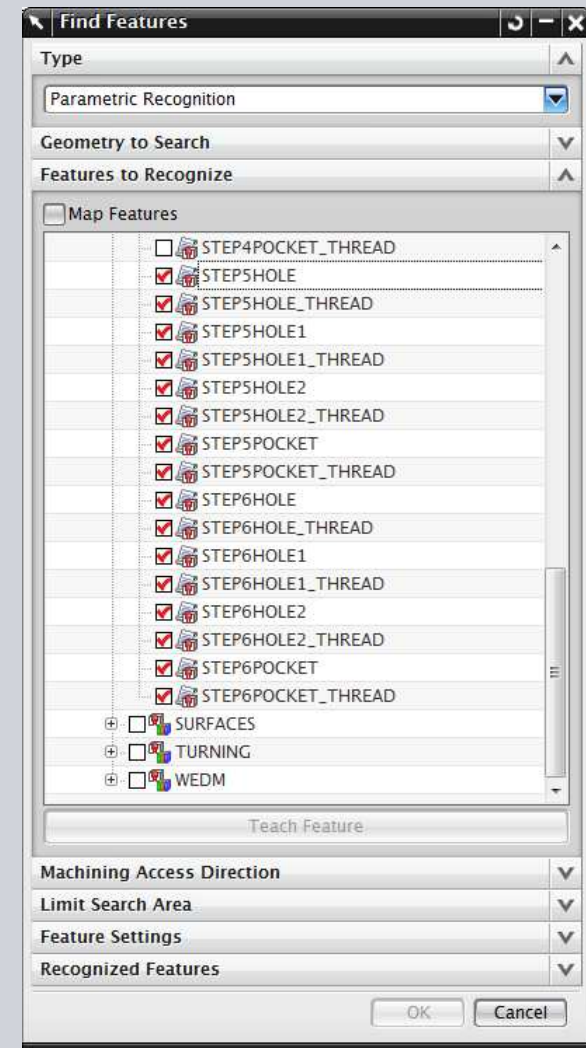
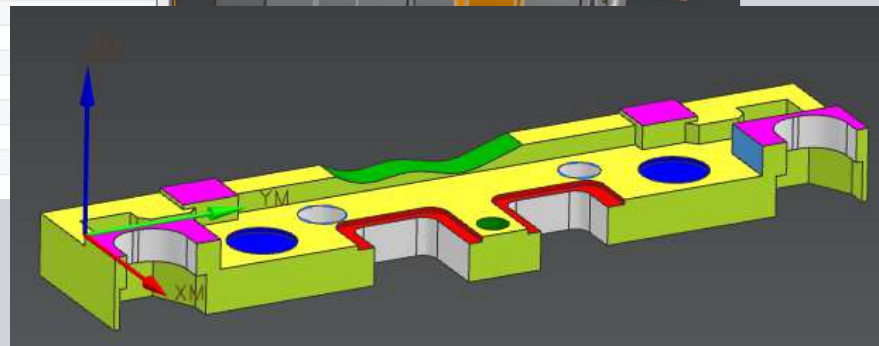
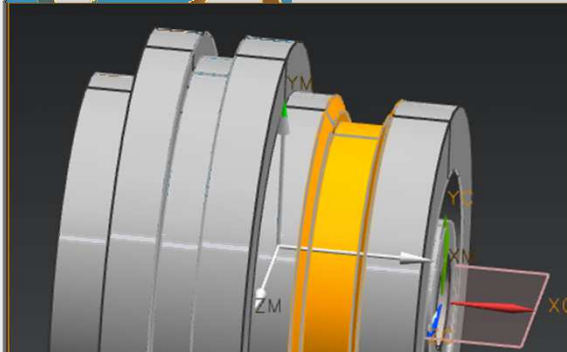
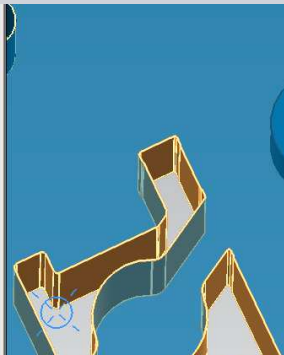
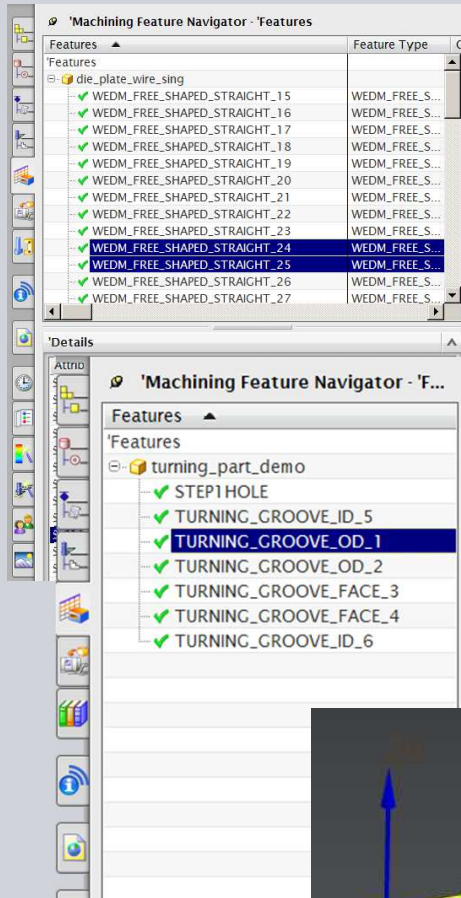
Where is FBM being implemented?

Most customers start with 2½D Prismatic Machining

- Standard features appear in many different parts like
 - Mold bases
 - Machinery parts
 - Automotive parts
 - Aerospace parts
- Predominantly holes, pockets and slots
- Using OOTB parametric feature types

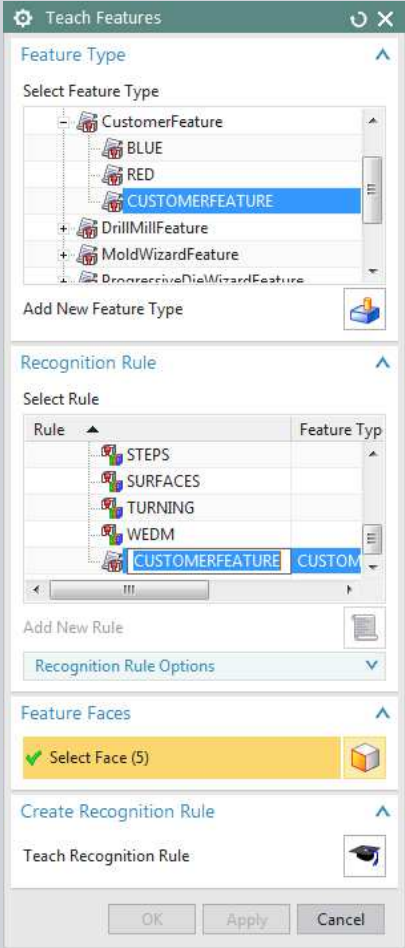
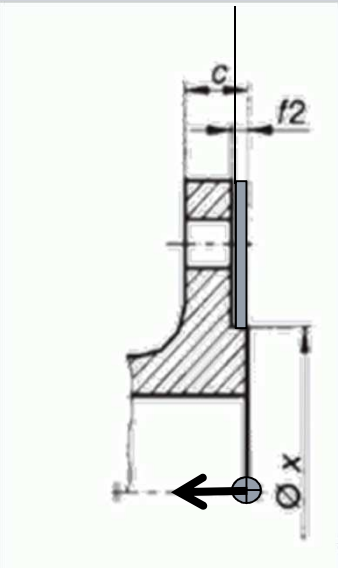
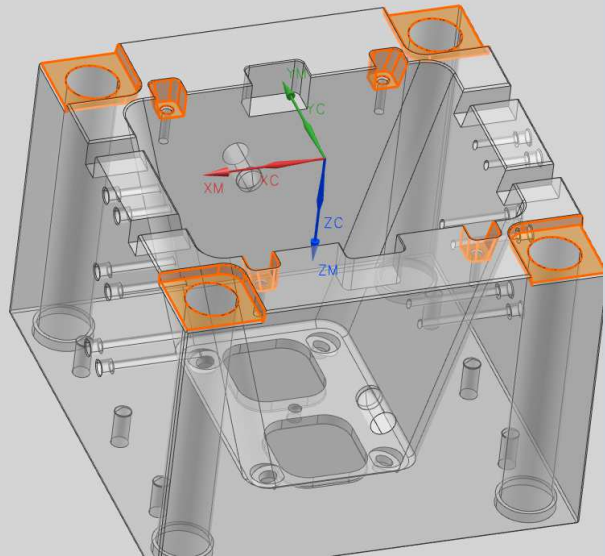
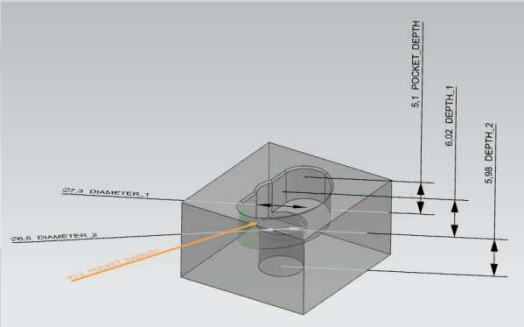
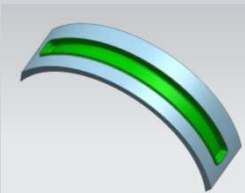
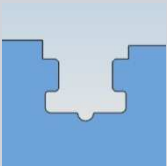
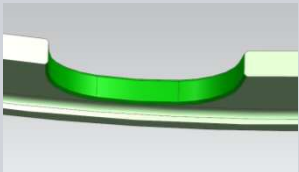


Turning, WEDM and Color & Attribute features were added in NX7.5



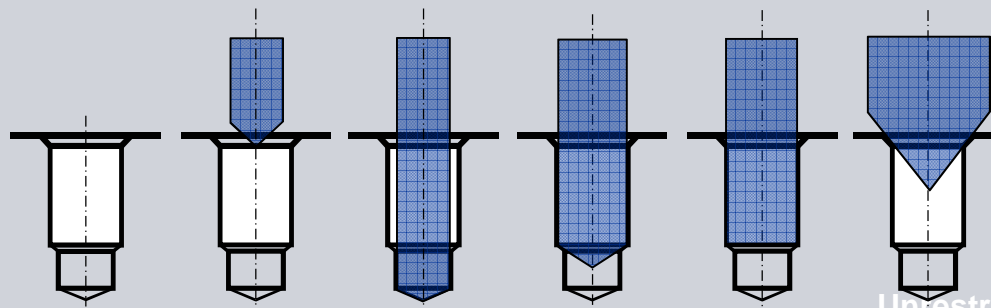
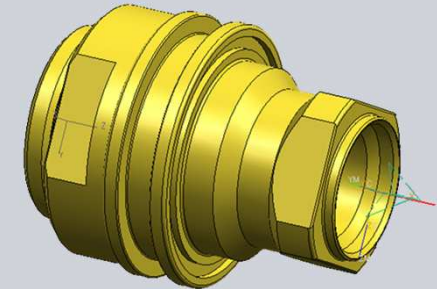
Feature Teaching was added in NX8.5

- Automatic Feature Recognition for your own, customer specific, (milling, drilling, turning, WEDM) feature types



Where can you implement FBM?

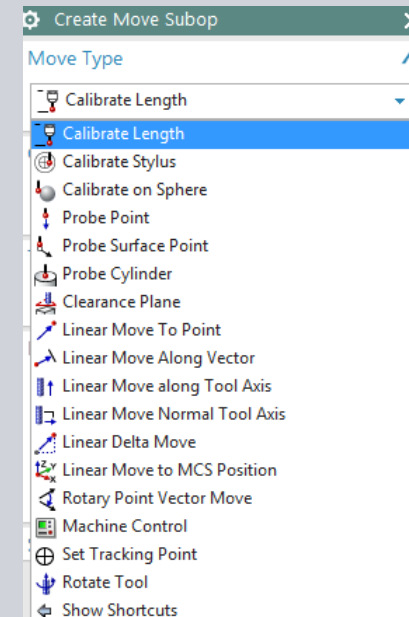
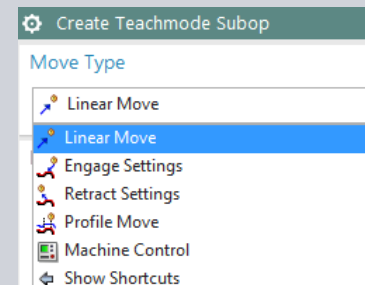
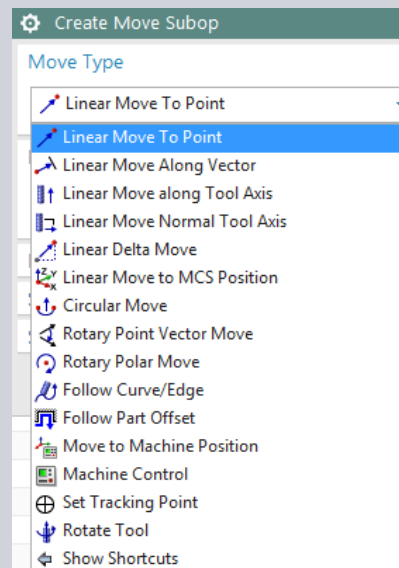
- Hole Making
- Floor/Wall Milling
- Cavity Milling
- Turning
- WEDM (2 and 4-axis Internal Trim and No Core)
- Thread Milling and Hole Milling
- Planar Milling
- Plunge Milling
- Z-Level Milling
- Fixed Axis Surface Contouring
- Variable Axis Z-Level Milling
- Variable Axis Surface Contouring (Streamline and Contour Profile)



FBM existing Limitations (1/2)

No support available yet for rule-based creation of sub-operations:

- Face Milling manual
- Generic Motion operation
- Turning Teach Mode operation
- Probing operation



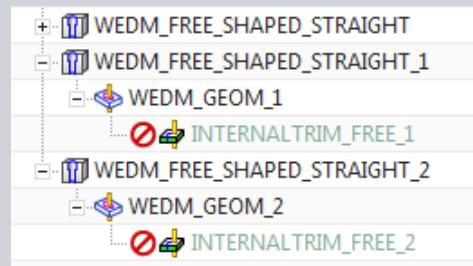
FBM existing Limitations (2/2)

Focus is on face-based operations; drive geometry is not support yet

- Machining Areas used to limit machining to a subset of the feature's faces

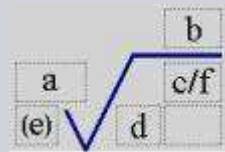
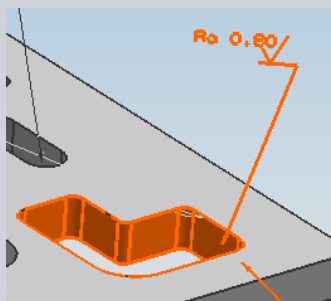
Only automatic boundary generation is supported for boundary based operation

- Machining Area support for boundaries is still on our to-do list



PMI support in FBM

- Dimension tolerances
 - Diameter tolerance
 - Radius tolerance
- Limits & Fits
- Surface Finish
- Thread
- Thread tolerances
- Face Color
- Face Attributes



Values: $\varnothing 12,0 \pm 0,0$ $\varnothing 14,0 \pm 0,0$

Ro 3.2

'Attribute	'Value	'Overridden	'Origin
C-BORE DIAMETER	14.250000...		14.250
C-BORE DEPTH	9.8787878...		9.8787
HOLE DIAMETER	9.0000000...		9.0000
HOLE DEPTH	67.878787...		67.8787
COLOR	36		36
MW_HOLE_SHCS_C_BORE	1		1
MW_HOLE_SHCS_CLR	1		1

Why are customers interested in FBM?

Process Automation

- Significantly reduce the time needed to create NC programs
- Productivity improvements of 10x have been documented

Process Quality

- Reduce the amount of mistakes in “simple” and “repetitive” NC programming tasks
- Spend more time on critical / non-standard tasks

Process Standardization

- Ensure that the “standard process” is used by default
- Support the standardization of cutting tools

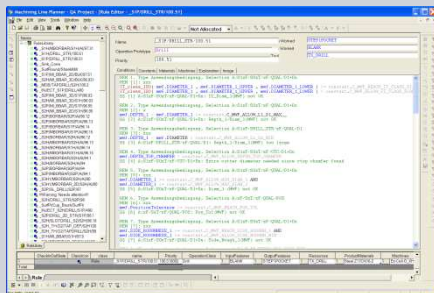
Machining Knowledge Definition

How does it work?



Expert: configures the best practice machining processes
(Machining Knowledge Editor application)

MKE



Machining Knowledge

NX CAM loads the appropriate Machining Knowledge

NX CAM

NC Programmer (NX CAM)

Machining Feature Navigator

Feature Name	Feature Type
COUNTER_BORE_HOLE_1	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_10	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_11	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_12	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_13	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_14	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_15	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_16	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_17	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_18	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_19	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_2	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_20	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_21	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_3	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_4	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_5	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_6	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_7	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_8	COUNTER_BORE_HOLE
COUNTER_BORE_HOLE_9	COUNTER_BORE_HOLE

Machining Knowledge

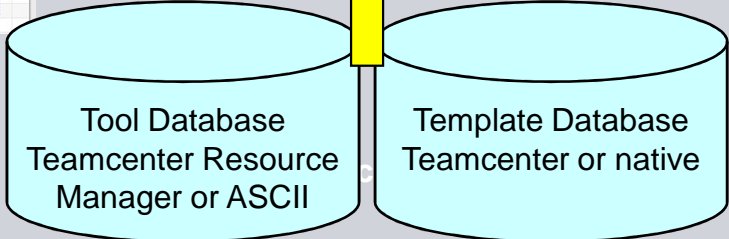
Create Feature Process command

Operation Navigator - Geometry

Name	Path
STANDARD_THREAD	
SPOT_DRILL_STD_THREAD	X
DRILL_STD_THREAD	X
THREAD_STD_THREAD	X
STANDARD_THREAD_1	
STANDARD_THREAD_2	
CB_HOLE	
SPOT_DRILL_CB_HOLE	X
DRILL_CB_HOLE	X
CBORE_CB_HOLE	X
CB_HOLE_1	

Features

Operations



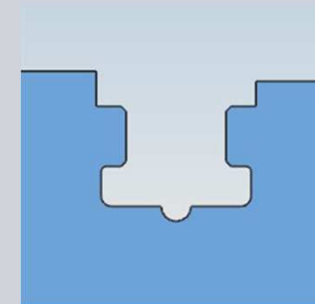
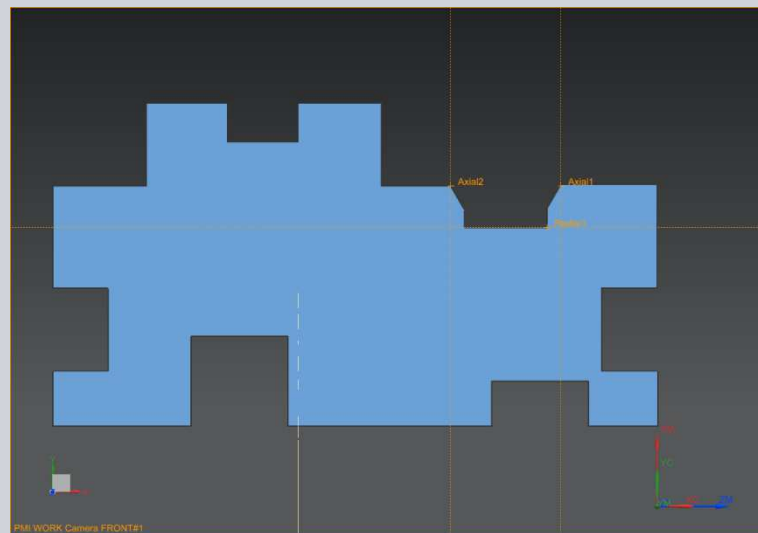
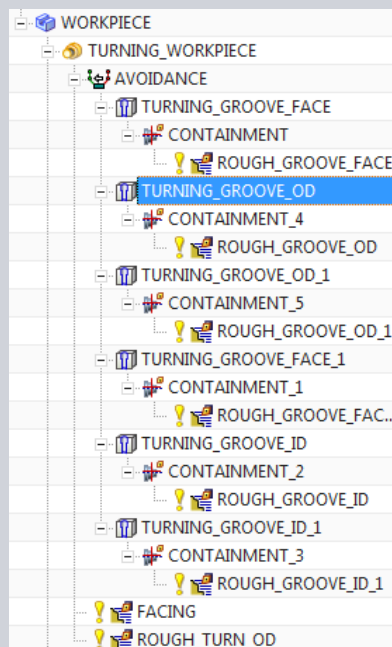
FBM – basic principles

- Operations are selected based on (customer specific) rules
 - Feature type
 - Feature parameters (dimensions, tolerances)
 - Product material & selected machine tool
- Tools are selected from the configured tool database
 - Tool type
 - Tool search parameters (from the tool database; not the internal tools)
- Once selected,
 - Operations are created by copying them from the selected template
 - Operation parameters can be overruled from the rules; this includes:
 - Cutting & non-cutting parameters, step overs, cut levels, etc.
 - Cycle parameters and UDE's
 - Feeds & speeds

Turning example

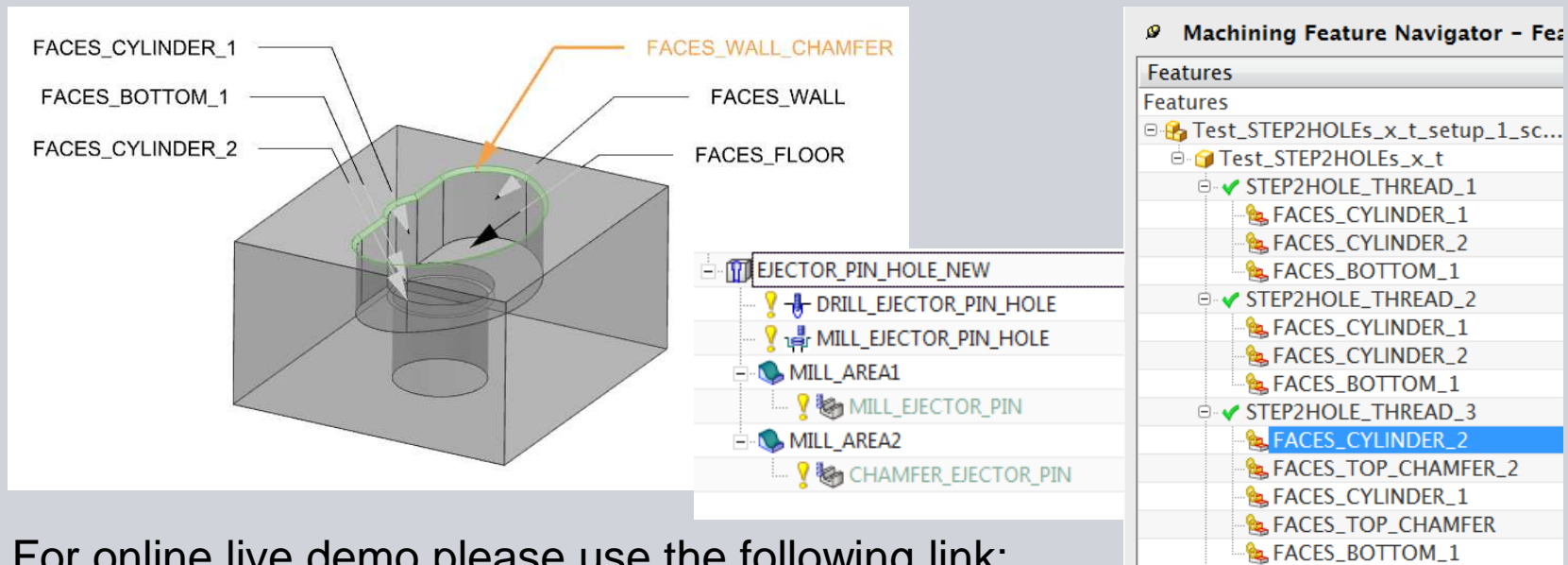
Typically used for complex and reoccurring features that require several operations

- Cut region definition through containment
- As mentioned before, no support available yet for teach mode operations



Machining Feature – Machining Area Extension to Feature Teaching

- Machining Area is a User defined “name” associated with a set of faces and/or edges
- Defined using standard NX PMI Labels
- Machining areas can be used to define operations that work on a subset a feature’s geometry



- For online live demo please use the following link:

- [Quickly add new feature definitions for feature-based machining](#)

Operation Teaching Is available since NX8

SIEMENS

1. Use NX CAM to generate machining rules from existing CAM operations and store in MKE
2. In the Machining Knowledge Editor (MKE), edit the machining rules to make them more general. Also add or optimize machining conditions & set the priorities

The image illustrates the workflow for generating and editing machining rules in NX CAM. It shows the 'Teach Operations' dialog, the 'Machining Rule Library', the 'MILL_AREA' tree, and the 'Machining Knowledge Editor' (MKE) interface. The MKE interface displays the 'POCKET_ROUGHING' rule configuration, including fields for Name, OperationClass, and Priority, and a code editor with REM Application Criteria and REM Tool Attributes.

```
REM Application Criteria
is_defined(mwf.MACHINING_RULE)
mwf.MACHINING_RULE = "POCKET_FINISHING_PROMO"

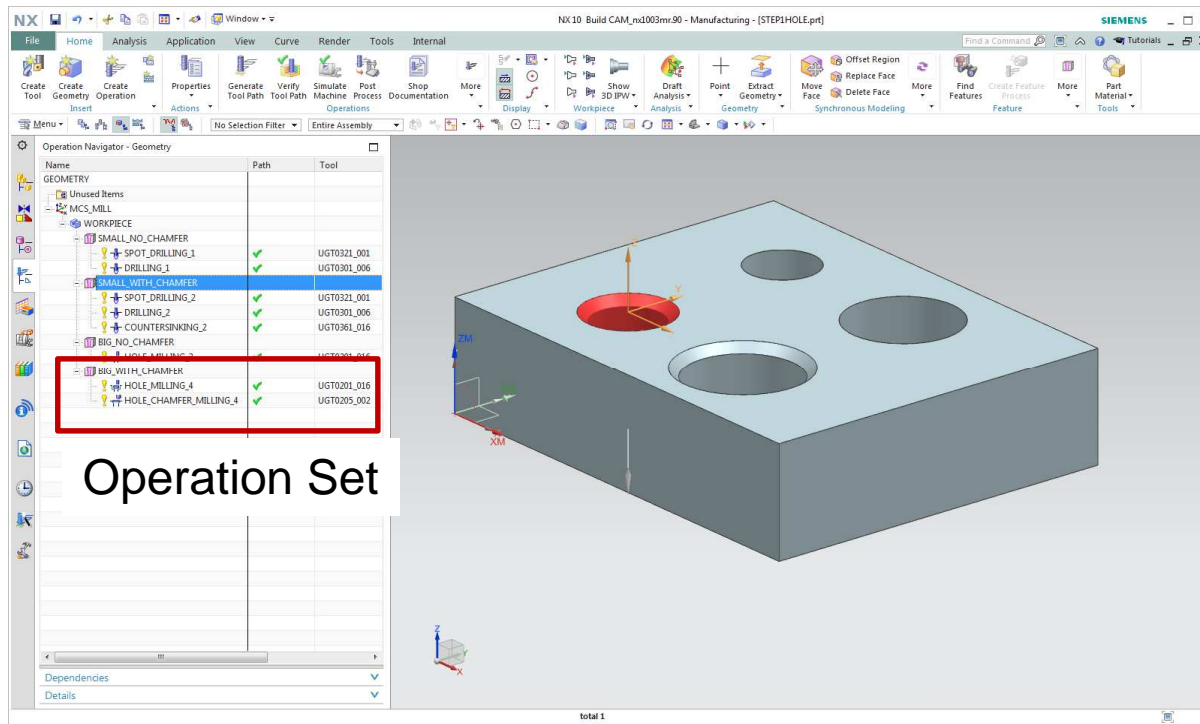
REM Tool Attributes
tool.CorRadMill = 0.0
tool.Descr = "End Mill 8 mm"
tool.Diameter = 8.0
tool.FluteLength = 19.0
tool.HolderDes = "Steep Taper SKG40"
tool.HolderRef = "HLD001_00001"
tool.MaterialDes = "HSS Coated"
tool.TaperAngleB = 0.0
tool.TaperedSDia = 0.0
tool.libref = "ugt0201_002"

REM Less Worked Feature Attributes
lwf.MACHINING_RULE = "POCKET_ROUGHING_PROMO"
lwf.SUBTYPE = 0
```

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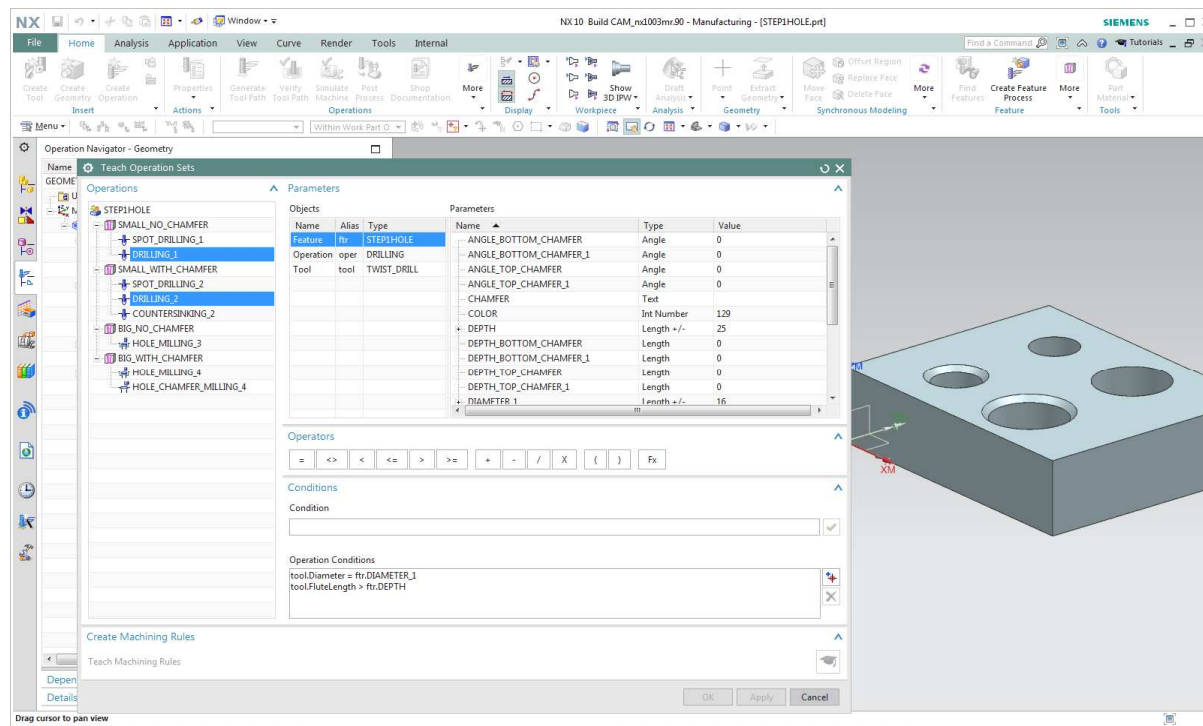
Operation Set Teaching – Introduced (as preview) with NX10.0.2

Uses part files with alternative operation sets per feature type



- Create a single “teach” part file per feature type
- Model a feature for each machining “variant”
- Recognize the features and create a feature group for each feature
- Per feature group, define the operations for that variant including:
 - Operation parameters
 - Tool
 - Cycle parameters
 - UDE's, etc.

Object -> Teach Operation Sets... Conditions are defined in NX CAM



Feature Group conditions

determine which variant to use

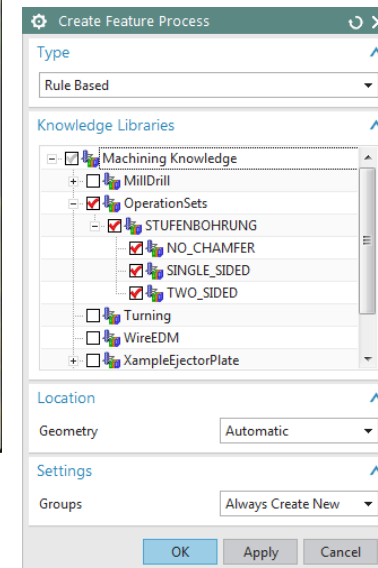
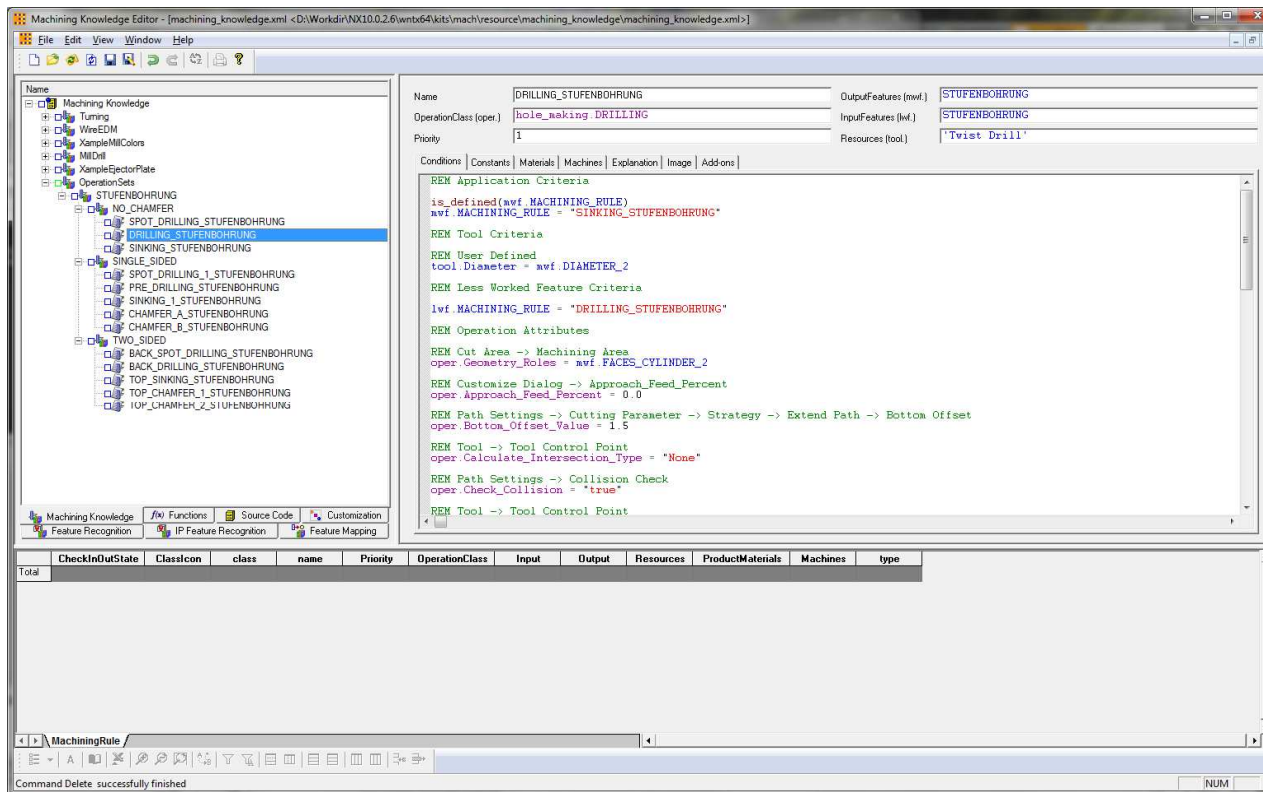
- Feature dimensions; Diameter ≤ 16.0
- Feature tolerances; Roughness < 3.2
- Feature color; Color = GREEN
- Feature attributes; ...

Operation conditions are used to match tool & operation parameters with feature parameters

- Tool.Diameter = Feature.Diameter_1
- Operation.DepthOfCut = $0.25 * \text{feature.Depth}$
- Etc.

Operation Set Teaching

Rules are stored in MKE; available for Create Feature Process



Operation Set Teaching - Benefits

- No need to learn an extra application; use NX CAM to define best machining practices
- Much faster ROI (Return on Investment) for initial FBM projects
- Much easier to make changes or add new / alternative processes (occasional use)

- Does not limit the future growth path or sacrifice any of the powerful MKE capabilities

- Does not require any additional licenses (just FBM_Author)

- Available as Preview from NX10.0.2 onwards
 - set UGII_CAM_FBM_ENABLE_TEACH_OPERATION_SETS=1
- Already used in production by selected customers
- Few additional enhancement required to streamline the workflow

How to implement FBM – Lessons learned (1/2)

- Use the OOTB rules to demonstrate the feasibility and get management buy-in for a small proof of concept
- Get basic training, study the OOTB rules to master the concepts
- DIY. This is your core business and your company's best practice and know how; document, implement and optimize it by yourself
- Assign a CAM expert with IT affinity; not an IT expert that does not understand CAM
- Start with a small proof of concept (1-3 weeks) with a limited scope
- Test drive the entire process from start to finish (use holes first before you do this on your own feature types)
 - Knowledge Acquisition & Standardization
 - Implementation & Testing
- Have something working to demonstrate to your management
- Provide ROI details if required
- Learn how to estimate a larger project implementation

How to implement FBM – Lessons learned (2/2)

- Enhance the scope incrementally
- Make sure you have regression tests in place
 - Capture validated Create Feature Process results before you start making changes
 - Re-run your tests and compare the new outcome with the validated results
 - Contact me if you need help automating this
- Stick to the 80-20 rule; do not get lost in the exceptions
- Only automate what “everybody” accepts as good practice
- People need to be able to trust the automatic results
- Some of the benefits are lost again if users constantly need to validate the automatic results

Licensing

What license is required ?

- No license required for end users
- “FBM Author” license is required for the definition of the company specific machining knowledge:
 - Save & Save As in Machining Knowledge Editor
 - Feature Teaching
 - Operation & Operation Set Teaching

FBM Author (NX31435) is available as add-on license

FBM Author is included in the Total Machining bundle

Foundation
CAD 2
2.5x Milling
3x Milling
Turning
Wire EDM
5 X Mill
Simulation
FBM Author

Total
Machining
NX13430

FBM & Teamcenter

- FBM uses the customer's standard CAM configuration to define:
 - Operation templates
 - Cutting tools
 - Cycles & UDE's
 - Machining Knowledge
 - Etc.

- It supports any mix of Native and Teamcenter.
- Most "managed" users store their machining knowledge xml in Teamcenter along with the operation templates and the cutting tools