ROBOTICS

Operating manual

Machining PowerPac - Machining Functionality

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Operating manual

Machining PowerPac - Machining Functionality

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Original instructions.

Table of contents

Overview of the manual 7

1 Introduction 11

1.1 About Machining PowerPac - Machining 11
1.2 Definitions and concepts 13
1.2.1 Main definitions 13
1.2.2 Coordinate systems 15

2 Installation 21

2.1 Getting the software and license 21
2.2 Prerequisites and system requirements 22
2.3 Installing 23
2.4 Getting started 24

3 Navigating Machining PowerPac - Machining 27

3.1 The main window 27
3.2 Machining ribbon tab 28
3.3 Operation Navigation Tree 34
3.4 3D graphics window 38
3.5 Preferences dialog box 39
3.6 Event Library dialog box 45

4 Workflow for Machining PowerPac - Machining 47

4.1 About the workflow 47
4.2 Importing 48
4.3 Creating work object and geometry 50
4.3.1 Creating a work object 50
4.3.2 General procedure for creating a geometry 54
4.3.3 Specific procedures for each geometry type 64
4.3.3.1 Projection geometry 64
4.3.3.2 Intersection geometry 73
4.3.3.3 UV curve 77
4.3.3.4 Edge curve 79
4.3.3.5 Customized curve 81
4.3.4 Configuring a target 83
4.4 Creating tool 89
4.5 Creating program group 95
4.6 Creating operation 98
4.7 Simulating robot path 108
4.7.1 Simulation window 109
4.7.2 Simulating robot path 112
4.7.3 Setting collision set for simulation 113
4.8 Path Editor 115
4.8.1 About the path editor 115
4.8.2 Entering path editor 116
4.8.3 Working with instruction list 117
4.8.4 Editing a path 121
4.9 Path Optimizing 129
4.9.1 Automatic path optimizing 129
4.9.2 Manual path optimizing 131
4.10 Calibrating 136
4.10.1 Creating calibration data 138
4.10.2 Calibrating in real world 140
4.11 Exporting RAPID file 141

5 Reference information 147

5.1 RAPID instructions 147
5.1.1 MachL - Moves linearly 147
5.1.2 MachJ - Moves using joint movement 149
5.1.3 MachC - Moves circularly 151
5.2 RAPID data types 153
5.2.1 MachiningPose - Coordinate transformations in machining programs 153
5.2.2 MachineProcess - Process definitions in machining programs 154

6 Troubleshooting 155

6.1 Version upgrade failure 155

Index 157

Overview of the manual

About this manual

This manual describes how to use Machining PowerPac - Machining to create RAPID machining programs based on CAD models.

Usage

This manual should be used during the work with Machining PowerPac - Machining.

Who should read this manual?

This manual is intended for RobotStudio users, proposal engineers, mechanical designers, offline programmers, robot technicians, and service technicians.

Prerequisites

The reader should have basic knowledge of:

- Industrial robots and their terminology
- RAPID programming language
- RobotStudio

Organization of chapters

The manual is organized in the following chapters:

Chapter	Content
1 *Introduction*	Describes definitions and concepts of Machining PowerPac - Machining.
2 *Installation*	Describes how to install Machining PowerPac - Machining.
3 *Navigating Machining PowerPac - Machining*	Describes the graphical user interface of Machining PowerPac - Machining.
4 *Workflow for Machining PowerPac - Machining*	Describes how to work with Machining PowerPac - Machining.

References

Reference	Document ID
Operating manual - RobotStudio	*3HAC032104-001*
Technical reference manual - RAPID Overview	*3HAC050947-001*

Revision

Revision	Description
-	First edition

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Continued

Revision	Description
A	Changes made in this revision: • Information added about home position for creating or editing program groups. See *Main definitions on page 13* and *Creating program group on page 95*. • Information added about safe path that is defined by start safe targets or end safe targets for creating or editing operations. See *Main definitions on page 13* and *Service move setting on page 101*. • Information added about node copying and pasting in **Operation Navigation Tree**. See *Task table on page 36*. • Information added about general settings in **Preference** dialog box. See *General on page 39*. • Information added about new interval calculation method using Overlapping Calculation function for specifying projection curves in auto pattern and manual pattern types as well as for specifying intersection curves in parallel plane type. See *Auto Pattern on page 64*, *Manual Pattern on page 66*, and *Intersection geometry on page 73*. • Information added about swallow and ball tool shapes. See "Procedure for creating a cutter" in *Creating tool on page 89*. • Information added about external axis settings during target configuration for supporting tracks. See *Settings with external axis on page 84*. • Changed the naming of windows **Geometry Builder** and **Operation Builder** to **Create Geometry** and **Create Operation** throughout the manual. • Changed part of figures to the latest GUIs throughout the manual.
B	Changes made in this revision: • Information added about safe plane for automatically generating safe path. See *Main definitions on page 13* and *Safe Plane on page 42*. • Added functions to help group in the ribbon tab, see *Help group on page 30*. • Changed GUI of the **Operation Navigation Tree** and supported setting of displayed columns. See *Information columns on page 35* and *Navigation Tree on page 42*. • Added two new pages **Safe Plane** and **Navigation Tree** in the **Preference** dialog box. See *Safe Plane on page 42* and *Navigation Tree on page 42*. • Information added about specifying boundary to define a more specific area to be processed within the selected surface area. See *Editing settings for a specific geometry on page 56*. • Information added about choosing safe path generation type, that is, generated based on safe plane settings or generated by manually specifying safe targets. See *Service move setting on page 101*. • Changed GUI naming **Origin (mm)** to **Position (mm)** and enabled tuple selection when specifying orientation values in the **Specify Frame** area. See *Manual Pattern on page 66* and *Specifying cutting plane on page 75*.

Continues on next page

Revision	Description
C	Changes made in this revision: • Added setting of naming rules for instruction node. See *Instruction Name on page 43* and *Icons and states on page 117*. • Renamed **Support** group to **Additional Tool** group in the ribbon tab and also changed GUI naming of **Robot Hold Tool** and **Robot Hold WorkObject** under this group. See *Machining ribbon tab on page 28*. • Added external axis setting for positioners. See *Positioner on page 86*. • Added **Circular move** motion type in instruction list to support circular paths. See *Motion on page 117* and *Context menu for instruction nodes on page 118*. • Application limitation of Machining PowerPac - Machining is added. See *Application limitation on page 12*.
D	Published in release R16.2. The following updates are done in this revision: • Information added about manual path optimizing. See *Path Optimizer on page 44* and *Manual path optimizing on page 131*. • Added troubleshooting for version upgrade failures. See *Version upgrade failure on page 155*.
E	Released with RobotStudio 2019.5. The following updates are done in this revision: • Updated parameters to the **General** and **Safe Plane** tab pages in the **Preferences** dialog box and updated related GUI. See *General on page 39* and *Safe Plane on page 42*. • Added point modification function for paths in the task table. See *Task table on page 36*. • Updated the function description for the **Recalculate** button in the **Simulation** window. See *Simulation control on page 110*. • Updated safe plane parameters in the **Create WorkObject** window. See Creating work object and geometry*Creating work object and geometry on page 50*. • Updated parameters in the **Process Move Setting** window. See *Process move setting on page 104*.
F	Released with RobotStudio 2021.2. The following updates are done in this revision: • Added the functions supporting the interaction with the Machining Shopfloor HMI. • Added function description to the **Reload** and **Path Events** icons in the tab. • Added the reference point setting for creating or editing program groups. • Added function description to the **Bind Events** item in the shortcut menu of the instruction list.
G	Released with RobotStudio 2022.2. The following updates are done in this revision: • Added a method selection to interpolation setting for process move setting. • Renamed the product Machining Shopfloor HMI to Machining Software. • Added description about multiple instruction exporting.
H	Released with RobotStudio 2023.1. The following updates are done in this revision: • Added a tool type belt sander. • Added function of specifying customized processing surface for geometries.

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Revision	Description
J	Released with Machining 2024.1. The following updates are done in this revision: • Added description about the software versions. • Added "Clear project" function in **Help** group. See *Help group on page 30*. • Added a note to the bind events. See *Context menu for instruction nodes on page 118* and *Binding events on page 128*. • Added machining related RAPID instructions and data types. See *Reference information on page 147*.

1 Introduction

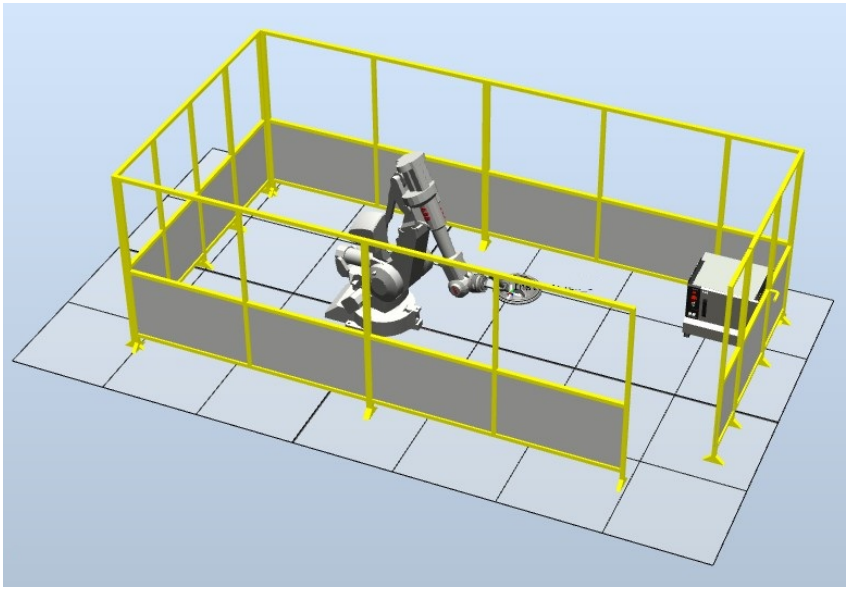
1.1 About Machining PowerPac - Machining

Overview

Machining PowerPac - Machining is a process-specific add-in to RobotStudio. This software provides an offline programming solution to ABB robots and allows the handling of complex geometry parts.

For details about robot points, RobotStudio coordinate systems, and camera adjustment, see the RobotStudio and RobotWare manuals.

The following picture shows a typical robotic machining cell, which uses a robot as the machining tool manipulator.



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Key features

- Machining PowerPac - Machining provides five strategies for generating machining lines and curves, satisfying different path generation requirements on free surfaces.
- Users can change one or several contact points of a tool on the machining part along a path.
- The tool library enables users to use a tool with defined settings directly or to save customized set tools as templates for further use. This is especially useful for complex tool shapes, saving time from repeated setting. Machining PowerPac - Machining provides an easy way to create a common machining tool that contains a geometry model and RobotStudio tool data, which is useful for users to perform simulation. The tool library enables to save the customized tool data as template(s) for reuse by others or in other cases.
- Several strategies are provided for automatic target configuration.

Continues on next page

- Through quick simulation and visual controller (VC) simulation, users can verify and modify robot paths before exporting them to RAPID files.
- Except adjusting axes, positions, orientations and contact points, the more powerful path editor provides a smooth adjustment function. This enables smoothness between target positions and targets' contact point positions, and also smoothness during target rotation around tool axis and tool rotation around contact points. Paths can also automatically optimized by Path Optimizer.
- Export templates allow users to export data in required formats to meet different application situations.

Prerequisites

For using Machining PowerPac - Machining, we recommend that you have a basic knowledge of:

- RobotStudio
- RAPID programming

Application limitation

Machining PowerPac - Machining supports only ABB 6-axis robots, except for IRB 6640ID, IRB 6640 LeanID, and 6-axis painting robots IRB 52, IRB 5400, and IRB 580.

1.2 Definitions and concepts

1.2.1 Main definitions

Definitions

The following table describes the main definitions in Machining PowerPac - Machining.

Definition	Description
Geometry view	In the geometry view, all work objects, geometries and related operations are displayed hierarchically. The **Uncategorized Items** node includes geometries and operations that do not belong to any work object or geometry.
Tool view	In the tool view, all tools and related operations are displayed. The **Uncategorized Items** node in this view contains only operations not belonging to any tool.
Program view	In the program view, all program groups and operations are displayed. If an operation belongs to no program group, it is displayed under the **Uncategorized Items** node.
Projection geometry	With projection geometry, a set of geometry curves are generated by projecting lines on the machining part surfaces.
Intersection geometry	With intersection geometry, a set of geometry curves are generated by intersecting planes with the machining part surfaces.
UV curve	A set of isoparametric curves in U/V direction are defined to generate robot paths.
Edge curve	One or more edges of the selected surfaces are defined to generate robot paths.
Customized curve	Users can select several points on the machining part surface, based on which geometry curves are generated.
Feature curve	Feature curves are a set of virtual curves shown on user-specified surfaces to provide a preview of generated machining path.
Template	Best practiced settings of geometries or operations can be saved as templates locally for reuse and share. Templates are .xml files.
Contact area	The contact area defines an area on a tool. Generated robot paths only use the defined contact area to process the machining part. Contact area can also be manually adjusted by using Path Editor.
Contact height	The contact height defines the height from the tool tip to the tool part that is actually used for processing.
Contact path	The processing path moves along based on the contact data.
Robot path	The processing path moves along based on the tool center point (TCP).

Continues on next page

1.2.1 Main definitions

Continued

Definition	Description
Home path	A home position is specified, with which the robot will move to this specified position first before moving on to the first target of the path or the first start safe target (if any). The home position can only be previewed using VC simulation and recorded in RAPID files. Path preview and quick simulation do not shown this position, and the path editor does not record this position.
Safe path	One or several safe targets can be specified, which form a safe path for the robot to move along before and after the processing path. Before moving to the processing path, the robot moves to the start safe targets first from the home position (if there is); after completing the processing path, the robot moves to the end safe targets first and then the home position (if there is). The safe targets can be previewed in path preview, path editor and simulation. If a safe plane is specified, the safe path can be generated automatically based on the safe plane settings when the path generation type is **Auto**.
Safe plane	Setting a safe plane is a strategy to automatically generate a safe path for all operations belonging to a work object. The safe plane is perpendicular to the Z axis of the work object. After a safe plane height is specified, all transfer moves between the operations will be preformed away from the work object by the specified height based on the object frame of the work object. Users can set a safe plane when creating or editing a work object and the settings will take effect for all operations under the work object. Alternatively, users can also set a default safe plane in the **Preferences** dialog box.
Start event	Customized RAPID modules defined as start events are invoked before the operations or specified targets.
End event	Customized RAPID modules defined as end events are invoked after the operations or specified targets.

1.2.2 Coordinate systems

Overview

This section provides an introduction to the coordinate systems used mostly for offline programming. In RobotStudio, you can either use the coordinate systems (that are explained below) or the user-defined coordinated systems for co-relating elements and objects.

Hierarchy

The coordinate systems are co-related hierarchically. The origin of each coordinate system is defined as a position in one of its ancestries. The following are the descriptions of the commonly used coordinate systems.

Tool Center Point Coordinate system

The tool center point coordinate system, also called TCP, is the center point of the tool. You can define different TCPs for one robot. All robots have one predefined TCP at the robot's tool mounting point, called *tool0*.

When a program runs, the robot moves the TCP to the programmed position.

RobotStudio World Coordinate system

The RobotStudio world coordinate system represents the entire station or robot cell. This is the top of the hierarchy to which all other coordinate systems are related (when using RobotStudio).

Base Frame (BF)

The base coordinate system is called the Base Frame (BF). Each robot in the station, both in RobotStudio and the real world has a base coordinate system which is always located at the base of the robot.

Task Frame (TF)

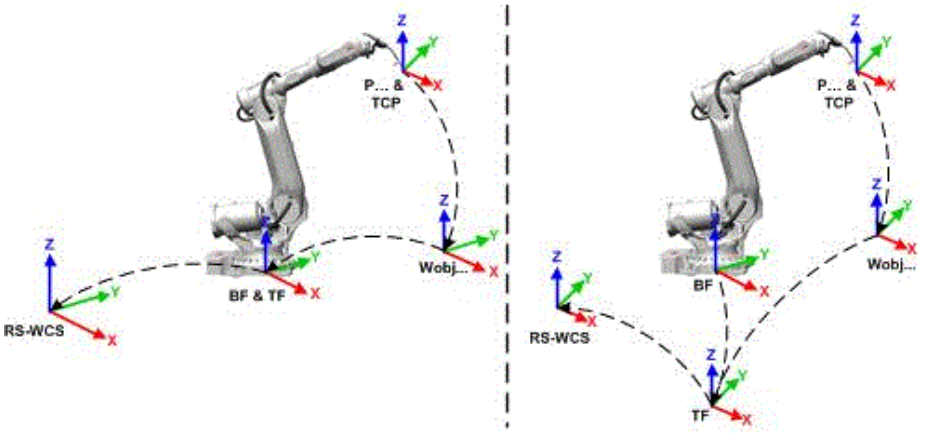
The Task Frame represents the origin of the robot controller world coordinate system in RobotStudio.

The following picture illustrates the difference between the base frame and the task frame.

Continues on next page

1.2.2 Coordinate systems
Continued

In the picture to the left, the task frame is located at the same position as the robot base frame. In the picture to the right, the taskframe has been moved to another position.



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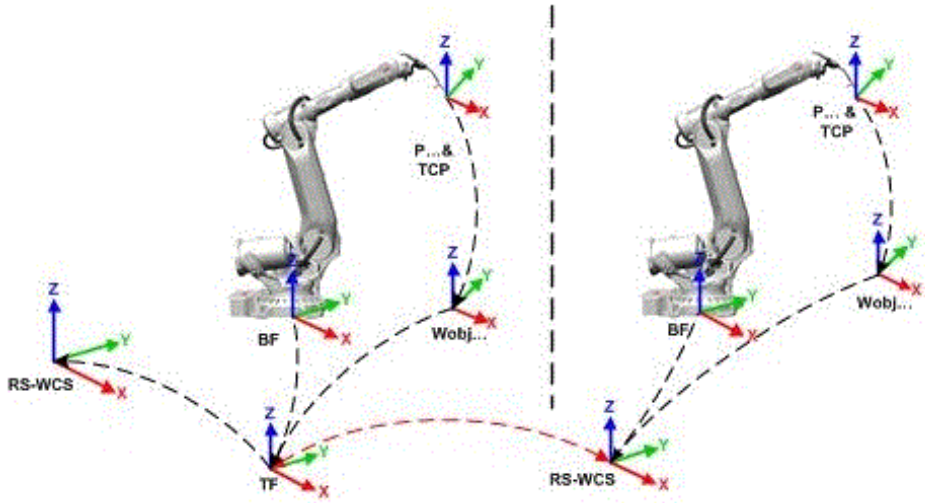
The following picture illustrates how a task frame in RobotStudio is mapped to the robot controller coordinate system in the real world. For example, on the shop floor.



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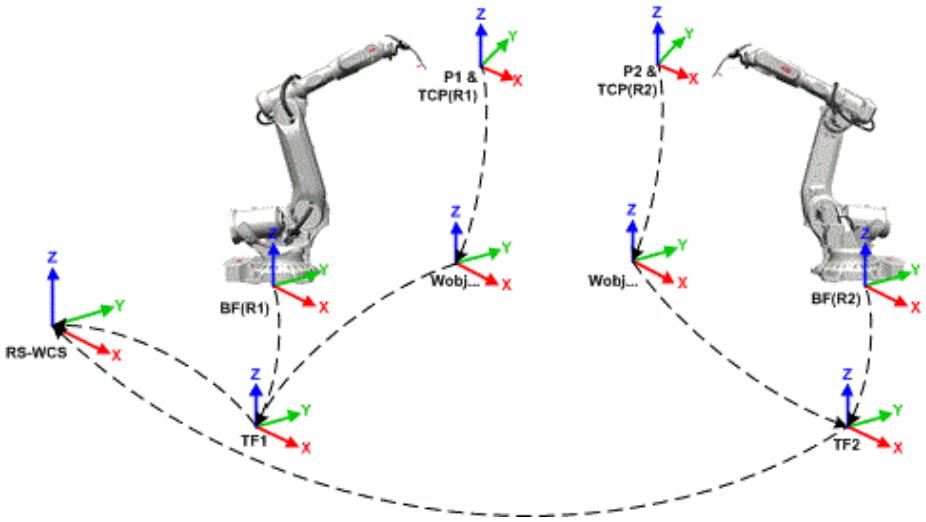
RS-WCS	World coordinate system in RobotStudio
RC-WCS	World coordinate system as defined in the robot controller. It corresponds to the task frame of RobotStudio.
BF	Robot Base Frame
TCP	Tool Center Point
P	Robot target
TF	Task Frame
Wobj	Workobject

Continues on next page

Stations with multiple robot systems

For a single robot system, RobotStudio's task frame corresponds to the robot controller world coordinate system. When several controllers are present in the station, the task frame allows the connected robots to work in different coordinate systems. That is, the robots can be located independent of each other by defining different task frames for each robot.



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RS-WCS	World coordinate system in RobotStudio
TCP(R1)	Tool Center Point of robot 1
TCP(R2)	Tool Center Point of robot 2
BF(R1)	Base Frame of robot system 1
BF(R2)	Base Frame of robot system 2
P1	Robot target 1
P2	Robot target 2
TF1	Task Frame of robot system 1
TF2	Task Frame of robot system 2
Wobj	Workobject

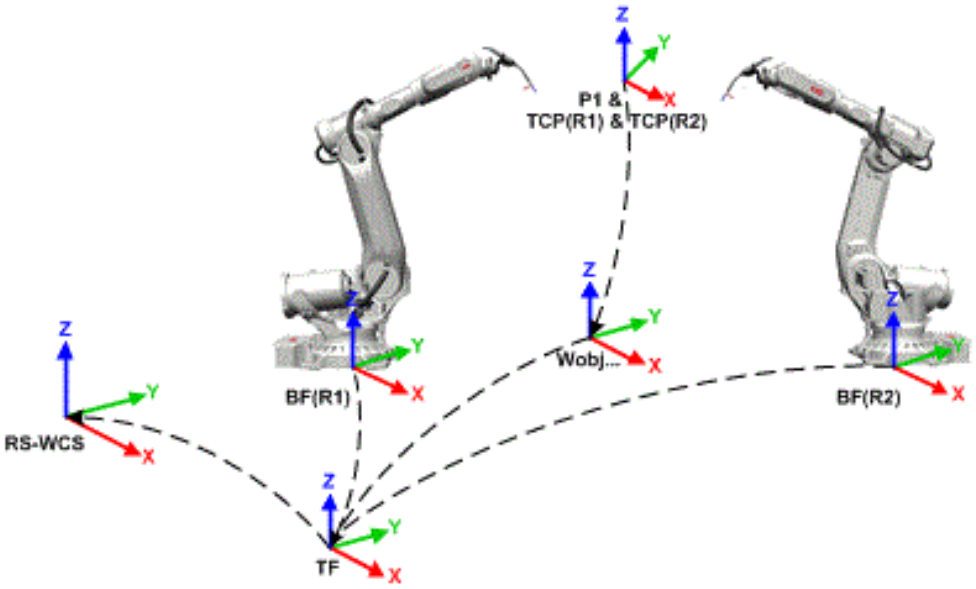
Continues on next page

1.2.2 Coordinate systems
Continued

MultiMove Coordinated systems

The MultiMove functions helps you create and optimize programs for MultiMove systems where one robot or positioner holds the work piece and other robots operate on it.

When using a robot system with the RobotWare option *MultiMove Coordinated*, it is important that the robots are working in the same coordinate system. As such, RobotStudio do not allow task frames of the controller to be separated.



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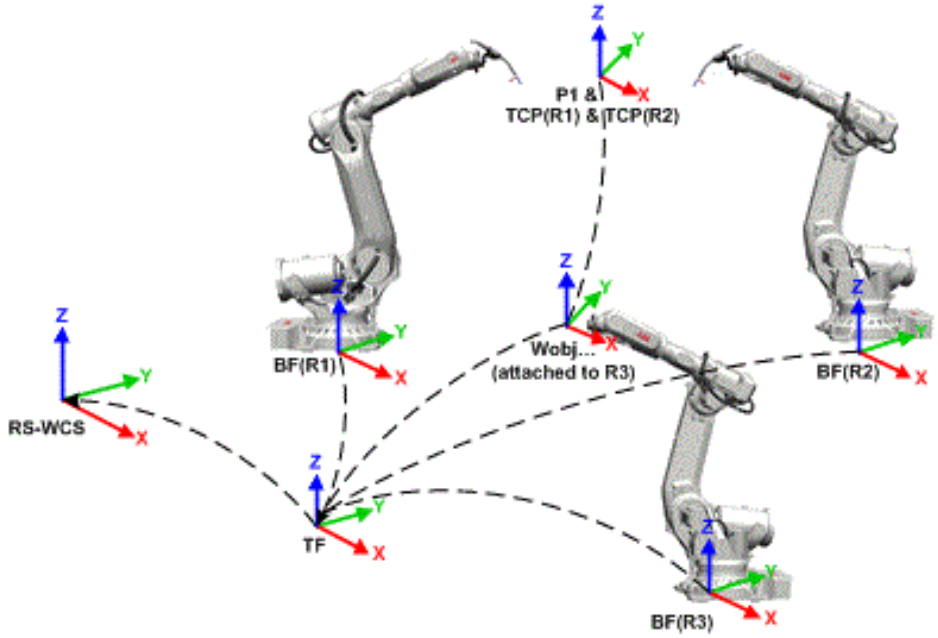

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RS-WCS	World coordinate system in RobotStudio
TCP(R1)	Tool Center Point of robot 1

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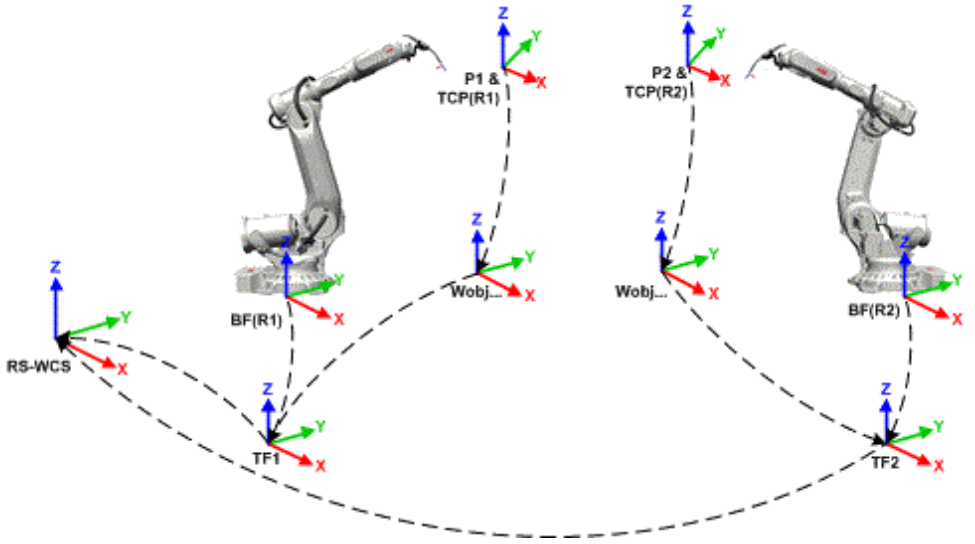
TCP(R2)	Tool Center Point of robot 2
BF(R1)	Base Frame of robot 1
BF(R2)	Base Frame of robot 2
BF(R3)	Base Frame of robot 3
P1	Robot target 1
TF	Task Frame
Wobj	Workobject

MultiMove Independent systems

For a robot system with the RobotWare option *MultiMove Independent*, robots operate simultaneously and independently while being controlled by one controller. Even though there is only one robot controller world coordinate system, robots often work in separate coordinate systems. To allow this setup in RobotStudio, the task frames for the robots can be separated and positioned independent of each other.



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RS-WCS	World coordinate system in RobotStudio
TCP(R1)	Tool Center Point of robot 1
TCP(R2)	Tool Center Point of robot 2
BF(R1)	Base Frame of robot 1
BF(R2)	Base Frame of robot 2
P1	Robot target 1
P2	Robot target 2
TF1	Task Frame 1
TF2	Task Frame 2
Wobj	Workobject

Continues on next page

1.2.2 Coordinate systems
Continued

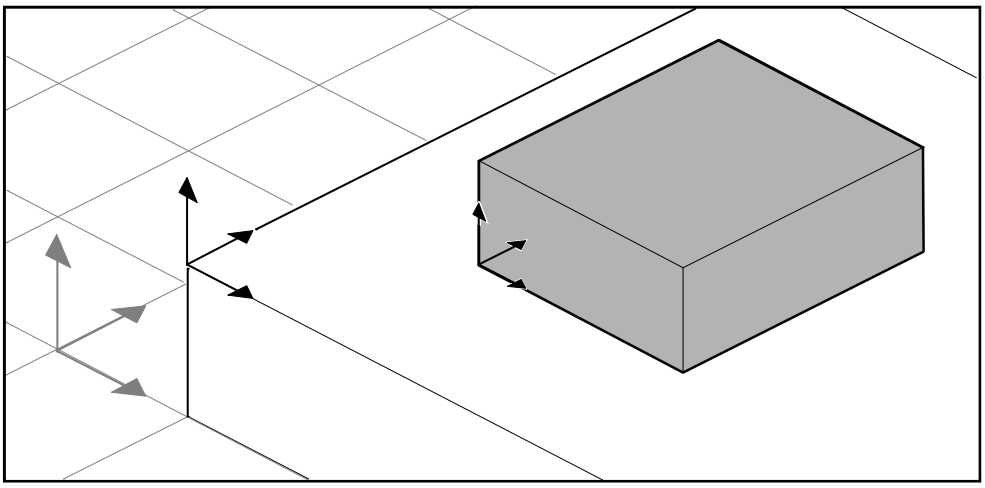
Workobject coordinate system

The workobject normally represents the physical work piece. It is composed of two coordinate systems: the *User frame* and the *Object frame*, where the latter is a child to the former. When programming a robot, all targets (positions) are related to the object frame of a workobject. If no other workobject is specified, the targets will be related to the default *Wobj0*, which always coincides with the base frame of the robot.

Using workobjects provides the chance to easily adjust robot programs with an offset, if the location of the work piece has been changed. Thus, workobjects can be used for calibrating offline programs. If the placement of the fixture or work piece relative to the robot in the real station does not completely match the placement in the offline station, you simply adjust the position of the workobject.

Workobjects are also used for coordinated motion. If a workobject is attached to a mechanical unit (and the system uses the option for coordinated motion), the robot will find the targets in the workobject even when the mechanical unit moves the workobject.

In the picture below the grey coordinate system is the world coordinate system, and the black ones are the object frame and the user frame of the workobject. Here the user frame is positioned at the table or fixture and the object frame at the workpiece.



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User coordinate systems

User coordinate systems are used for creating reference points of your choice. For example, you can create user coordinate systems at strategic points in the work piece to simplify programming.

2 Installation

2.1 Getting the software and license

Getting the software

The latest version of Machining PowerPac with the Machining functionality can be downloaded at: *http://new.abb.com/products/robotics/robotstudio/downloads*. The downloaded software will give you 30 days free use of the Add-In.

Obtaining a license

30-day free use is available after the software is downloaded for the first time. After 30 days, you must purchase a license for commercial use.

2.2 Prerequisites and system requirements

Prerequisites

To install Machining PowerPac with the Machining functionality, you must have the following items:

- RobotStudio and RobotWare installed on your computer.
- Machining PowerPac installation package.
- A license certificate.
- A Windows account with administrator's privileges.

System requirements

To work with Machining PowerPac - Machining, the following is required:

Required hardware

- CPU: 2.0 GHz Intel Pentium 4 or faster processor.
- Memory: 1 GB RAM or more (more is recommended).
- Available disk space: 5+ GB on the system disk, 250+ MB on the installation disk.
- Screen resolution: 1920 x 1080 pixels (recommended).
- Colors: 256 or higher.
- DPI: 120 dpi.
- Mouse: Three-button mouse.

Software requirements

- Microsoft Windows 7
- RobotStudio 2021.2

Note

Listed versions are the minimum versions required for running the Machining PowerPac - Machining. To use the latest features, it is highly recommended to update all the software to its latest version.

2.3 Installing

Overview

Before installing Machining PowerPac with the Machining functionality, make sure that RobotStudio and RobotWare have been installed on your computer.

Installing Machining PowerPac with the Machining functionality

Use this procedure to install Machining PowerPac with the Machining functionality:

	Action	Illustration/Note
1	Unzip the downloaded Machining PowerPac installation package and navigate to the decompressed directory.	
2	Double-click **ABB Machining PowerPac *XX*.exe**. The installation starts.	*XX* refers to the actual version to be installed.
3	Read the License Agreement and accept the terms. Then, click **Next**.	
4	Select a setup type, **Complete** or **Custom**. Then, click **Next**.	The **Complete** option is selected by default.
5	Click **Install**.	
6	When the installation is finished, click **Finish** to close the installation wizard.	

Installing a license

The procedure of installing a license is the same as that of RobotStudio. See *Operating manual - RobotStudio*.

2.4 Getting started

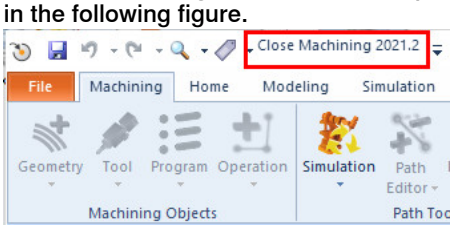
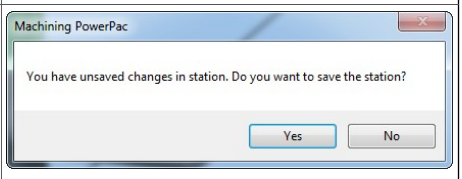
Starting Machining PowerPac - Machining

Use this procedure to start Machining PowerPac - Machining:

	Action	Illustration/Note
1	Open **RobotStudio**.	
2	Create a new station or load an existing one. For more information on how to manage a station, see *Operating manual - RobotStudio*.	**Note** Machining PowerPac - Machining cannot be started with an empty station.
3	On the **Add-Ins** ribbon tab on the RobotStudio ribbon, click **Machining** *XX* in the **PowerPacs** group.	*XX* refers to the actual version to be installed. **Machining 2021.2** is an example in the following figure.  xx1500000132
4	The **Machining** ribbon tab is displayed on the RobotStudio ribbon.	 xx1500000202

Closing Machining PowerPac - Machining

Use one of the following methods to close Machining PowerPac - Machining:

	Action	Illustration/Note
1	Click **Close Machining** *XX* on the RobotStudio tool bar.	*XX* refers to the actual version to be installed. **Machining 2021.2** is an example in the following figure.  xx1500000133
2	Alternatively, you can click **Machining** *XX* in the **PowerPacs** group on the **Add-Ins** ribbon tab.	*XX* refers to the actual version to be installed.
3	If there are any unsaved changes in the station, a dialog box is displayed. Click **Yes** to save the changes, or click **No** to discard the changes.	 xx1500000201

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	Action	Illustration/Note
4	The Machining PowerPac - Machining is closed.	

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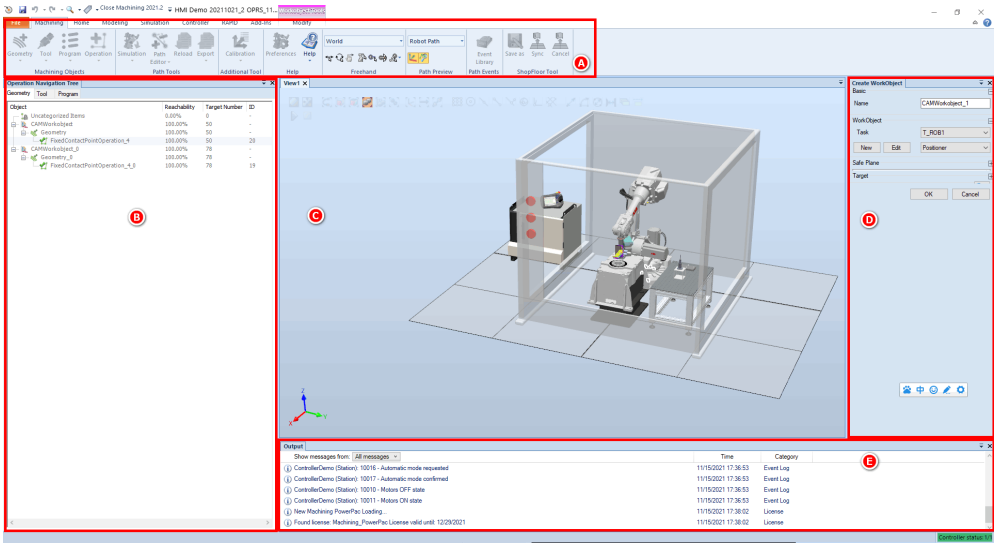
3 Navigating Machining PowerPac - Machining

3.1 The main window

Overview of the main window

The graphical user interface (GUI) of Machining PowerPac - Machining contains six main parts as shown in the following picture:



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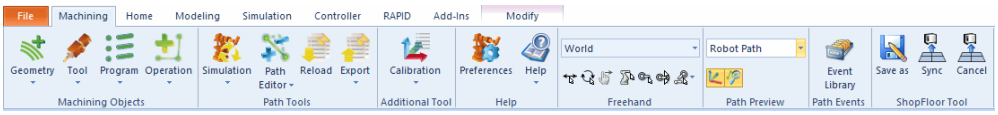
	Item	Description
A	Machining ribbon tab	The ribbon tab contains general commands.
B	Operation Navigation Tree	The **Operation Navigation Tree** organizes work objects, geometries, tools, program groups and operations in a tree structure in three tab pages, **Geometry**, **Tool** and **Program**.
C	3D graphics window	The graphics window provides an intuitive and real-time preview of settings. A path whose corresponding node is highlighted in the **Operation Navigation Tree**, is highlighted in the graphics window. The path simulation also demonstrates in the graphics window.
D	Setting window	After a specific function such as geometry creation and path editor is activated, a corresponding setting window is displayed.
E	Path simulation window	The path simulation window is a simulation control panel providing several functions facilitating the view of paths. This window is displayed in the same place as the **Output** window.
	Output window	The **Output** window is used to display system announcements and alerts.

3.2 Machining ribbon tab

Overview

The following figure shows the **Machining** ribbon tab. For guidelines on how to execute a certain function, see *Workflow for Machining PowerPac - Machining on page 47*.



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The tab consists of the following groups:

Group	Functions used for
Machining Objects	Creating work objects, geometries, tools, program groups and operations, and also setting their properties.
Path Tools	Working with generated paths, such as path editing, simulation, reload and export.
Additional Tool	Providing calibration functions.
Help	Providing preference settings and online help.
Freehand	Selecting coordinate system and moving or rotating selected objects.
Path Preview	Selecting path preview modes.
Path Events	Managing start events and end events that can be invoked before or after targets in a path.
ShopFloor Tool	Interacting with Machining ShopFloor HMI.

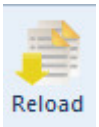
Machining Objects group

Function group	Button	Description
Geometry 	Import CAD Model 	For importing a CAD model into the Machining PowerPac - Machining.
	Create WorkObject 	For creating a work object on which the machining is processed.
	Create Geometry 	For creating a geometry curve that is the basis for generating a robot path.
	Check/Heal Model 	For checking or healing a selected part.

Continues on next page

Function group	Button	Description
Tool 	Create Tool 	For creating a tool used for machining.
	Tool Library 	For managing tools, such as tool name modification, tool deletion and tool sorting.
Program 	Create Program Group 	For creating a program for grouping operations.
Operation 	Create Operation 	For creating an operation to set specific path settings. Only operations associated with geometries and tools are valid.

Path Tools group

Function group	Button	Description
Simulation 	Simulate 	For simulating paths based on a chosen geometry or operation to test layout and robot program.
	Edit Collision Set 	For editing collision sets and selecting objects for collision check.
Path Editor 	Path Editor 	For adjusting robot target(s)' position and orientation.
	Path Optimize 	For automatically checking and resolving robot path process errors.
Reload 	-	For reloading the RAPID files to the Machining PowerPac - Machining, either from the controller or a local folder.

Continues on next page

Function group	Button	Description
Export 	Export Setting 	For adjusting export settings.
	Export Rapid 	Exports ABB RAPID files.
	Export to RW MFC 	Exports RobotWare Machining Force Control project files.

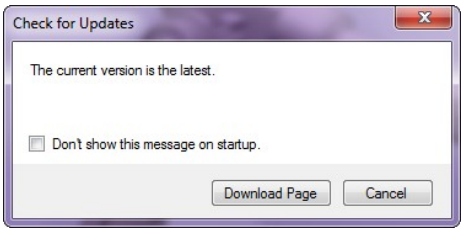
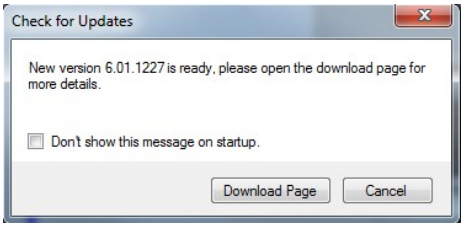
Additional Tool group

Function group	Button	Description
Calibration 	Calibration List 	Lists calibration tasks.
	Create Calibration (Robot Hold Tool) 	For calibrating fixed work objects.
	Create Calibration (Robot Hold WorkObject) 	For calibrating robot-hold work objects.
	Export 	Exports calibration tasks.

Help group

Function group	Button	Description
Preferences 	-	For setting general properties based on user preferences. See *Preferences dialog box on page 39* for detailed functions provided.

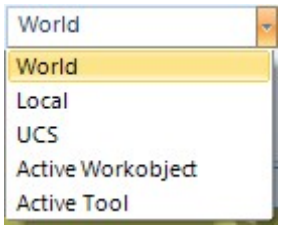
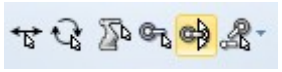
Continues on next page

Function group	Button	Description
Help 	Contents 	For opening the help file.
	Tutorials 	For opening tutorial with cases.
	Product Information 	For opening the product information webpage on ABB website.
	Check for Updates 	For checking updates. • If the software is in latest version, no further action is required. Click **Cancel** to close the displayed dialog box.  xx1500001751 • If the software is available for version update, click **Download Page** in the displayed dialog box to open the download webpage on ABB website.  xx1500001752
	About 	For displaying the version and other useful information.
	Clear Project 	For clearing all the data configured in Machining PowerPac - Machining and set the project to initialization status. In the displayed dialog box, entering capitalized "CONFIRM" to confirm the clearing operation.

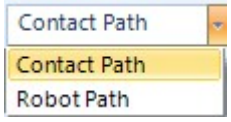
Continues on next page

3.2 Machining ribbon tab
Continued

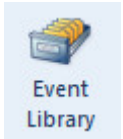
Freehand group

Button	Description
Reference Coordinate System 	For selecting a coordinate system. For more information, see *Operating manual - RobotStudio*.
Freehand option 	For moving and rotating the selected object in the station in relation with the specified coordinate system. For more information, see *Operating manual - RobotStudio*.

Path Preview group

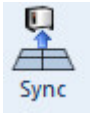
Button	Description
Path Preview Type 	For choosing a path preview type, contact path or robot path.
Frame 	For showing the target's frame.
Path 	For showing the path. This option is chosen by default.

Path Events group

Button	Description
Event Library 	For managing start events and end events that can be invoked before or after targets in a path. See *Event Library dialog box on page 45* for detailed functions provided.

Continues on next page

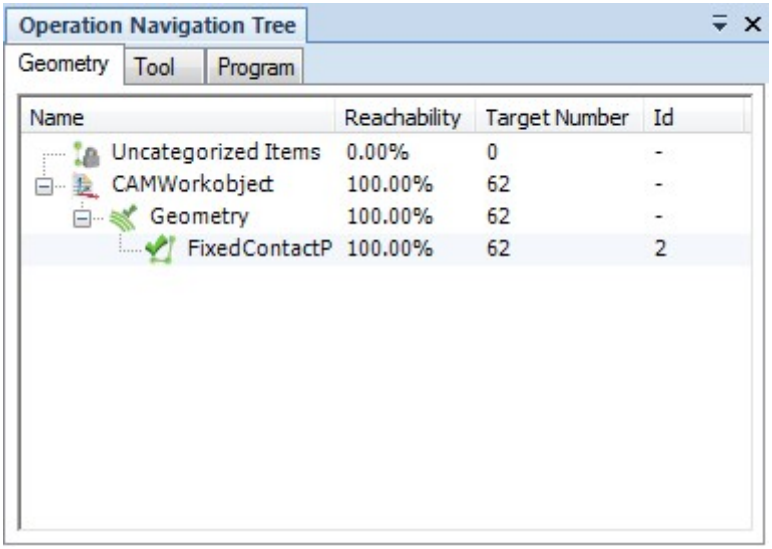
ShopFloor Tool group

Button	Description
Save as 	Saves the data edited in Machining PowerPac - Machining to a **.mpstn** file, which can be loaded in Machining ShopFloor HMI later.
Sync 	Synchronizes the data edited in Machining PowerPac - Machining to the connected Machining ShopFloor HMI. Machining PowerPac - Machining and Machining ShopFloor HMI must connect to the same controller.
Cancel 	Cancels the synchronization to Machining ShopFloor HMI.

3.3 Operation Navigation Tree

Overview

The **Operation Navigation Tree** is always visible on the left pane of the screen and provides an overview of different work objects, geometries, tools, and operations in three tab pages, **Geometry**, **Tool**, and **Program**.



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Node types

The following table describes the types of nodes in the **Operation Navigation Tree**.

Node type	Description
Uncategorized Items	An **Uncategorized Items** node is available in all tab pages, containing geometries who have no work object defined and operations that are not specified with any geometry, tool, or program group. If **Uncategorized Items** is selected from the **Work Object**/**Geometry** drop-down list during the geometry/operation creating, a message is displayed to notify you of no work object/geometry specified for the geometry/operation. (Note that this message is not displayed when no tool or program group is specified for an operation). After you confirm the setting, the geometry/operation is listed under this node in related view tab page but in error status. The nodes under the **Uncategorized Items** are invalid for processing.
Work object	Each work object is displayed as a separate node in the **Geometry** tab page with the specified name. A work object can have several geometry nodes.
Geometry	A geometry belonging to a specific work object is displayed as a child node under the corresponding work object node. A geometry can have several operation nodes.
Operation	An operation node is displayed under all its associated geometry and tool nodes. Operation nodes are allowed to be dragged to another parent node. After moving an operation node, you have to regenerate it to update its status.

Continues on next page

Node type	Description
Tool	Each tool is displayed as a separate node in the **Tool** tab page no matter whether the tools are in the same type. A tool can have several operations using the same tool data.
Program group	A program group node includes one or more operation nodes that will be processed as a group. The sequence of the operation nodes under a program node is the processing sequence. You can drag the operation nodes to modify the sequence.

Node status

The icons in the **Operation Navigation Tree** may vary depending on its current status. The following table describes different icon status.

Icon	Status	Description
	Error (On Geometry node)	Parameters of the geometry are invaild.
	Out of date (On Geometry node)	Parameters of the geometry are out of time and need to be regenerated.
	Up to date (On Geometry node)	Latest parameters of the geometry have been updated in the path. The nodes in this status is available for use.
	Error (On Operation node)	Parameters of the operation are invalid so that the path cannot be generated.
	Out of date (On Operation node)	Some settings have been modified and the robot path is out of time. Regenerate it.
	Up to date (On Operation node)	Latest parameters have been updated in the path. The nodes in this status is available for use.

Information columns

Four columns **Name**, **Reachability**, **Target Number**, and **Id** are displayed in the **Operation Navigation Tree**, enabling a quick view of required information about the created nodes.

- All created nodes are hierarchically listed by their default or specified names in the **Name** column.
- In the **Reachability** column, the reachable rates of nodes are shown in the brackets. The reachable rate of a parent node is calculated based the rates of all its child nodes. Only when all child nodes reach 100.00%, their parent node gets a 100.00% rate.
- The **Target Number** column provides the target quantities of the nodes. A parent node adds up the target quantities of all its child nodes and use the sum as its target quantity. If a child node changes its parent node, you must right-click the node and regenerate the path. Then, the target quantity of all nodes are automatically updated.
- A program group and an operation automatically get an ID after being created. IDs are assigned according to the creation sequence no matter whether an earlier ID is deleted. In the **Id** column, program group nodes and operation

Continues on next page

nodes are followed by their IDs and an en dash symbol "-" is displayed for other nodes.

Users can set which columns to be displayed and the column displaying order based on requirements. See *Navigation Tree on page 42*.

Task table

When right-clicking a node, a shortcut context menu is displayed. This menu is unavailable for the **Uncategorized** node.

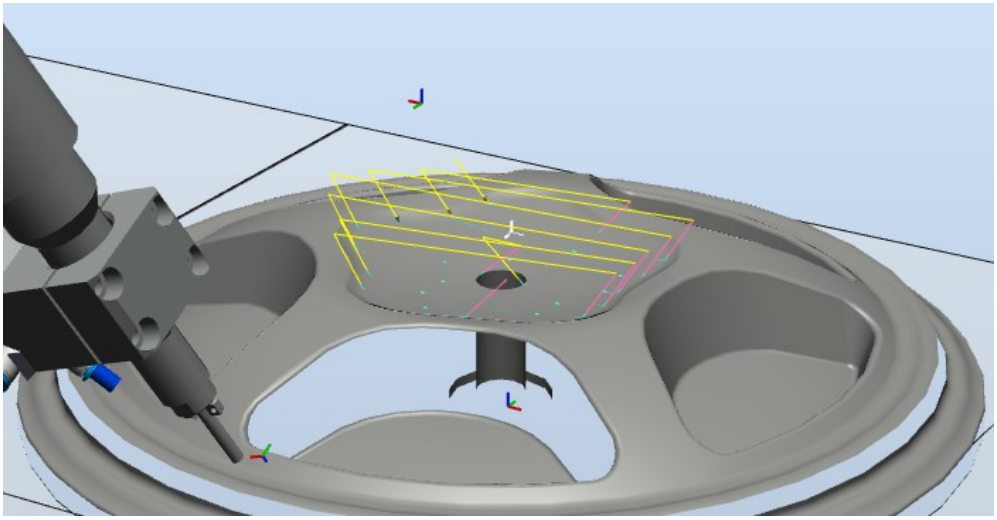
The following table describes the tasks in the context menus.

Task	Description
Edit	Displays the setting window for the selected node.
Delete	Deletes the node and all its child nodes.
Copy	Copies all attributes of the selected node.
Paste	Pastes the selected node as a new node that has all attributes of the original node. When a WorkObject node is copied, this command is displayed only when clicking on WorkObject nodes. When a Geometry, Tool, or Operation node is copied, the node can be pasted as a new node under its original parent node or under another parent node.
Regenerate Geometry	Updates geometry parameters to the latest settings.
Edit Feature Curve	Opens the **Edit Feature Curve** window on the right pane of the screen and edit the wires related to the geometry. This task is available only for the Geometry node.
Modify Start Point	Opens the **Modify Start Point** window on the right pane of the screen and allows to edit the start point of each wire related to the geometry. A proper point can be chosen and previewed while scrolling the position track bar. Click the **Modify Start Point** button to confirm the modification. The path must be regenerated to make the modification take effect. This task is available only for the Geometry node.
Export Geometry	Exports geometries to the modeling. This task is available only for the WorkObject and Geometry nodes.
Regenerate Path	Updates path parameters to the latest settings.
Show Path	Displays tool paths in the 3D graphics window. The task is unavailable for the Operation node.
Simulate Path	Opens the **Simulate** window on the lower pane of the screen.
Edit Path	Opens the setting window for Path Editor on the right pane of the screen.
Export Rapid	Exports Robot paths into RAPID files to the directory that the system identified. This task is available only for the Operation node.

Continues on next page

Actions

In the **Operation Navigation Tree**, when you click any node, the related paths will be displayed in the 3D graphics window as shown in the following figure.



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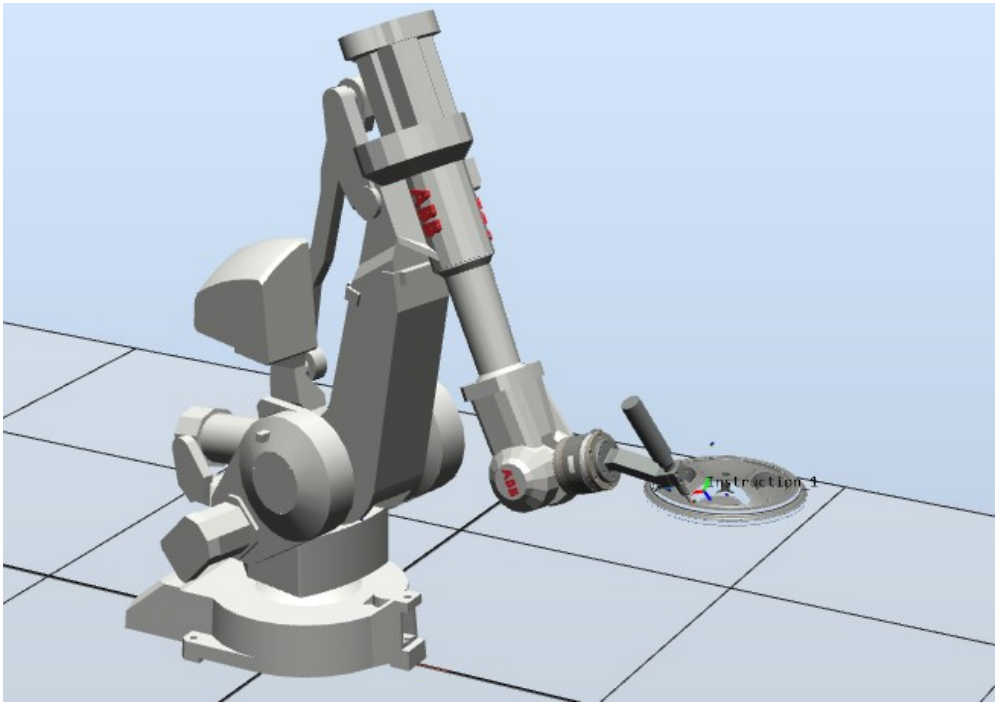
In addition, except for the **Uncategorized Items** node, you can double-click any node to open the related setting window for modification. Only one setting window can be opened each time, and geometry type and tool type cannot be modified.

3.4 3D graphics window

3D view interface

In this window, you can view settings, control graphics view, create new views, view/hide the selected targets, frames, paths, parts, and mechanisms. For detailed information, see *Operating manual - RobotStudio*.



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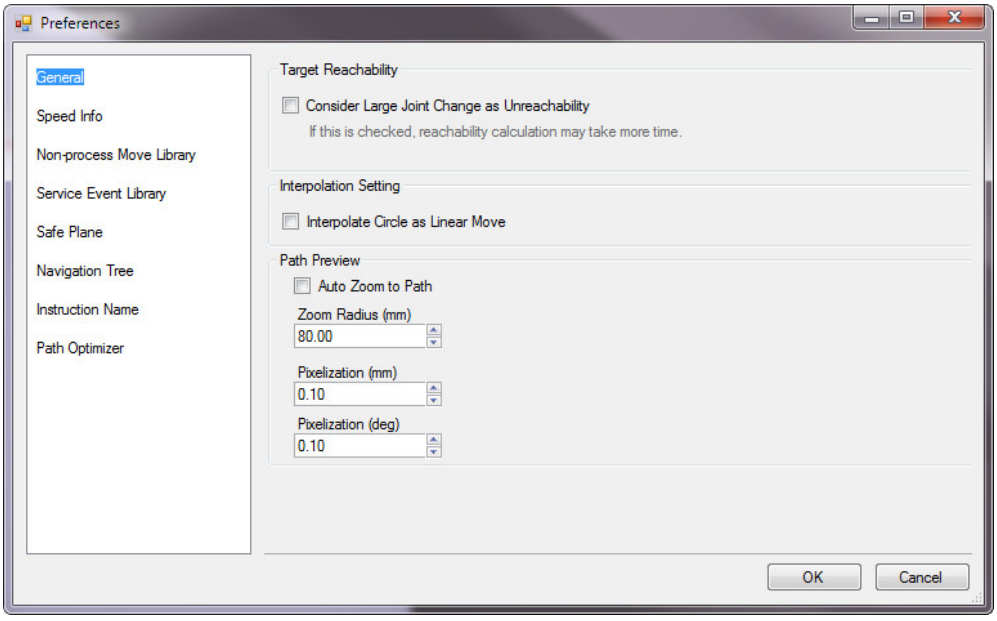
3.5 Preferences dialog box

Overview

In the **Preferences** dialog box, default and recommended preferences are provided.

General



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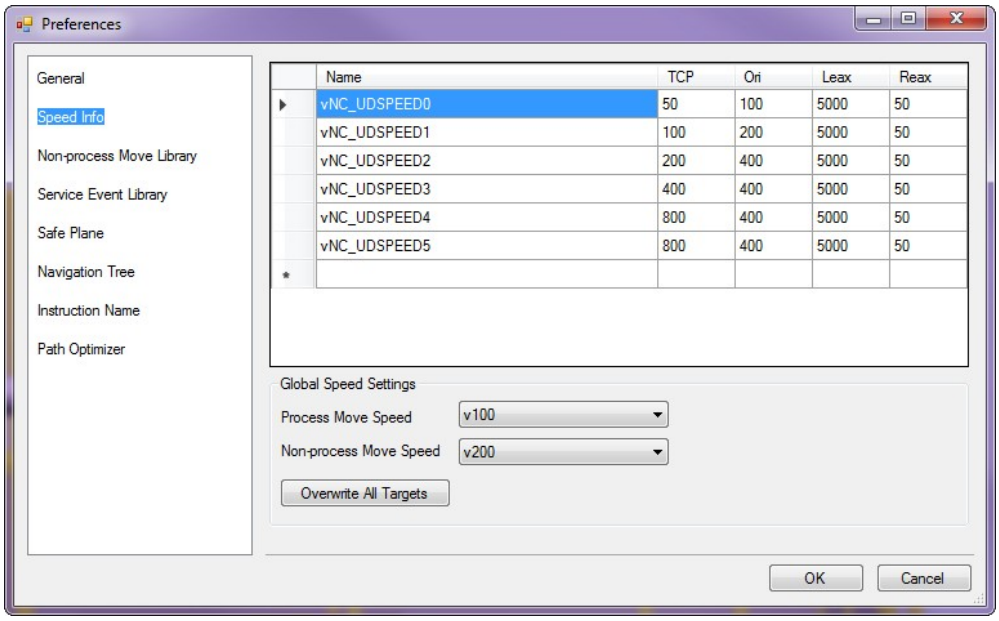
Item	Description
Consider Large Joint Change as Unreachability	If this check box is selected, the Large Joint Change targets, at which the robot axes may have large movements, will not be counted when calculating the reachable target rate.
Interpolate Circle as Linear Move	If this check box is selected, the tool moves using MoveL at the circles; if not selected, the tool moves using MoveC.
Auto Zoom to Path	If this check box is selected, the path is automatically displayed at the center of the 3D graphics window when clicking an operation node.
Zoom Radius (mm)	This parameter specifies the path preview size and its value defines the radius from the path center.
Pixelization (mm)	This parameter defines the minimum distance between two adjacent contact points of the tool along the path. If the actual distance is smaller than the defined value, the two contact points will be considered as one.
Pixelization (deg)	This parameter defines the minimum angles between two adjacent contact points of the tool along the path. If the actual angle is smaller than the defined value, the two contact points will be considered as one.

Continues on next page

3.5 Preferences dialog box
Continued

Speed Info



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Customized speed info

There is a customized speed info table. Users can add or modify speed info by setting a group of data here.

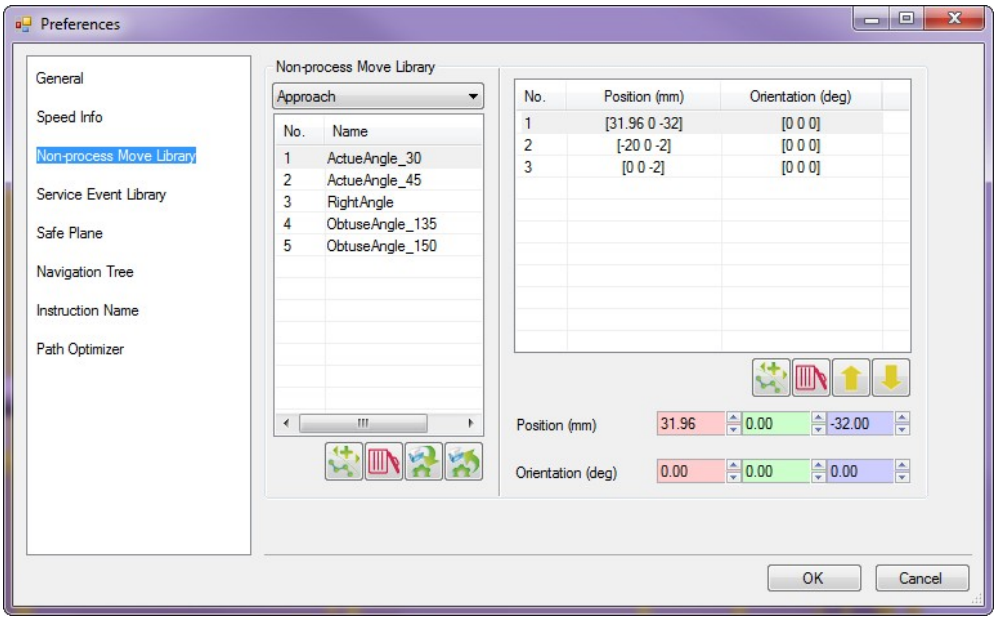
Item	Description
Name	Speed object name.
TCP	The speed of the tool center point (TCP) in mm/s.
Ori	The reorientation speed of the TCP expressed in degrees/s.
Leax	The speed of linear external axes in mm/s.
Reax	The speed of rotating external axes in degrees/s.

Global speed settings

Process move speed and non-process move speed can be set independently by selecting defined or customized speed data. After the setting, newly created operations will use the global speed settings by default. If you want to apply the settings to existed operations, click **Overwrite all targets** so that the operations will use the global speed settings.

Continues on next page

Non-process Move Library



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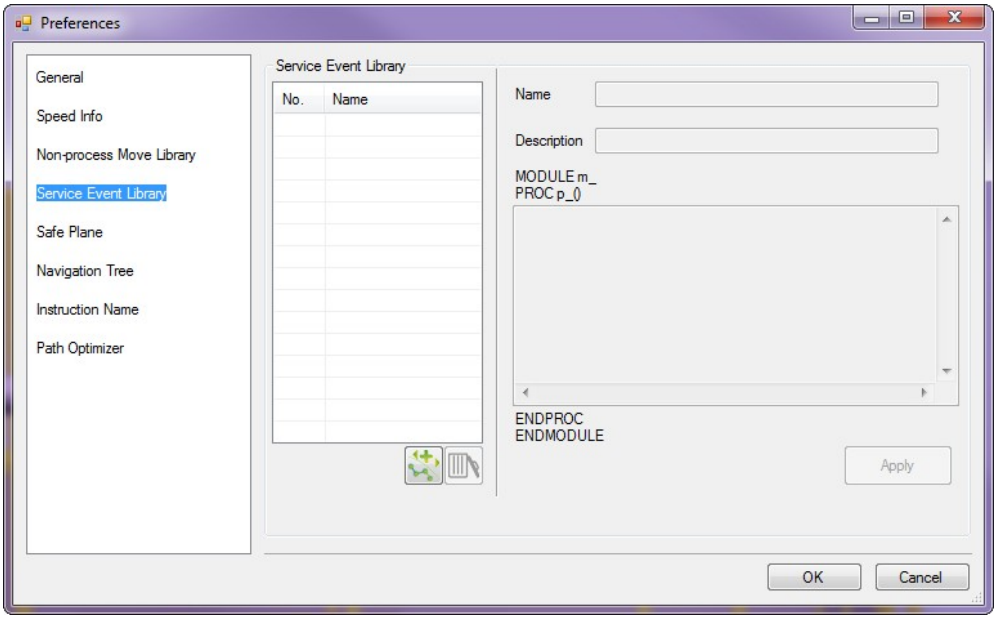
There are templates for tool approach or departure. These templates can be modified, deleted, or created by users. Each template may have one or more setting groups of positions and orientations, with the group sequence being able to be adjusted. When creating an operation, the templates are available for non-process move settings.

Service Event Library



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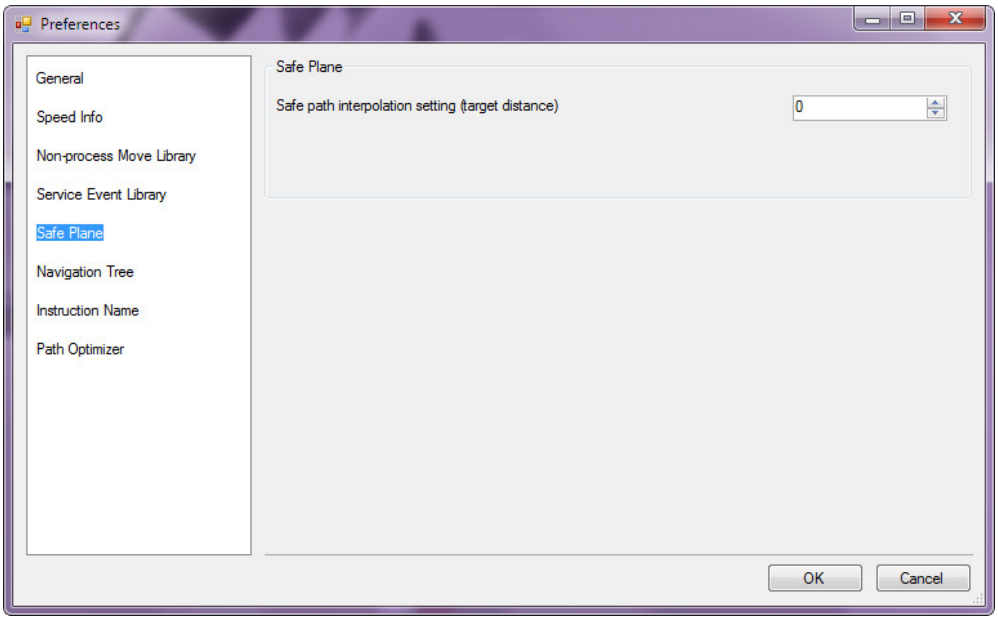
3.5 Preferences dialog box
Continued

If RAPID programs are required to be invoked before or after the operations, they can be set as start events or end events in the service event library. An existing event can also be modified or deleted.

Safe Plane



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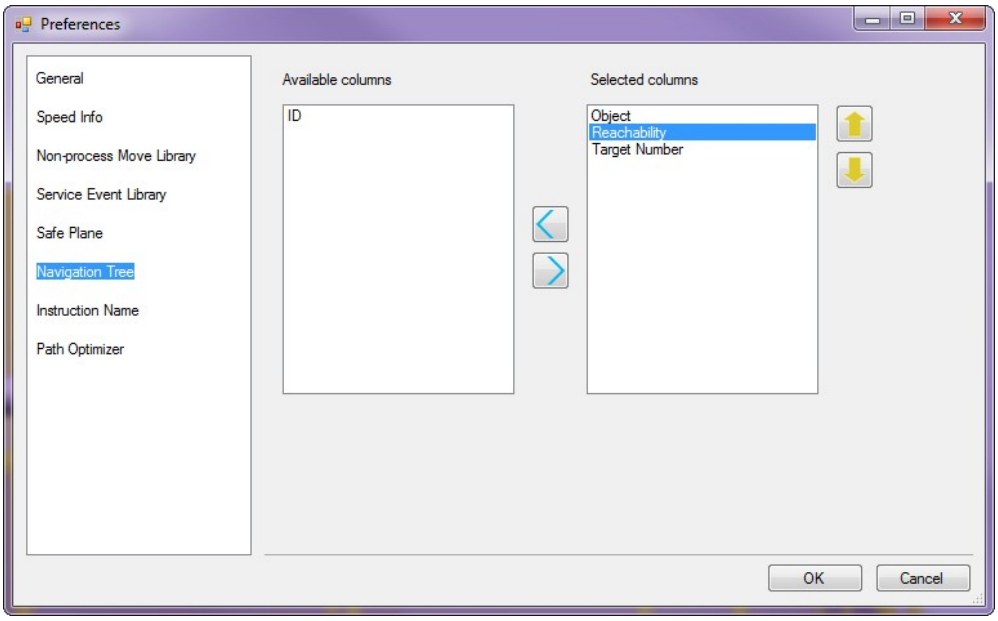
Item	Description
Safe path interpolation setting (target distance)	Distance between safe targets on the safe path. The default setting is 100 mm.

Navigation Tree



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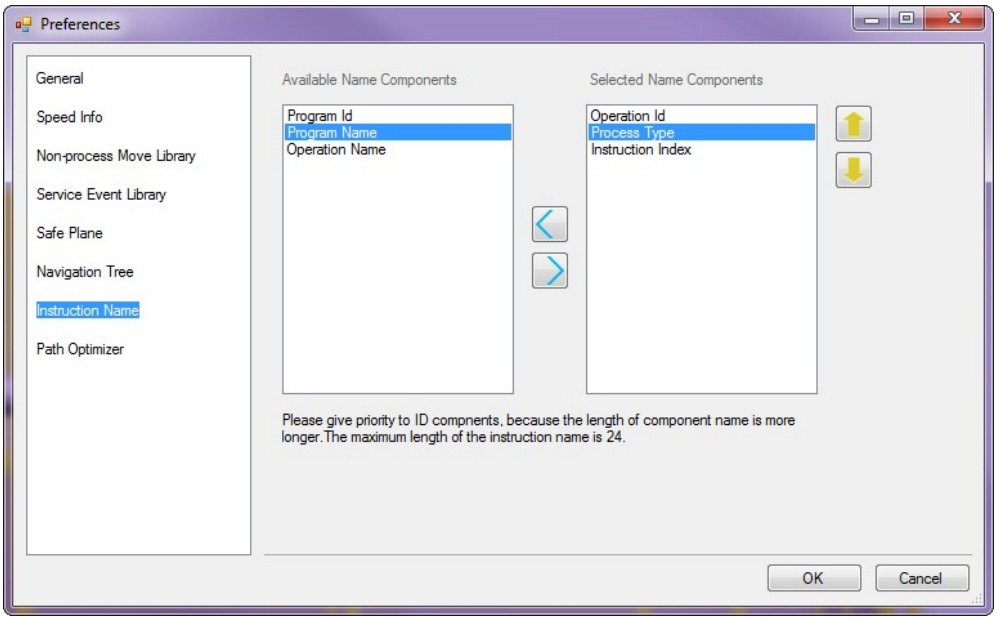
Information columns to be displayed in the **Operation Navigation Tree** can be set in this page. Users can select required column(s) from the **Available columns** area to the **Selected columns** by clicking the **Right** button or remove the selection by clicking the **Left** button. The displaying order of the selected columns can also be modified by clicking the **Up** and **Down** buttons.

Instruction Name



xx1500003071

Naming rules can be set in this page for instruction nodes displayed in the path editor.

Instruction names are formed by selected components. Users can select required component(s) from the **Available Name Components** area to the **Selected Name Components** area by clicking the **Right** button or remove the selection by clicking the **Left** button. **Instruction Index** is mandatory. The displaying order of the selected components can also be modified by clicking the **Up** and **Down** buttons. Because the maximum allowed length of an instruction name is 24 characters, it's recommended to set **Instruction Index**, **Program Id**, or **Operation Id** as the first component. When displayed, the components are separated by underlines, for example, Opr2_ProcStart_1.

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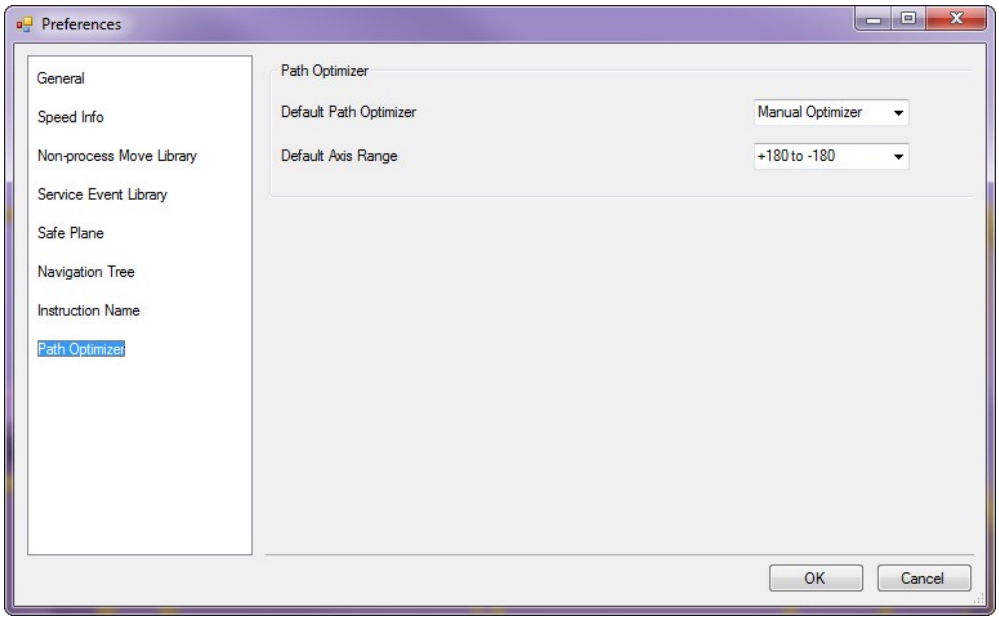
Path Optimizer



xx1600001205

Two optimizing methods are available, automatic path optimizing and manual path optimizing.

- If **Automatic Optimizer** is selected from the **Default Path Optimizer** drop-down list, automatic path optimizing is enabled. When choosing **Path Optimize** in the **Path Editor** category, users can perform automatic optimizing on path targets in the displayed **Path Optimize** window. For details, see *Automatic path optimizing on page 129*.

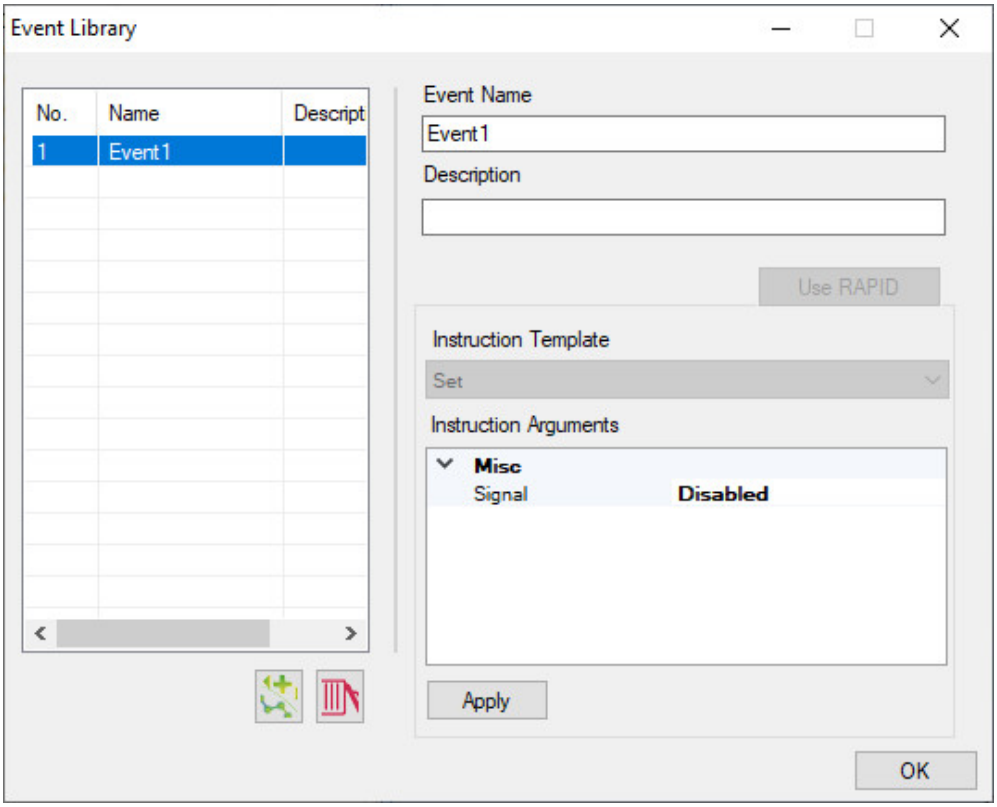
  > **Note**
  >
  > The setting in the **Default Axis Range** drop-down list is invalid for automatic path optimizing.

- If **Manual Optimizer** is selected from the **Default Path Optimizer** drop-down list, manual path optimizing is enabled. When choosing **Path Optimize** in the **Path Editor** category, users can perform manual optimizing on path targets in the displayed **Path Optimize** window. For details, see *Manual path optimizing on page 131*.

  For manual path optimizing, users can also choose the target rotation range by selecting **+180 to -180** or **+360 to -360** from the **Default Axis Range** drop-down list.

3.6 Event Library dialog box

Event Library



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If RAPID programs or signal triggers are required to be invoked before or after targets in a path, they can be set as start events or end events in the event library. An existing event can also be modified or deleted.

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4 Workflow for Machining PowerPac - Machining

4.1 About the workflow

Overview

The following is a recommended workflow for working with Machining PowerPac - Machining. After you complete the workflow, you can perform these tasks in any order.

Commands on the **Machining** ribbon tab will be described in each section.

> **Note**
>
> The Machining station (contains at least one robot system) should be set up in RobotStudio environment before starting Machining PowerPac - Machining, as the Machining PowerPac - Machining can only generate RAPID paths based on imported CAD models and cannot build stations. See *Operating manual - RobotStudio* for detailed information on how to setup a station in RobotStudio.

Workflow of Machining PowerPac - Machining

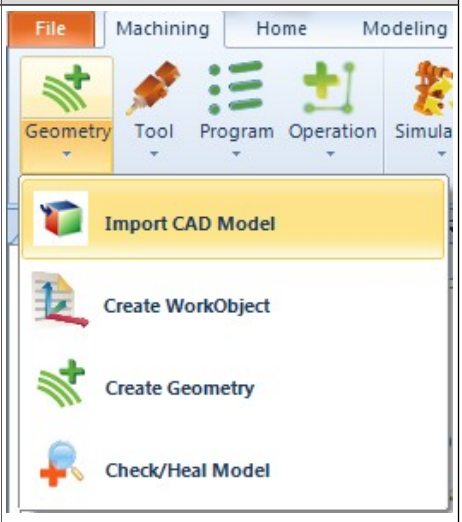
	Action	See
1	Import CAD models.	*Importing on page 48*
2	Create work objects and geometries.	*Creating work object and geometry on page 50*
3	Create tools.	*Creating tool on page 89*
4	Create program groups.	*Creating program group on page 95*
5	Create operations.	*Creating operation on page 98*
6	Simulate robot paths.	*Simulating robot path on page 108*
7	Edit and optimize the generated robot paths.	• *Path Editor on page 115* • *Automatic path optimizing on page 129* • *Manual path optimizing on page 131*
8	Perform calibration RAPID.	*Calibrating on page 136*
9	Export RAPID files or RW MFC project files.	*Exporting RAPID file on page 141*

4.2 Importing

Overview

CAD models are imported into the Machining PowerPac - Machining, based on which RAPID programs are generated.

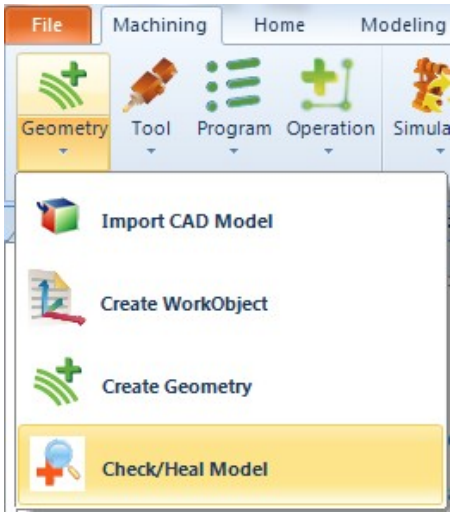
Use this procedure to import a CAD model.

	Action	Note
1	Select **Import CAD Model** from the **Geometry** category in the ribbon tab to start the import.	 xx1500000140
2	Locate your CAD file and click **Open**. The CAD model will be imported into the Machining PowerPac - Machining.	
3	The imported CAD model is automatically selected upon import, and ready for further adjustment. The default position is changed to (0, 0, 0).	
4	Drag the CAD model using the freehand functions to change its position and orientation in the 3D graphics window.	

Continues on next page

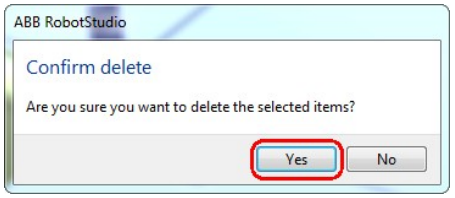
Checking/healing CAD model

If the imported CAD model has logical errors, use this procedure to check or heal the part.

	Action	Illustration/Note
1	Select **Check/Heal CAD Model** from the **Geometry** category in the ribbon tab.	 xx1500000142
2	Select the part to be checked or healed from the **Select Part** drop-down list.	 xx1500000143
3	Click **Check** or **Heal** to start the checking or healing. This function performs automatically.	

Deleting imported CAD model

After importing, the CAD model is listed as a node in the layout navigation tree of the **Home** page of the RobotStudio. Use one of the following methods to delete an imported CAD model.

	Action	Illustration/Note
1	Right-click the node and choose **Delete** from the shortcut menu.	
2	Click the node so that the part is high-lighted in the 3D graphics window. Then, press **Delete** on the keyboard.	
3	Click **Yes** in the prompted dialog box to confirm the deletion.	 xx1500000144

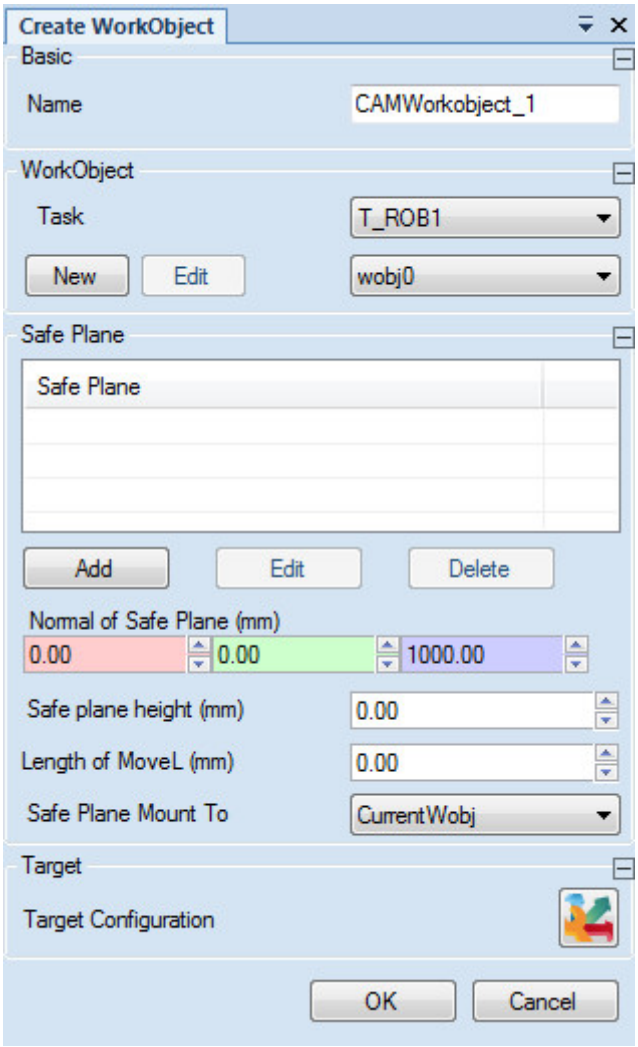
4.3 Creating work object and geometry

4.3.1 Creating a work object

Overview

Work objects set in RobotStudio are also available and valid for Machining PowerPac - Machining. Work objects created in Machining PowerPac - Machining can use the settings of RobotStudio work objects as a basis but work independently from those RobotStudio work objects. Only geometries associated to a work object can generate robot paths.

Create WorkObject window



xx1500000145

Group	Item	Description
Basic	Name	For specifying the name of the work object.

Continues on next page

Group	Item	Description
Workobject	Task	For selecting a work object already set in the RobotStudio.
	New	For creating a new work object.
	Edit	For editing the parameters of the selected work object.
Safe Plane	Add/Edit/Delete	For adding/deleting a safe plane for the specified work object to/from the list, and applying the direction modification.
	Normal of Safe Plane (mm)	The safe plane direction is specified. The combo box in red defines the direction along the X axis based on the specified work object, the combo box in green along the Y axis, and the combo box in blue along the Z axis.
	Safe plane height (mm)	For specifying the height of the safe plane from the work object. The safe plane is perpendicular to the Z axis of the work object. The value is larger than or equal to 0.
	Length of MoveL (mm)	For specifying the distance of MoveL interpolation along the tool axis. If a safe plane is specified, the tool departs along the tool axis using MoveL with the specified distance and then departs to the safe plane vertically using MoveJ. The value is larger than or equal to 0.
	Safe Plane Mount To	For specifying the reference of the to-be-defined safe plane. If **CurrentWobj** is selected, the values of **Normal of Safe Plane** and **Safe plane height** will be set based on the coordinate system of the current work object; If **WCS** is selected, the values of **Normal of Safe Plane** and **Safe plane height** will be set based on the world coordinate system.
Target	Target Configuration	For editing robot configuration and target settings.

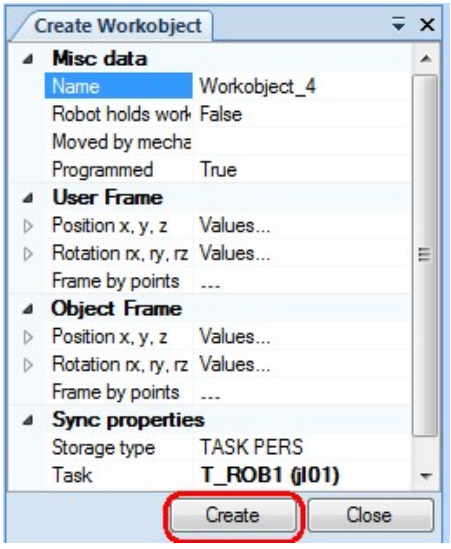
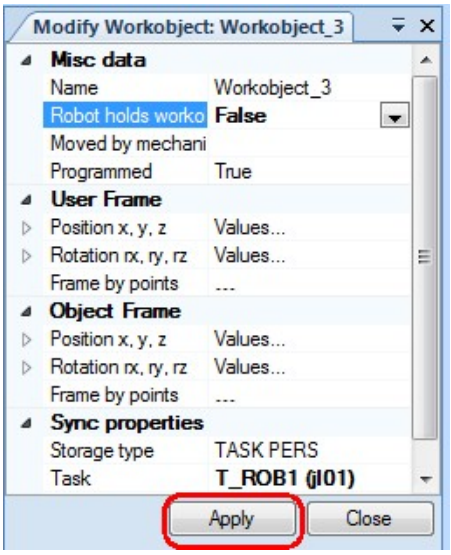
Procedure

Use this procedure to create a work object.

	Action	Illustration/Note
1	Select **Create WorkObject** from the **Geometry** category in the ribbon tab to open the work object creating window.	
2	Enter a name or remain the defaulted name for the work object in the **Name** text box.	

Continues on next page

4.3.1 Creating a work object
Continued

	Action	Illustration/Note
3	Select a work object from the drop-down list. **Tip** The work objects in the list are those set in the RobotStudio. If no work object is usable, click **New** to create a new one. Then, a parameter setting window is displayed on the left pane of the screen. You can modify the parameters as required and then click **Create**.	 xx1500000150 See detailed descriptions about parameter settings in RobotStudio.
4	If needed, edit work object parameters by clicking **Edit**. A parameter setting window in displayed on the left pane of the screen. You can modify the parameters as required and then click **Apply**.	 xx1500000151 **Note** Although the work objects created in Machining PowerPac - Machining are independent from the RobotStudio work objects, the parameter modifications still affect the RobotStudio work objects because they use RobotStudio work object settings as the basis.
5	Set the safe plane height and distance of MoveJ along the tool axis.	The settings will take effect for all operations belonging to the work object.

Continues on next page

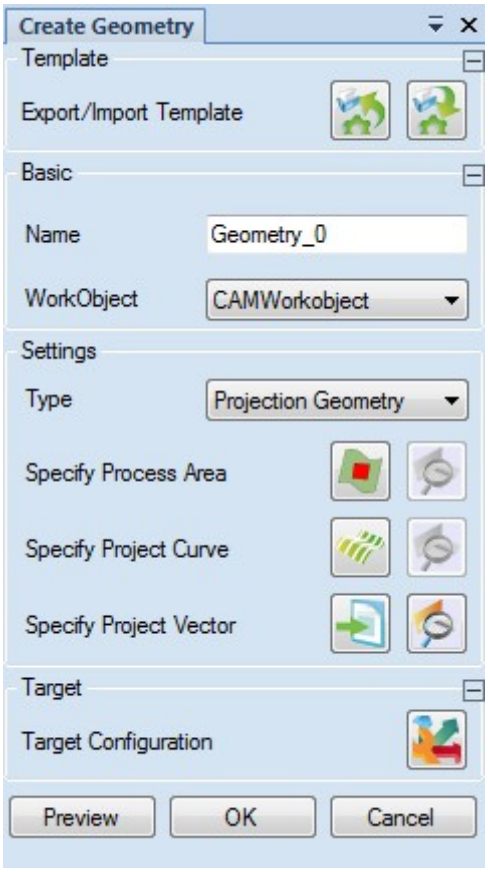
	Action	Illustration/Note
6	Edit robot configuration and target settings. For details, see *Configuring a target on page 83*.	
7	Click **OK** to apply the settings. A work object node is displayed in **Geometry** tab page of the **Operation Navigation Tree**.	

4.3.2 General procedure for creating a geometry

Overview

Based on the feature of the imported CAD model, users can create geometries that are then used for generating the robot path. Geometry settings are allowed to be exported as templates for reusing. In addition, geometries can also be exported as independent modeling to RobotStudio for reuse by others or in other cases. Five types of geometry curves are described below to meet different application scenarios. For the detailed definition of each curve, see *Main definitions on page 13*.

Create Geometry window



xx1500000146

Note

The **Create Geometry** window uses the creating of a projection geometry as an example. The available buttons vary based on the selected geometry type in the **Settings** area in the **Create Geometry** window.

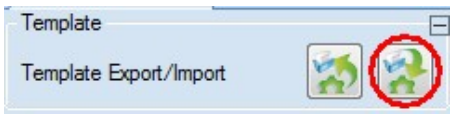
Button	Description
Template Export	Opens a new window to select a directory for saving the currently set parameters as a template. The template is saved in an .xml file.

Continues on next page

Button	Description
Template Import	Opens a new window to select a geometry template with preset parameters. After a template is imported, the parameters can be set as required.
Specify Process Area	Opens the **Process Area** window to select faces on which the machining is processed. For details, see *Editing settings for a specific geometry on page 56*.
Specify Project Curve	Available for creating a projection geometry. Opens a new window to set properties of the project curves. For details, see *Specifying project curves on page 64*.
Specify Project Vector	Available for creating a projection geometry. Opens a new window to set properties of the project vector. For details, see *Specifying project vector on page 71*.
Specify Cutting Plane	Available for creating a intersection geometry. Opens a new window to set properties of the cutting plane. For details, see *Specifying cutting plane on page 75*.
Specify UV Parameter	Available for creating U/V curves. Opens a new window to set parameters of the U/V curves. For details, see *Specifying UV parameters on page 77*.
Specify Edge	Available for creating edge-based curves. Opens a new window to set parameters of edge-based curves. For details, see *Specifying edges on page 80*.
Customized Curve	Available for creating customized curves. Opens a new window to set parameters of the customized curves. For details, see *Specifying customized curve on page 81*.
Preview	Displays a preview based on the parameter settings in the 3D graphics window.
Target Configuration	Opens the configuration window for editing target settings.

Importing geometry settings

If existing geometry settings are available for reusing, you can use this procedure to import them for creating the geometry. After the import, the settings can either be used directly or modified as required.

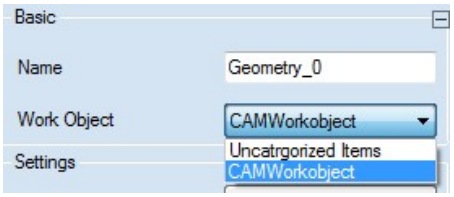
	Action	Illustration/Note
1	Select **Create Geometry** from the **Geometry** category in the ribbon tab to open the **Create Geometry** window.	
2	Click the **Import** button to open the import window.	 xx1500000152
3	Navigate to the directory where the geometry template is saved.	
4	Select the template file.	
5	Click **Open**.	

Continues on next page

4.3.2 General procedure for creating a geometry
Continued

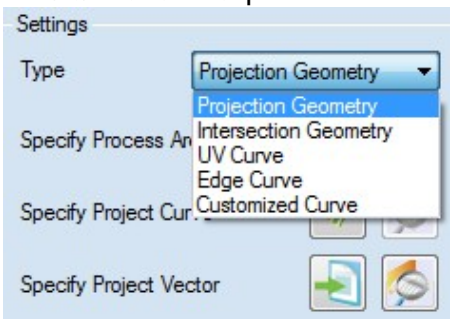
Editing basic info

Use this procedure to edit basic info about a geometry.

	Action	Illustration/Note
1	Enter a name or remain the defaulted name for the geometry in the **Name** text box.	
2	Select the work object to which the geometry belongs. **Note** The latest created work object is selected by default. **Uncategorized Items** can also be selected for a temporarily created geometry.	 xx1500000154

Editing settings for a specific geometry

Use this procedure to edit settings for a specific geometry.

	Action	Illustration/Note
1	Select the required geometry type from the **Type** drop-down list.	The selection of a projection geometry is illustrated as an example.  xx1500000153

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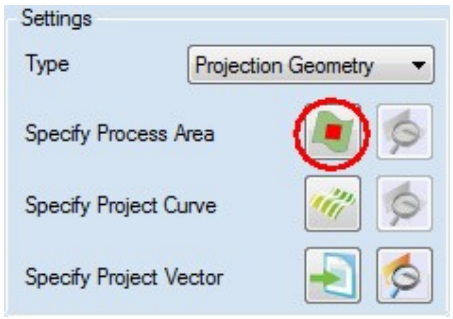
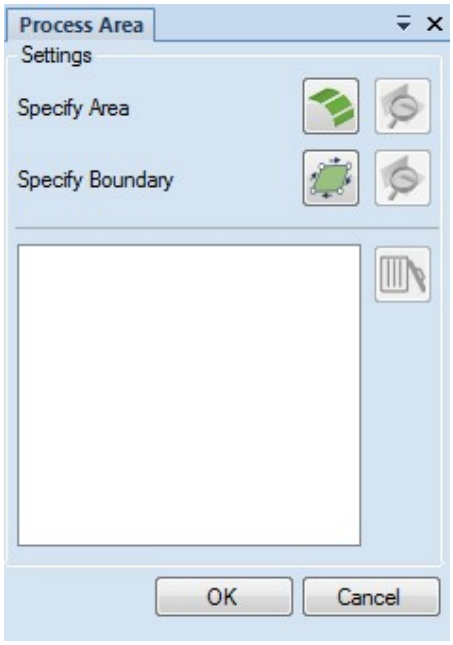
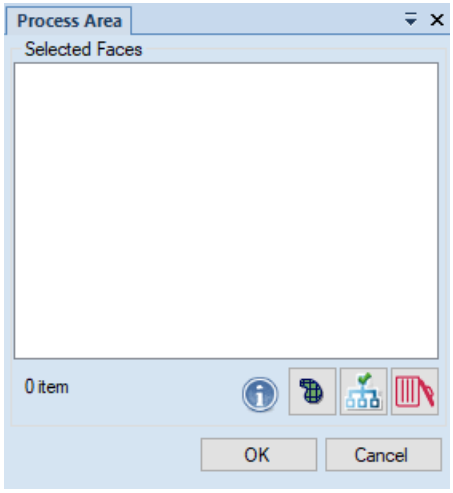
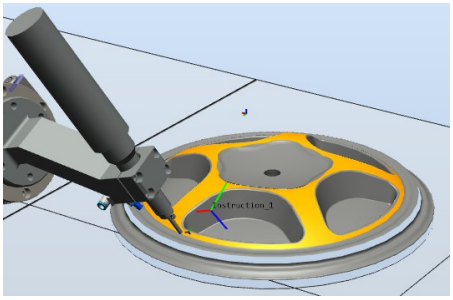
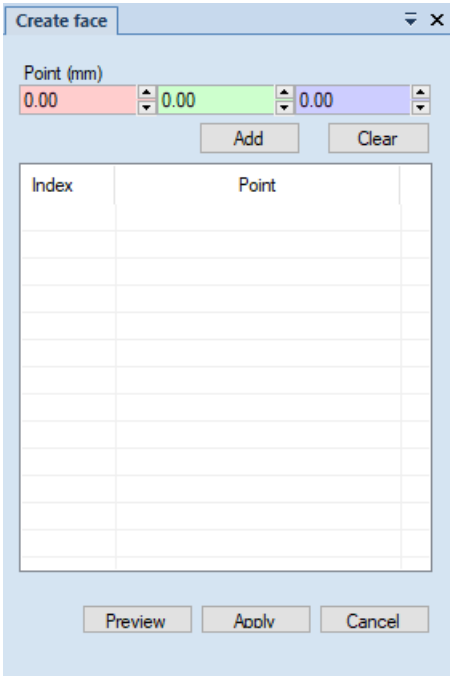
	Action	Illustration/Note
2	Click **Specify Process Area**. The **Process Area** window with the **Settings** area is displayed.	 xx1500000155  xx1500000157
3	Click **Specify Area**. The **Selected Faces** area for listing all selected surfaces is displayed.	 xx1500001746  xx1500001750

Continues on next page

4.3.2 General procedure for creating a geometry

Continued

	Action	Illustration/Note
4	Click part surfaces in the 3D graphics window. The selected parts are highlighted and listed in the **Selected Faces** area.	 xx1500000158
5	If the existing part surfaces cannot be selected to meet the processing requirement, click the **Customized face(s)??** button to specify a required area to generate a separate surface for processing. **Note** If some of part surfaces are already selected, the **Customized face(s)** button is unavailable.	
	In the displayed **Create face** window, specify the surface as follows: 1 Click the combo boxes in the **Point (mm)** area to activate the point selection. 2 Select required points by clicking in the 3D graphics window. The coordinates of the selected points are automatically displayed in the point list. You can also add points by modifying the coordinates in the **Point (mm)** combo boxes and clicking **Add**. To remove points, click **Clear**. Then, all the points in the list will be removed. 3 Choose the index of four points that will be used to form the surface. You can add as many points as you want but only four could be selected. Other points will function as the transition points. The first point shall be always selected. 4 Click the **Preview** button to have a preview on the defined surface. If needed, modify the selection. 5 Click **Apply**.	 xx2200002038

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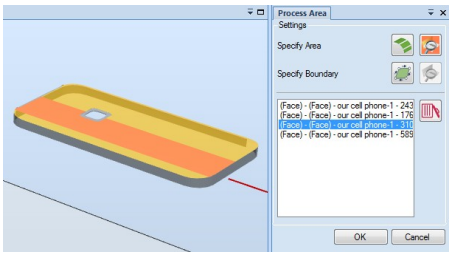
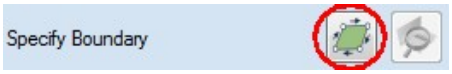
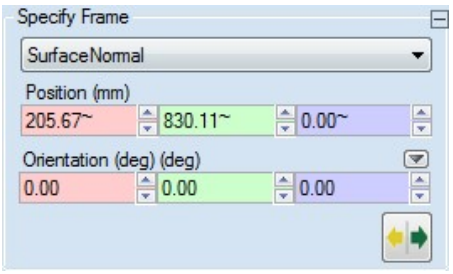
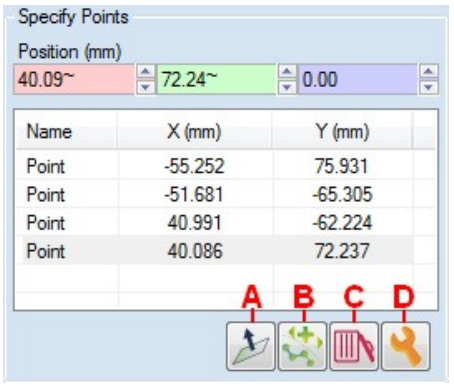
	Action	Illustration/Note
6	Click an item in the list to view a specific selected surface or select several items by pressing **Ctrl** or **Shift** while dragging the mouse to view some selected surfaces. **Note** You can view all selected surfaces once by clicking the **Select all face(s) in the list** button. **Note** If it is a customized face defined in previous step, only the customized face is displayed in the list and no other part surfaces can be selected.	
7	To delete a surface in the selected face list, right-click the item to be deleted and choose **Delete** from the shortcut menu, or click the item to be deleted and then click the **Delete selected face(s)** button.	
8	Click **OK** to return to the **Process Area** window with the **Settings** area. All selected surfaces are also listed in this area.	
9	Click the **Preview** button to have a preview on the selected surfaces. If needed, modify the selection.	 xx1500001773
10	To define a more specific area to be processed within the specified surface area, click **Specify Boundary**. **Note** Specifying boundary function is unavailable when creating an edge geometry or customized geometry.	 xx1500001748

Continues on next page

4.3.2 General procedure for creating a geometry
Continued

	Action	Illustration/Note
11	In the displayed area, specify a frame as follows: 1 Select a frame type from the **Specify Frame** drop-down list. 2 Click the combo boxes to activate **Position (mm)** and **Orientation (deg)**. **Tip** You can specify orientation values in either triple mode or quadruple mode by selecting between **PRY angles (Euler ZYX)** and **Quaternions**. 3 Click a point whose frame will be used in the 3D graphics view. You can also enter a value directly in the combo boxes or click the up/down arrows to choose a value. 4 If needed, click the **Reverse** button to obtain a reversed orientation based on the entered values. The values are changed after clicking the button. Click the button again to return the original entered values of the orientation.	 xx1500001744

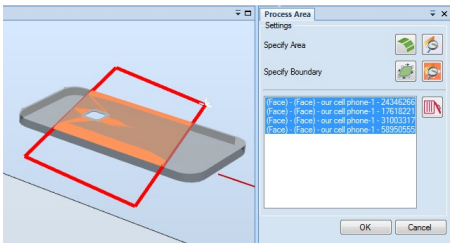
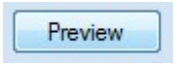
Continues on next page

	Action	Illustration/Note
12	Specify the points used to form the boundary as follows: 1 To change the view to facilitate the point selection, click the **Change view** button to have a top view based on the selected frame. 2 Select a required point by clicking in the 3D graphics window. The coordinate of the selected point is automatically displayed in the combo boxes in the **Position (mm)** area. 3 If the point location is as intended, click the **Add point** button to add the point. The point with detailed data of its coordinate will be shown in the list. You can also double-click a required point in the 3D graphics window to simply add the point directly. 4 Repeat point selection until all points for generating a required processing area are selected. A line is automatically displayed between two consecutively selected points in the 3D graphics window. After three or more points have been selected, an enclosing area is generated and displayed automatically. 5 If a point needs to be modified, click the point in the list. Then, drag the freehand to move the point to a desired position and then click the **Modify selected point** button to accept. 6 If a point needs to be deleted, click the point in the list and then click the **Delete selected point(s)** button to delete it. It is possible to select and delete several points by pressing **Ctrl** or **Shift** while dragging the mouse.	 xx1500001745 A — Change view B — Add point C — Delete selected point(s) D — Modify selected point
13	Select the processing area cutting side by choosing either **Inside** or **Outside** from the **Material Side** drop-down list. • If **Inside** is selected, the area within the specified boundary will be the actual processing area. • If **Outside** is selected, the area beyond the specified boundary but within the specified surfaces will be the actual processing area.	 xx1500001749
14	Click **OK** to return to the **Process Area** window with the **Settings** area.	

Continues on next page

4.3.2 General procedure for creating a geometry

Continued

	Action	Illustration/Note
15	Click the **Preview** button to have a preview on the surfaces to be processed within the specified boundary. If the surfaces are improper or required to be removed, click the **Delete selected face(s)** button to remove. If they are the required ones, click **OK** to return to the **Create Geometry** window.	 xx1500001774
16	Set detailed parameters for the specific geometry. **Note** Parameters for setting vary based on geometry types. Refer to the related section below for detailed information. • Projection geometry: See *Projection geometry on page 64*. • Intersection geometry: See *Intersection geometry on page 73*. • UV curve: See *UV curve on page 77*. • Edge curve: See *Edge curve on page 79*. • Customized curve: See *Customized curve on page 81*.	
17	Click the **Preview** button to have a preview on the settings. If needed, modify the settings.	
18	If needed, configure the target by clicking **Target Configuration**. For details, see *Configuring a target on page 83*.	 xx1500000159
19	Click the **Preview** button to preview the generated curve.	
20	Click **OK** to apply the settings. A geometry node with the specified name is displayed under the related work object node or **Uncategorized Items** node.	

Continues on next page

Exporting geometry settings

Parameter settings of a geometry can be saved as a template in .xml format for further use. Using templates provides conveniences to apply same or similar settings from one work object/station to another. Use this procedure to export geometry settings.

	Action	Illustration/Note
1	Click the **Export** button open the export window.	 xx1500000160
2	Navigate to the directory where the geometry template is to be saved.	
3	Specify a name for the template.	
4	Click **Save**.	

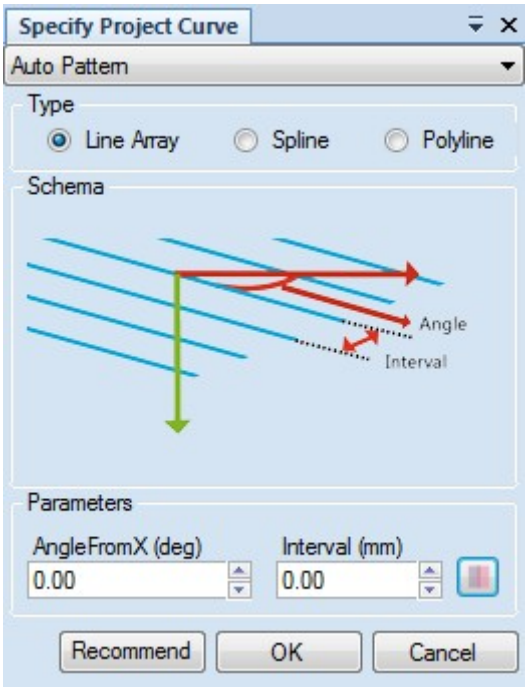
4.3.3 Specific procedures for each geometry type

4.3.3.1 Projection geometry

Specifying project curves

Project curves can be specified in three modes, by using automatically set patterns, manually creating new patterns or using selected RobotStudio curves. Specifying curves by automatically set patterns is the default mode that provide the easiest way to specify curves. Manually creating new patterns is similar to specifying by auto patterns but enables users to customize frame and line parameters. Users can also use existed curve(s) defined in RobotStudio by selecting them.

Auto Pattern



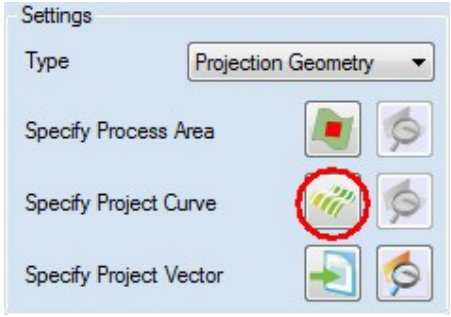
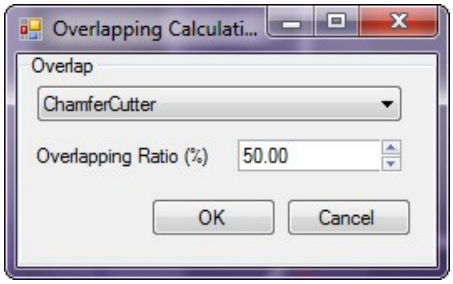
xx1500000161

Group	Item	Description
Type	Line Array	A set of parallel lines will be projected onto the selected surfaces to generate feature curve(s). This is the default type.
	Spline	A set of B-curves will be projected onto the selected surfaces to generate feature curve(s).
	Polyline	A set of zig-zag curves will be projected onto the selected surfaces to generate feature curve(s).
Schema	-	A simple schema of the selected type is shown in this area.

Continues on next page

Group	Item	Description
Parameters	AngleFromX (deg)	The lines rotate along the X axis to the specified degree. The value must be set to larger than 0. A larger value enables the lines to rotate counterclockwise, while a smaller value enables to rotate clockwise.
	Interval (mm)	The interval between two lines. The value must be set to larger than 0. A larger value indicates a wider interval between lines and a smaller value provides an opposite effect.
	Overlapping Calculation	The interval between two lines is automatically calculated based on the selected tool and set overlapping ratio. After clicking the button, a dialog box is displayed for choosing a tool from the tool list and setting the ratio to a value ranging from 0% to 99.99%. Only face-machining tools are listed and the default ratio is 50%.
Others	Recommend	The parameters are set to the recommended values.

Use this procedure to specify a project curve by patterns.

	Action	Illustration/Note
1	Click the **Specify Project Curves** button. A new window is displayed.	 xx1500000156
2	Select **Auto Pattern** from the drop-down list.	
3	Select a curve type as required.	
4	Set **AngleFromX (deg)** and **Interval (mm)** as required by entering a value directly in the text boxes or clicking the up/down arrows to choose a value. For setting line interval, you can also click the **Overlapping Calculation** button to perform an automatic calculation by specifying a face-machining tool and setting the overlapping ratio in the displayed dialog box.	 xx1500001376
5	If needed, click the **Recommend** button to obtain recommended values.	**CAUTION** All user settings will be overwritten when clicking **Recommend**.
6	Click **OK** to return to the **Create Geometry** window or click **Cancel** to discard all settings.	

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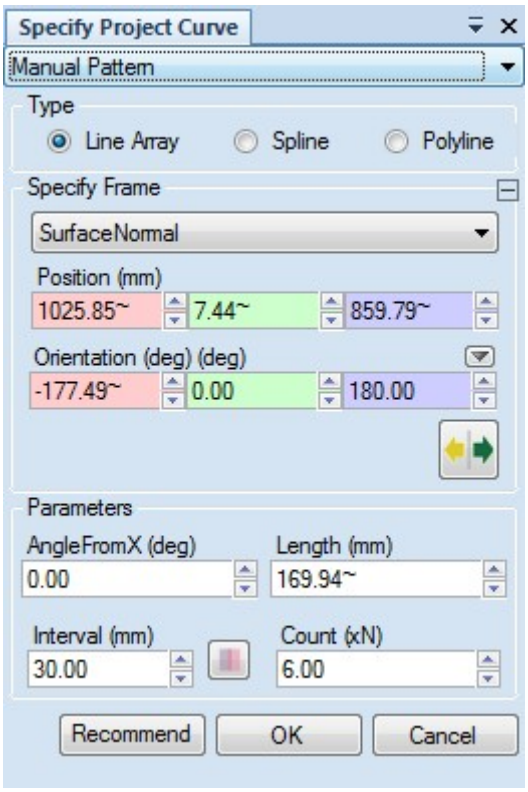
4.3.3.1 Projection geometry

Continued

Manual Pattern



xx1500000162

Group	Item	Description
Type	Line Array	A set of parallel lines will be projected onto the selected surfaces to generate feature curve(s). This is the default type.
	Spline	A set of B-curves will be projected onto the selected surfaces to generate feature curve(s).
	Polyline	A set of zig-zag curves will be projected onto the selected surfaces to generate feature curve(s).

Continues on next page

Group	Item	Description
Specify Frame	Specify Frame	Users can specify the type of a coordinate direction that will be used as the Z axis of the frame based on which the curves to be projected are generated. The following options are available: • SurfaceNormal: The normal of a selected point on the specified surface is used. • Curve Tangency: The curve tangent direction of a selected point on the specified surface is used. • Edge Tangency: The edge tangent direction of a selected point on the specified surface is used. • Global_X/Y/Z: The X/Y/Z axis of the global frame is used. • User_Frame_X/Y/Z: The X/Y/Z axis of the user frame is used. • Object_Frame_X/Y/Z: The X/Y/Z axis of the object frame is used. • Body_Frame_X/Y/Z: The X/Y/Z axis of the part frame is used.
	Position (mm)	A fixed point is specified as the original position for the frame. The combo box in red defines coordinate of the point in X axis, the combo box in green in the Y axis, and the combo box in blue in the Z axis. The value range is 0 to 180.
	Orientation (deg)	Frame orientation with the original position as the center. The combo box in red defines the orientation with the X axis as the center, the combo box in green with the Y axis as the center, and the combo box in blue with the Z axis as the center. All values must be set to larger than 0.
Parameters[i]	AngleFromX (deg)	The lines rotate along the X axis to the specified degree. The value must be set to larger than 0. A larger value enables the lines to rotate counterclockwise, while a smaller value enables to rotate clockwise.
	Length	The line length is specified. The value must be set to larger than 0. A larger value indicates longer lines and a smaller value indicates shorter.
	Interval (mm)	The interval between two lines. The value must be set to larger than 0. A larger value indicates a wider interval between lines and a smaller value indicates a narrower interval.
	Overlapping Calculation	The interval between two lines is automatically calculated based on the selected tool and set overlapping ratio. After clicking the button, a dialog box is displayed for choosing a tool from the tool list and setting the ratio to a value ranging from 0% to 99.99%. Only face-machining tools are listed and the default ratio is 50%.
	Count (xN)	The line quantity is specified. The value must be set to larger than 0. A larger value indicates more lines and a smaller value indicates less.
Specify Points[ii]	Point (mm)	A set of points can be specified, based on which the spline or polyline is generated. The combo boxes in red, green and blue indicate the coordinate of a point in X axis, Y axis and Z axis, respectively.

Continues on next page

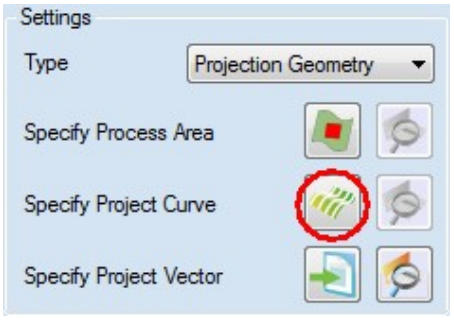
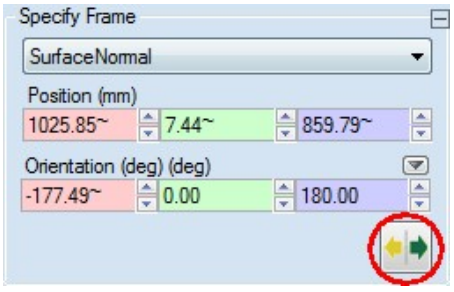
4.3.3.1 Projection geometry

Continued

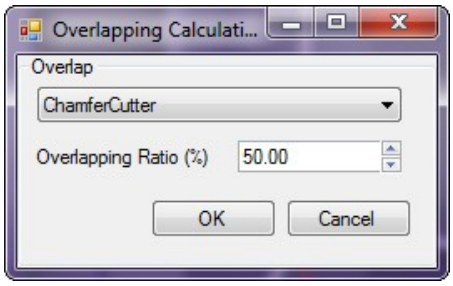
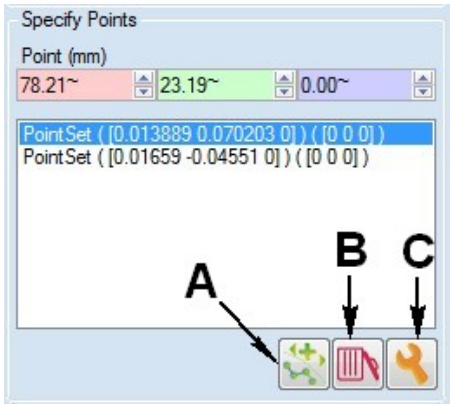
Group	Item	Description
Others	Recommend	The parameters are set to the recommended values.

i This parameter group is available only to line array.
ii This parameter group is available only to spline and polyline.

Use this procedure to specify new project curves.

	Action	Illustration/Note
1	Click the **Specify Project Curves** button. A new window is displayed.	 xx1500000156
2	Select **Manual Pattern** from the drop-down list.	
3	Select a curve type as required.	
4	Specify a frame type from the **Specify Frame** drop-down list.	
5	Click the combo boxes to activate **Position (mm)** and **Orientation (deg)**. **Tip** You can specify orientation values in either triple mode or quadruple mode by selecting between **PRY angles (Euler ZYX)** and **Quanternions**.	
6	Click a point whose frame will be used in the 3D graphics view. You can also enter a value directly in the combo boxes or click the up/down arrows to choose a value. For the line array type, the line patterns are displayed in real time with the change of values.	
7	If needed, click the **Reverse** button to obtain a reversed orientation based on the entered values. The values are changed after clicking the button. Click the button again to return the original entered values of the orientation.	 xx1500000164

Continues on next page

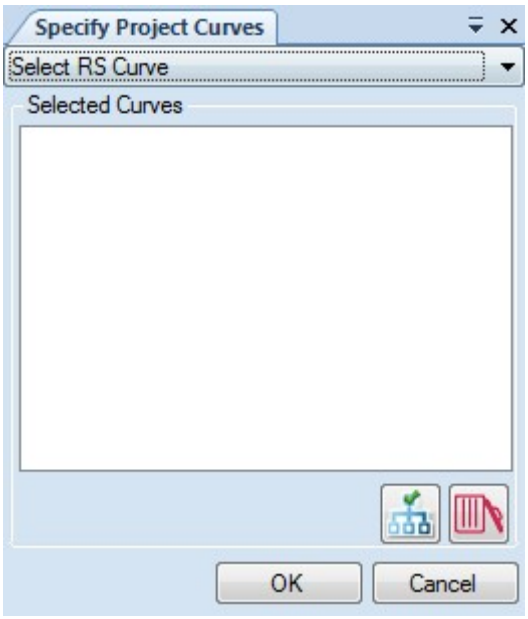
	Action	Illustration/Note
8	For the line array type: Set **AngleFromX (deg)**, **Length**, **Interval (mm)** and **Count (xN)** to obtain a set of required lines. For setting line interval, you can also click the **Overlapping Calculation** button to perform an automatic calculation by specifying a face-machining tool and setting the overlapping ratio in the displayed dialog box.	 xx1500001376
9	For the spline and polyline type: 1 Select a required point by clicking in the 3D graphics window. The coordinate of the selected point is automatically displayed in the combo boxes in the **Point (mm)** area. 2 If the point location is as intended, click the **Add point** button to add the point. The point with detailed data of its coordinate will be shown in the list. 3 You can also double-click a required point in the 3D graphics window to simply add the point directly. 4 Repeat point selection until all points for generating a required spline or polyline are selected. A line is automatically displayed between two consecutively selected points in the 3D graphics window. 5 If a point needs to be modified, click the point in the list and then click the **Modify selected point** button to modify it. 6 If a point needs to be deleted, click the point in the list and then click the **Delete selected point(s)** button to delete it. It is possible to select and delete several points by pressing **Ctrl** or **Shift** while dragging the mouse.	 xx1500000165 A Add point B Delete selected point(s) C Modify selected point
10	If needed, click the **Recommend** button to obtain recommended values.	**CAUTION** All user settings will be overwritten when clicking **Recommend**.
11	Click **OK** to return to the **Create Geometry** window or click **Cancel** to discard all settings.	

Continues on next page

4.3.3.1 Projection geometry

Continued

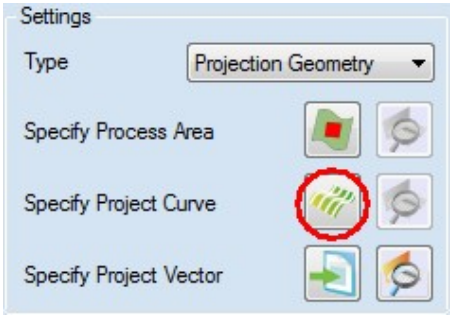
Select RS Curve



xx1500000163

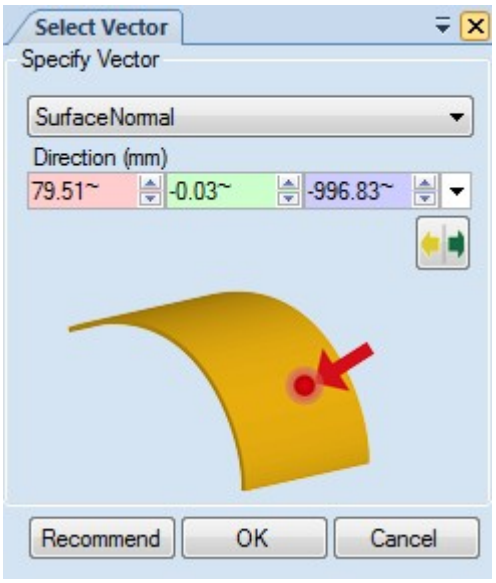
Item	Description
Selected Curves	The selected curves are listed.

Use this procedure to select existed curves.

	Action	Illustration/Note
1	Click the **Specify Project Curves** button. A new window is displayed.	 xx1500000156
2	Choose **Select RS Curve** from the drop-down list.	
3	The curves set in RobotStudio are listed. Choose unnecessary curves and delete them by clicking the **Delete selected curve** button.	
4	Click **OK** to return to the **Create Geometry** window or click **Cancel** to discard all settings.	

Continues on next page

Specifying project vector



xx1500000167

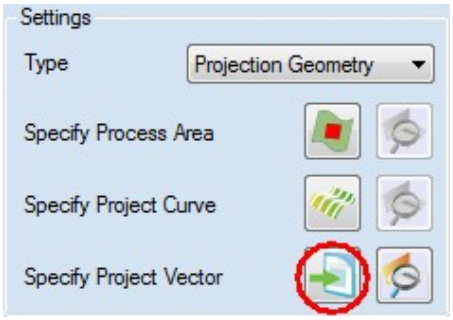
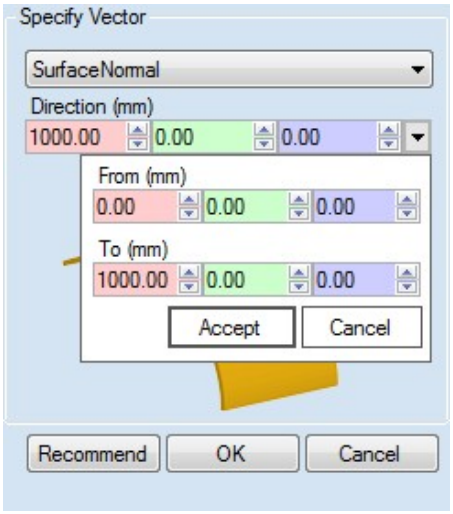
Item	
Specify Vector	Users can specify the type of a coordinate direction that will be used as the vector. The following options are available: • SurfaceNormal: The normal of a selected point on the specified surface is used. • Curve Tangency: The curve tangent direction of a selected point on the specified surface is used. • Edge Tangency: The edge tangent direction of a selected point on the specified surface is used. • Global_X/Y/Z: The X/Y/Z axis of the global frame is used. • User_Frame_X/Y/Z: The X/Y/Z axis of the user frame is used. • Object_Frame_X/Y/Z: The X/Y/Z axis of the object frame is used. • Body_Frame_X/Y/Z: The X/Y/Z axis of the part frame is used.
Direction (mm)	The projection direction is specified. The combo box in red defines the direction along the X axis based on the specified frame, the combo box in green along the Y axis, and the combo box in blue along the Z axis.
Recommend	The parameters are set to the recommended values.

Continues on next page

4.3.3.1 Projection geometry

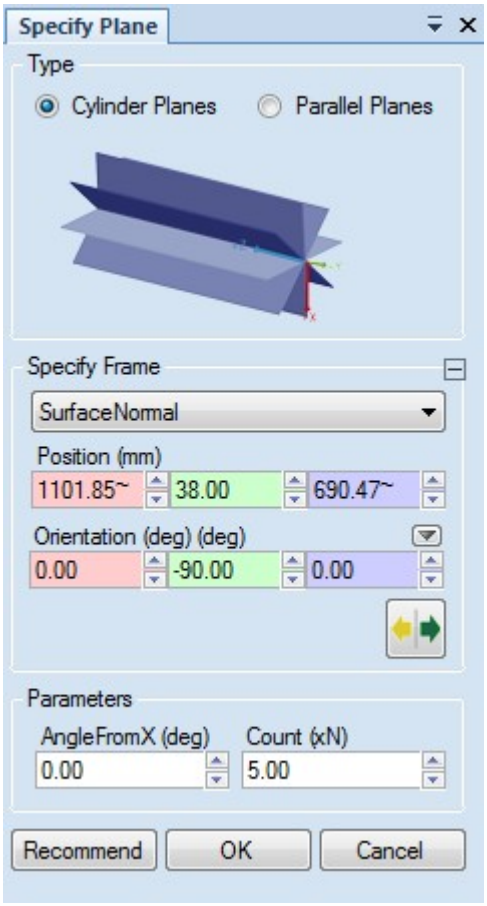
Continued

Use this procedure to select a project vector.

	Action	Illustration/Note
1	Click the **Specify Project Vector** button. A new window is displayed.	 xx1500000166
2	Specify a vector type from the drop-down list.	
3	Click the drop-down arrow to specify the start point and end point locations. The difference between the two locations will be the direction. You can also click the combo boxes to activate **Direction (mm)** and then select a point in the 3D graphics window to generate the direction. The **Reverse** button is available to reverse the settings.	 xx1500000168
4	If needed, click the **Recommend** button to obtain recommended values.	**CAUTION** All user settings will be overwritten when clicking **Recommend**.
5	Click **OK** to return to the **Create Geometry** window or click **Cancel** to discard all settings.	

4.3.3.2 Intersection geometry

Overview



xx1500000169

Group	Item	Description
Type	Cylinder Planes	A set of planes with Z axis of the specified frame as the center will be intersected with the selected surface to generate curves.
	Parallel Planes	A set of parallel planes will be intersected with the selected surface to generate curves. This is the default type.

Continues on next page

4.3.3.2 Intersection geometry
Continued

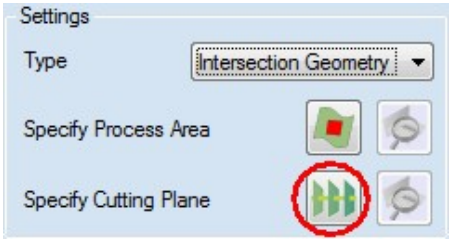
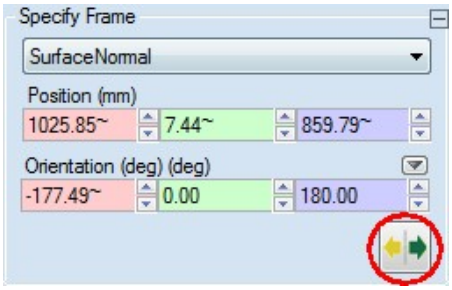
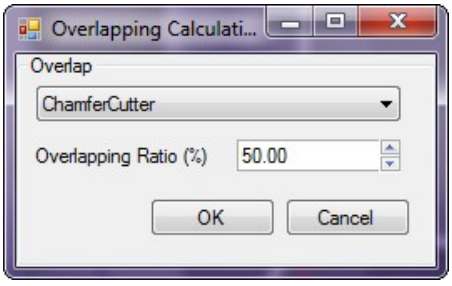
Group	Item	Description
Specify Frame	Specify Frame	Users can specify the type of a coordinate direction that will be used as the Z axis of the frame based on which the curves to be projected are generated. The following options are available: • SurfaceNormal: The normal of a selected point on the specified surface is used. • Curve Tangency: The curve tangent direction of a selected point on the specified surface is used. • Edge Tangency: The edge tangent direction of a selected point on the specified surface is used. • Global_X/Y/Z: The X/Y/Z axis of the global frame is used. • User_Frame_X/Y/Z: The X/Y/Z axis of the user frame is used. • Object_Frame_X/Y/Z: The X/Y/Z axis of the object frame is used. • Body_Frame_X/Y/Z: The X/Y/Z axis of the part frame is used.
	Position (mm)	A fixed point is specified as the original position for the frame. The combo box in red defines the coordinate of the point in the X axis, the combo box in green in the Y axis, and the combo box in blue in the Z axis. The value range is 0 to 180.
	Orientation (deg)	Frame orientation with the original position as the center. The combo box in red defines the orientation with the X axis as the center, the combo box in green with the Y axis as the center, and the combo box in blue with the Z axis as the center. All values must be set to larger than 0.
Parameters	AngleFromX (deg) [i]	The planes rotate along the X axis to the specified degree. The value must be set to larger than 0. A larger value enables the planes to rotate counterclockwise, while a smaller value enables to rotate clockwise.
	Interval (mm) [ii]	The interval between two planes. The value must be set to larger than 0. A larger value indicates a wider interval between planes and a smaller value indicates a narrower interval.
	Overlapping Calculation [ii]	The interval between two lines is automatically calculated based on the selected tool and set overlapping ratio. After clicking the button, a dialog box is displayed for choosing a tool from the tool list and setting the ratio to a value ranging from 0% to 99.99%. Only face-machining tools are listed and the default ratio is 50%.
	Count (xN)	The plane quantity is specified. The value must be set to larger than 0. A larger value indicates more planes and a smaller value indicates less.
Others	Recommend	The parameters are set to the recommended values.

i This parameter is available only to cylinder plane.
ii This parameter is available only to parallel plane.

Continues on next page

Specifying cutting plane

Use this procedure to specify planes.

	Action	Illustration/Note
1	Click the **Specify Cutting Plane** button. A new window is displayed.	 xx1500000170
2	Select a curve type as required.	
3	Specify a frame type from the **Specify Frame** drop-down list.	
4	Click the combo boxes to activate **Position (mm)** and **Orientation (deg)**. **Tip** You can specify orientation values in either triple mode or quadruple mode by selecting between **PRY angles (Euler ZYX)** and **Quanternions**.	
5	Click a point whose frame will be used in the 3D graphics view. You can also enter a value directly in the combo boxes or click the up/down arrows to choose a value. The plane patterns are displayed in real time with the change of values.	
6	If needed, click the **Reverse** button to obtain a reversed orientation based on the entered values. The values are changed after clicking the button. Click the button again to return the original entered values of the orientation.	 xx1500000164
7	Set **AngelFromX (deg)** (for cylinder planes) / **Interval (mm)** (for parallel planes) and **Count (xN)** as required by entering a value directly in the text boxes or clicking the up/down arrows to choose a value. For setting line interval, you can also click the **Overlapping Calculation** button to perform an automatic calculation by specifying a face-machining tool and setting the overlapping ratio in the displayed dialog box.	 xx1500001376

Continues on next page

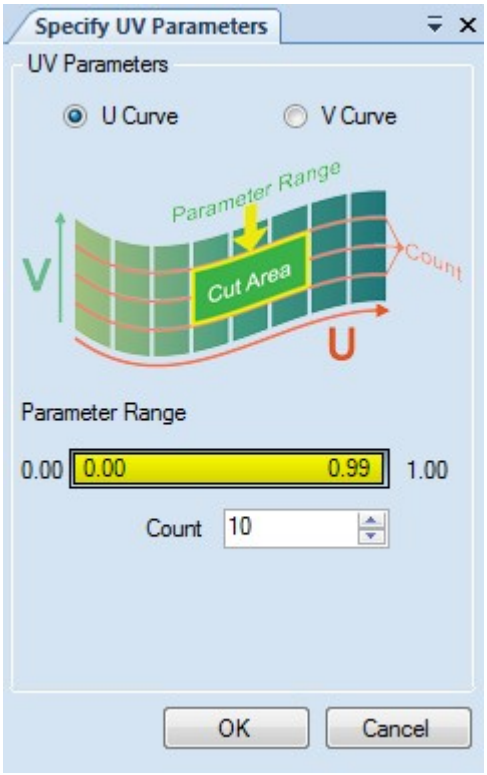
4.3.3.2 Intersection geometry

Continued

	Action	Illustration/Note
8	If needed, click the **Recommend** button to obtain the recommended values.	**CAUTION** All user settings will be overwritten when clicking **Recommend**.
9	Click **OK** to return to the **Create Geometry** window or click **Cancel** to discard all settings.	

4.3.3.3 UV curve

Overview

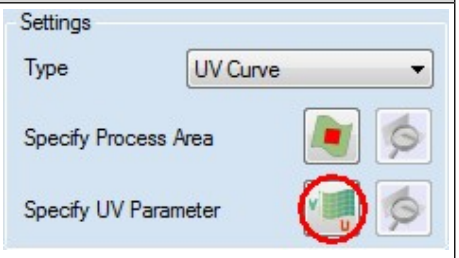


xx1500000171

Group	Item	Description
UV Parameters	U Curve	Isoparametric curves in U directions will be generated as feature curves on the surfaces.
	V Curve	Isoparametric curves in V directions will be generated as feature curves on the surfaces.
	Parameter Range	The U/V curves will be generated within the specified range.
	Count	The number of curves is specified.

Specifying UV parameters

Use this procedure to specify U/V curves.

	Action	Illustration/Note
1	Click the **Specify UV Parameter** button. A new window is displayed.	 xx1500000204

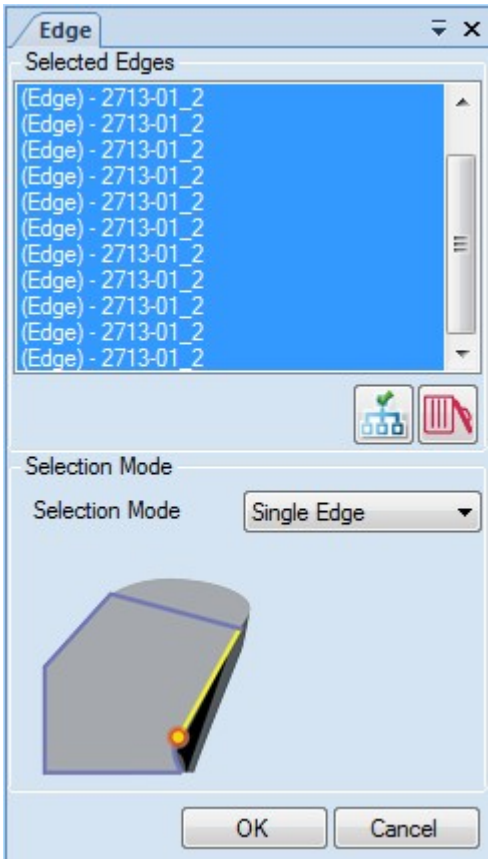
Continues on next page

4.3.3.3 UV curve
Continued

	Action	Illustration/Note
2	Select **U Curve** or **V Curve** option button as required.	
3	Drag the slider in the **Parameter range** scrollbar to specify the range of isoparametric curves.	
4	Set **Count** as required by entering a value directly in the text box or clicking the up/down arrows to choose a value.	
5	Click **OK** to return to the **Create Geometry** window or click **Cancel** to discard all settings.	

4.3.3.4 Edge curve

Overview



xx1500000172

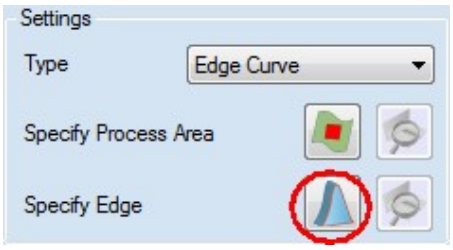
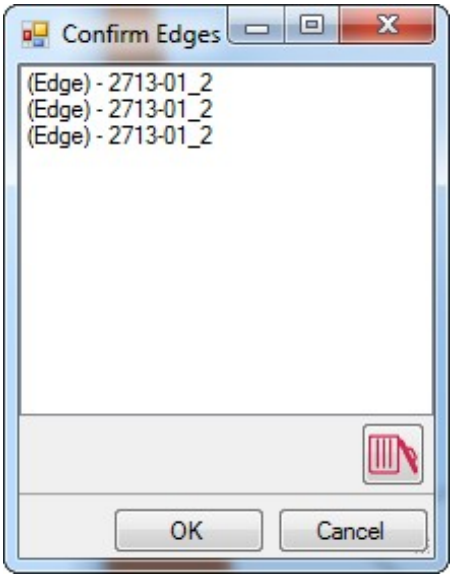
Item	Description
Selected Edges	All edges of the selected surfaces are listed.
Selection Mode	• Single Edge: The user can specify an edge and then the system will automatically select the edge as the path curve. • Tangent Edges: The user can specify an edge and the the system will automatically select all edges smoothly connected to the edge as the path curve. • Boundary: The user can specify an edge and the system will automatically select the boundary of the surface to which the edge belongs as the path curve. Note that, if the surface shares an edge with another surface, the system will automatically select the boundary (excluding the shared edge) of all surfaces.

Continues on next page

4.3.3.4 Edge curve
Continued

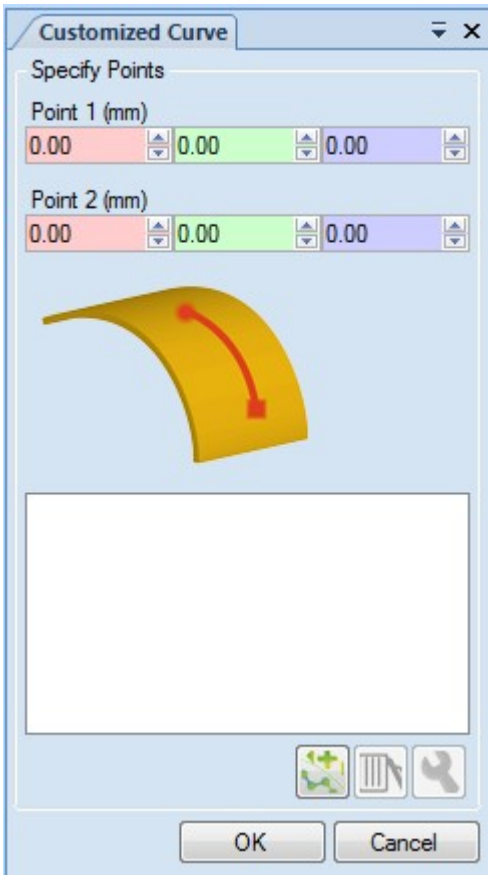
Specifying edges

Use this procedure to specify edge curves.

	Action	Illustration/Note
1	Click the **Specify Edge** button. A new window is displayed.	 xx1500000205
2	All edges of the selected surfaces are listed. Choose unnecessary edges and delete them by clicking the **Delete selected edge(s)** button.	
3	You can also choose an edge selection mode and specify required edges. **Single Edge**: Click the required edge directly in the 3D graphics window. **Tangent Edges**: A dialog box is displayed after clicking an edge of the selected surface(s) in the 3D graphics window, listing all edges meeting the requirement. If needed, remove edge(s) not required. Click **OK** to accept the choice. **Boundary**: A dialog box is displayed after clicking a selected surface in the 3D graphics window, listing all edges meeting the requirement. If needed, remove edge(s) not required. Click **OK** to accept the choice.	 xx1500000173 **Note** An edge available for selection will be highlighted when moving the cursor on it. After selection, all edges listed will be displayed in green in the 3D graphics window. If you choose any edges in the list, it will change to red for highlight in the graphics window. For the boundary mode, the system automatically selects the boundary of the specified surface and its edge-sharing surface(s), but the shared edge is not included.
4	Click **OK** to return to the **Create Geometry** window or click **Cancel** to discard all settings.	

4.3.3.5 Customized curve

Overview

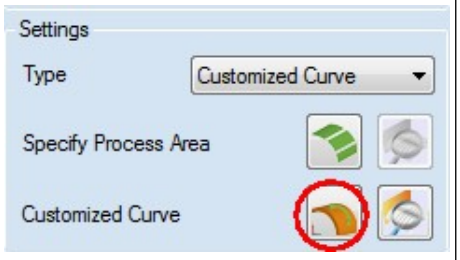


xx1500000174

Item	Description
Point 1 (mm)	The coordinate of the start point to generate a line is specified.
Point 2 (mm)	The coordinate of the end point to generate a line is specified.

Specifying customized curve

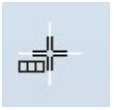
Use this procedure to specify customized curves.

	Action	Illustration/Note
1	Click the **Customized Curve** button. A new window is displayed.	 xx1500000206

Continues on next page

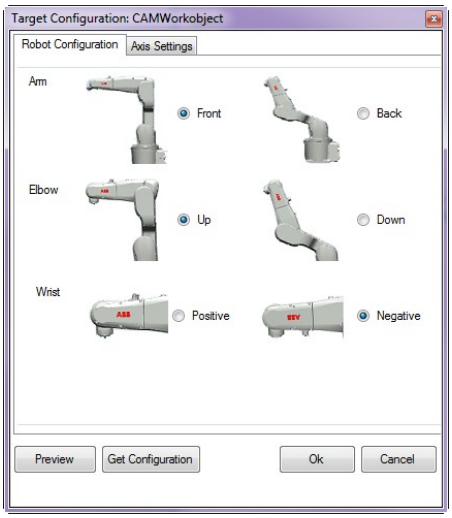
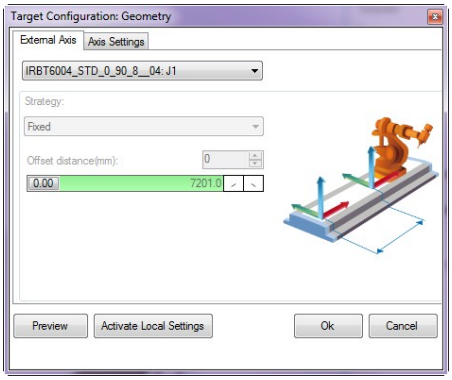
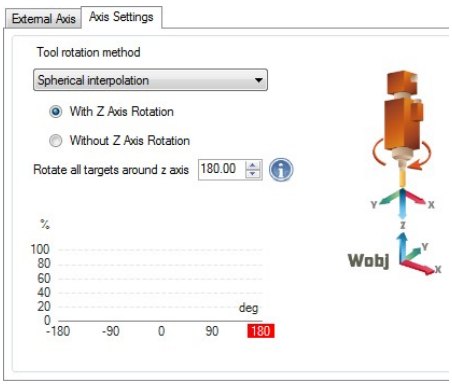
4.3.3.5 Customized curve

Continued

	Action	Illustration/Note
2	Click any combo box under **Point 1 (mm)** to activate the setting of point 1.	**Note** Move the cursor to the 3D graphics window. If the cursor changes its icon to the following pattern, the setting is activated. 
3	Click a required point on the selected surface in the 3D graphics window. Point 1 is automatically set to the start point of the first line to be generated.	
4	After point 1 is selected, the setting of point 2 is automatically activated. Select point 2 directly in the 3D graphics window to set the end point of the first line. If point 2 is activated and selected first in step *2*, you must manually click any combo box under **Point 1 (mm)** to activate the setting of point 1.	
5	Click the **Add a point set to the list** button to add the point set. The point set with detailed data of the coordination is shown in the list.	
6	Repeat point selection until all point sets for generating required lines are selected.	
7	If a point set needs to be modified, click the point set in the list and then click the **Modify the selected point set** button to modify it.	
8	If a point set needs to be deleted, click the point set in the list and then click the **Delete selected point set(s)** button to delete it. It is possible to select and delete several point sets by pressing **Ctrl** or **Shift** while dragging the mouse.	
9	Click **OK** to return to the **Create Geometry** window or click **Cancel** to discard all settings.	

4.3.4 Configuring a target

Start Target Configure Settings

	Action	Illustration/Note
1	Select **Target Configuration** in the **Target** area to start target configuration.	 xx1500000159
2	Set configurations for the robot on the **Robot Configuration** tab page: • **Arm**: Sets arm position to Front or Behind. • **Elbow**: Sets elbow position to Up or Down. • **Wrist**: Sets wrist position to Positive or Negative. • **Get Configuration**: Gets the current configurations of the robot. **Note** Robot configuration can be accessed only from the **Create Workobject** window.	 xx1500000175
3	Set external axis settings on the **External Axis** tab page. **Note** You can access the external axis setting from the creating or editing window for WorkObject, Geometry, and Operation. Generally, a geometry and operation directly use the settings of the work object and geometry belonged to, respectively. If you need to modify the settings, refer to *Settings with external axis on page 84*.	 xx1500001377
4	Set axis settings on the **Axis Settings** tab page. **Note** You can access the axis setting from the creating or editing window for WorkObject, Geometry, and Operation. Generally, a geometry and operation directly use the settings of the work object and geometry belonged to, respectively. If you need to modify the settings, refer to *Editing Axis Settings on page 87*.	 xx1500000176

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4.3.4 Configuring a target
Continued

Settings with external axis

Linear track

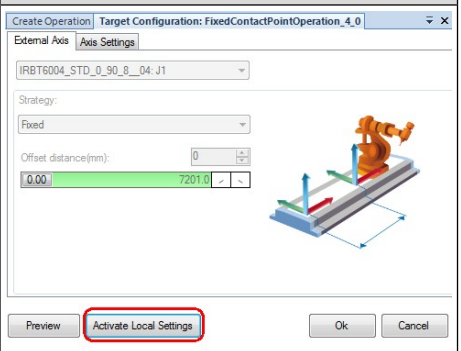
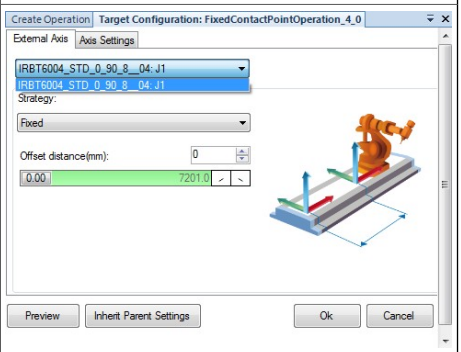
Linear track component makes the robot move along with the linear track and handle the large scale work object. It interpolates the whole movement into robot and linear track and ensure they can work together. There are three types of motion modes for linear track:

- Fixed

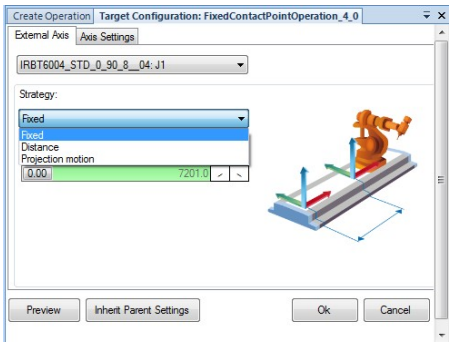
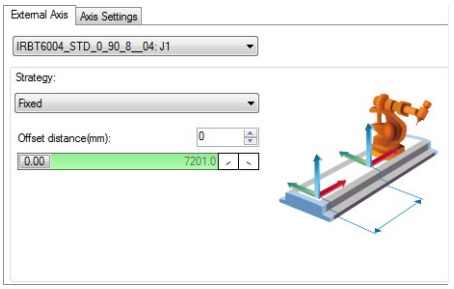
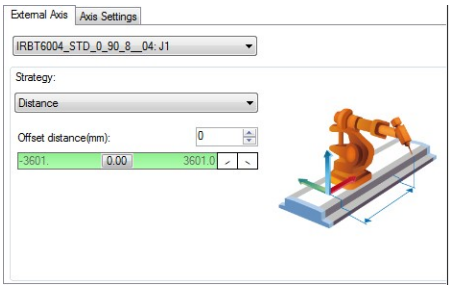
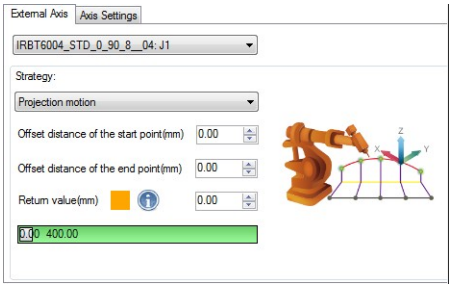
  The robot base is in a fixed position on the linear track.
- Distance

  The distance between the robot base and robot target in linear track direction is fixed.
- Projection

  When the robot path swings forward and backward, users can use this strategy to prevent the swing motion of robot on linear track.

	Action	Illustration/Note
1	Make sure that the settings are activated by clicking **Active Local Setting** (accessing from geometry or operation creating/editing window).	 xx1600000030
2	Select the track model from the drop-down list.	 xx1600000028

Continues on next page

	Action	Illustration/Note
3	Choose one of three types of **Strategy** options: • Fixed • Distance • Projection motion	 xx1600000029
4	If the option **Fixed** is selected, drag the slider or fill out the offset distance to change the distance between fixed position and linear track origin.	 xx1500001379
5	If the option **Distance** is selected, drag the slider or fill out the offset distance to change the distance between the robot base and robot target in linear track direction.	 xx1500001378
6	If the option **Projection motion** is selected, resize the slider's cursor to change the offset distance region of the robot base on linear track.	 xx1500001380

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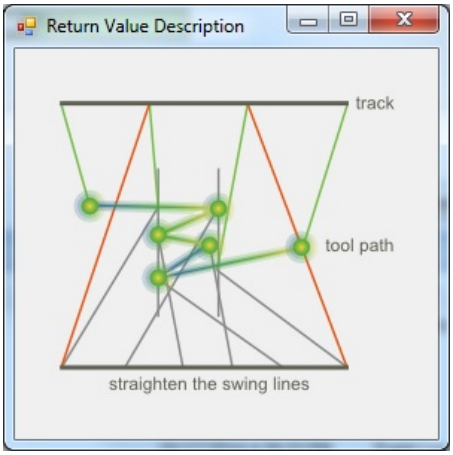
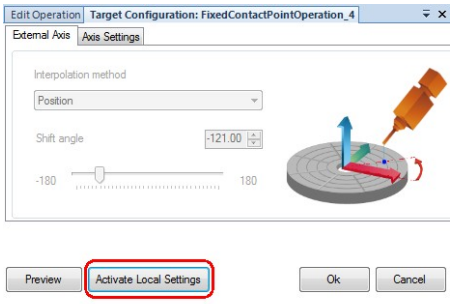
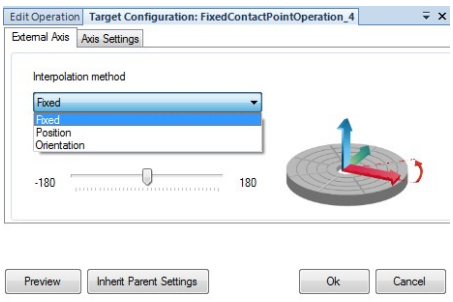
4.3.4 Configuring a target
Continued

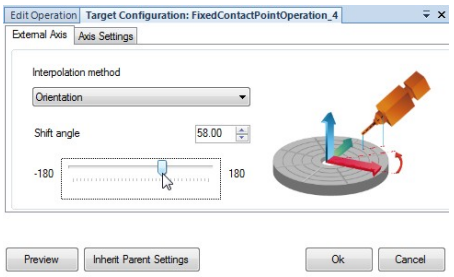
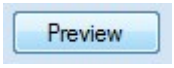
	Action	Illustration/Note
7	The orange block following **Return value Description** represents that the swing robot targets in preview is in orange color. If you hover the mouse on **info** icon, the picture will show to depict the principle of projection mode.	

Positioner

Positioner component facilitates the robot to move in an optimal way from the TCP to reach all target. Currently, Machining PowerPac - Machining supports only the MTD.

	Action	Illustration/Note
1	Make sure that the settings are activated by clicking **Active Local Setting** (accessing from geometry or operation creating/editing window).	 xx1600000025
2	Choose one of three types of **Interpolation method** options: • Fixed The positioner is in a fixed position. • Position The TCP projection always falls on a defined axis. • Orientation The projection of the z axis of the TCP always falls on a defined axis.	 xx1600000026

Continues on next page

	Action	Illustration/Note
3	Drag the slider or directly enter a value in the text box to set **Shift angle**. • If **Interpolation method** is set to **Fixed**, the positioner shifts from the zero position counter-clockwise with the set angle. • If **Interpolation method** is set to **Position** or **Orientation**, an axis deviated from the X axis of the work object with the set angle is defined as the axis on which the TCP/tool is projected.	 xx1600000027
4	Preview the settings by clicking the **Preview** button.	
5	Click **OK** to return to the original window or click **Cancel** to discard all settings.	

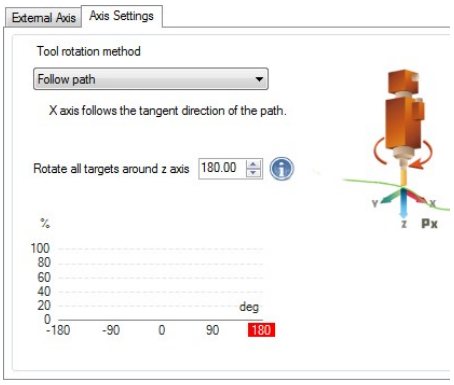
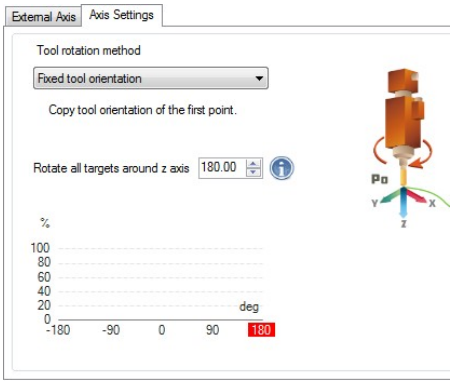
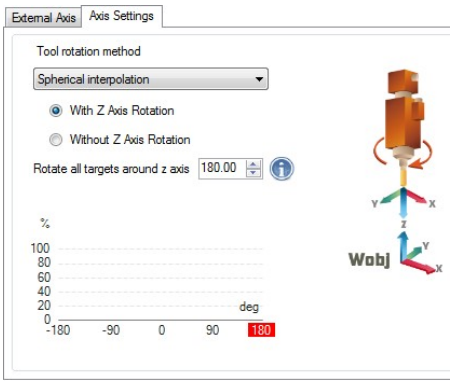
Editing Axis Settings

	Action	Illustration/Note
1	Make sure that the settings are activated by clicking **Active Local Setting** (accessing from geometry or operation creating/editing window). There are three types of **Tool rotation method** options: • Follow path • Fixed tool orientation • Spherical interpolation	**Note** The **Spherical Interpolation** option is unavailable for the belt sander tool type. If selected, a message is displayed, prompting you to change a tool rotation method.

Continues on next page

4.3.4 Configuring a target

Continued

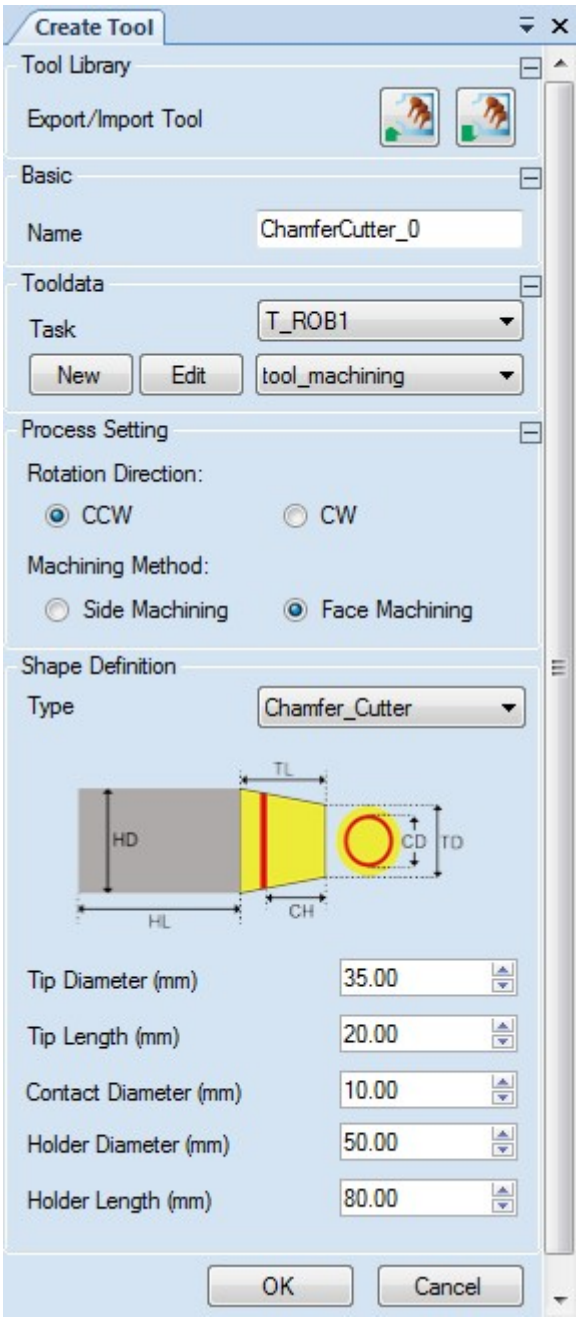
	Action	Illustration/Note
2	If the option **Follow path** or **Fixed tool orientation** is selected, keep the default setting. No other settings are required.	 xx1500001381  xx1500001382
3	If the option **Spherical interpolation** is selected, one more setting is required by choosing one of the following option button: • With Z Axis Rotation • Without Z Axis Rotation	 xx1500000176 **Note** The **Spherical Interpolation** option is unavailable for the belt sander tool type. If selected, a message is displayed, prompting you to change a tool rotation method.
4	Click **OK** to return to the original window or click **Cancel** to discard all settings.	

4.4 Creating tool

Overview

RobotStudio tool data is also available and valid for Machining PowerPac - Machining. Tools created in Machining PowerPac - Machining can use the RobotStudio tool data as a basis but also includes a CAD tool model, which makes the tools actually independent from RobotStudio tools.

Create Tool window



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4.4 Creating tool
Continued

Group	Item	Description
Tool Library	Export/Import Tool	For exporting/importing the setting of a tool to/from the tool library.
Basic	Name	For specifying the name of the tool.
Tooldata	Task	For specifying the tool task already set in the RobotStudio.
	New	For creating a tool with newly-set tool data.
	Edit	For editing the tool data of a selected tool.
	Tooldata	For selecting a tool with tool data already set in the RobotStudio.
Process Setting	Rotation Direction	For specifying the direction that the tool rotates, counterclockwise (CCW) or clockwise (CW).
	Machining Method	For specifying whether the tool tip face or tool side is used to process on the machining part.
Shape Definition[1]	Type	For specifying the tool shape type.
	Tip Diameter (TD)	For specifying the diameter of the entire tool tip.
	Tip Length (TL)	For specifying the length of the tool tip.
	Contact Height (CH)	Available only to side machining for specifying the height from the tool tip to the tool part that is actually used to process.
	Contact Diameter (CD)	Available only to face machining for specifying the diameter of tool face that is actually used to process.
	Holder Diameter (HD)	For specifying the diameter of the tool holder.
	Holder Length (HL)	For specifying the length of the tool holder.

Continues on next page

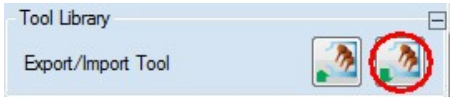
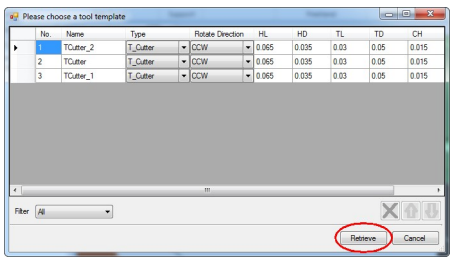
Group	Item	Description
Belt Sander Setting[ii]	Belt Width (mm)	For specifying the belt width of the belt sander.
	Belt Thickness (mm)	For specifying the belt thickness of the belt sander.
	Roller Radius (mm)	For specifying the radius of the roller on which the belt runs.
	Edge B (degree)	For defining a processing range on the belt. The processing point on the belt, which will be actually used to process, will be always within this range. The belt roller is normally a cylinder, and by setting Edge A and Edge B, two generatrixes are defined. The range between two generatrixes will be the processing range. The value range for both Edge A and Edge B is 0° to 175°. When Edge A is set to 0°, its corresponding generatrix is in the same direction as the X+ axis of the tool; when Edge B is set to 0°, its corresponding generatrix is in the same direction as the X- axis of the tool.
	Edge A (degree)	
	Weft Ratio (%)	For defining a processing line on the belt. The processing point on the belt, which will be actually used to process, will locate on this line and also within the defined processing range. Dragging the slider will move the line in the direction along the Z+ axis of the tool. Generally, the processing point on the belt locates at the cross point of the processing line and the center line between the two generatrixes defined by Edge A and Edge B.

i The parameters in this group, except for the parameter "Type", are available only for tools whose type is cutter.

ii The parameters in this group are available only for tools whose type is belt sander.

Procedure for creating a tool, cutter or belt sander

Use this procedure to create a tool in cutter or belt sander type.

	Action	Illustration/Note
1	Select **Create Tool** from the **Tool** category in the ribbon tab to open the tool creating window.	
2	To reuse a tool, click the **Import** button to open the tool library. In the displayed dialog box, choose the required tool and click **Retrieve**.	 xx1500000208  xx1500000177
3	Enter a name or remain the defaulted name for the tool in the **Name** text box.	

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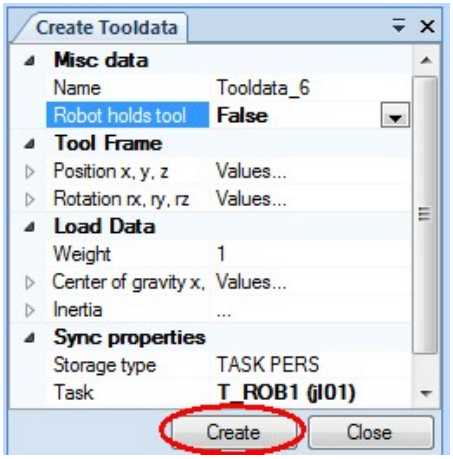
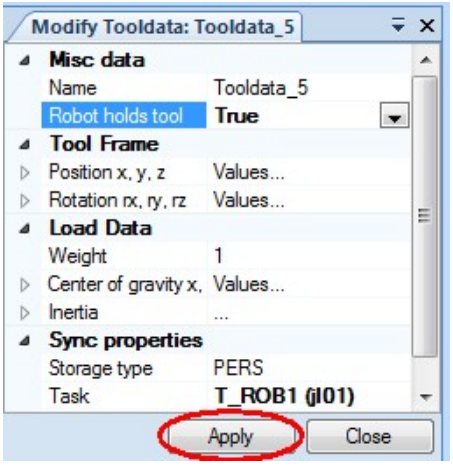
	Action	Illustration/Note
4	Select a tool with tool data already set in the RobotStudio from the drop-down list. **Tip** If no tool is usable, click **New** to create a new one. Then, a parameter setting window is displayed on the left pane of the screen. You can modify the parameters as required and then click **Create**.	 xx1500000178 See detailed descriptions about parameter setting in RobotStudio.
5	If needed, edit tool data by clicking **Edit**. A parameter setting window in displayed on the left pane of the screen. You can modify the parameters as required and then click **Apply**.	 xx1500000179
6	Choose **CCW** or **CW** option button for setting tool rotation direction, and choose **Side Machining** or **Face Machining** for setting the machining method. **Note** **Face Machining** is unavailable for flame and ball tool shapes.	
7	Select a tool shape from the **Type** drop-down list. The schema of the selected tool shape is shown.	

Continues on next page

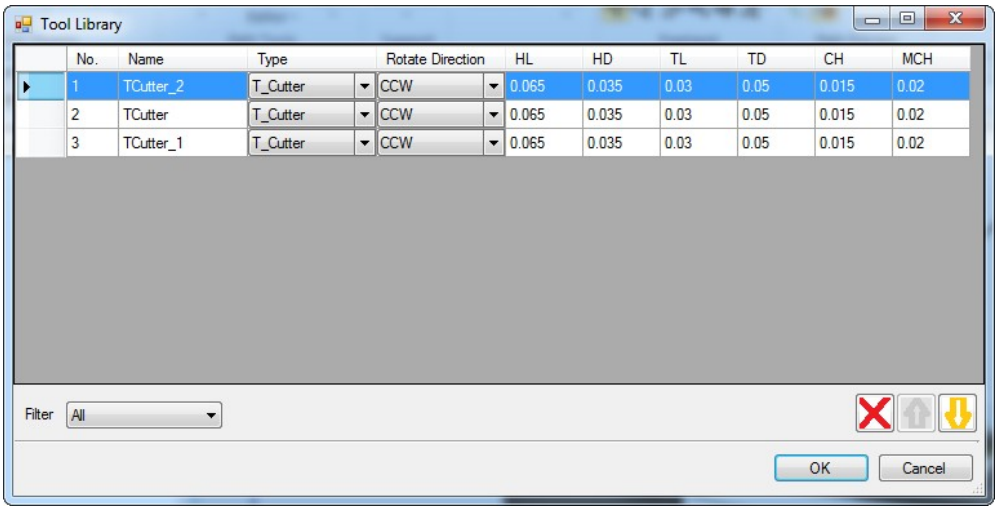
	Action	Illustration/Note
8	Set other parameters for the tool. **Note** During the setting of a cutter, the following rules must be followed : • The **Tip Length** value must be larger than the **Contact Height** value. • The **Tip Diameter** value must be smaller than the **Holder Diameter** value. If the setting does not meet the preceding rules, a warning message shows to prompt you to modify the settings.	
9	To save the tool settings for reuse, click the **Export** button. The tool is automatically saved in the tool library.	**CAUTION** Each tool must have a unique name in the tool library. If a tool whose settings are to be exported (tool A) has the same name with another tool already existed in the tool library (tool B), a message displays to prompt you to rename tool A; otherwise, the settings of tool B will be overwritten.
10	Click **OK** to apply the settings. A tool node with the specified name is displayed in the **Tool** tab page of the **Operation Navigation Tree**.	

Procedure for creating a tool in other shapes

If you want to use a tool that is not a cutter or a belt sander, choose **None** from the **Type** drop-down list in the **Shape Definition** area. In this case, the system will not create a geometric shape for the tool. Other functions, such as import and tool data setting, are the same.

Continues on next page

Tool Library



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The tool library contains tool templates and enables tool management. Open the tool library by clicking **Tool Library** from the **Tool** category in the ribbon tab.

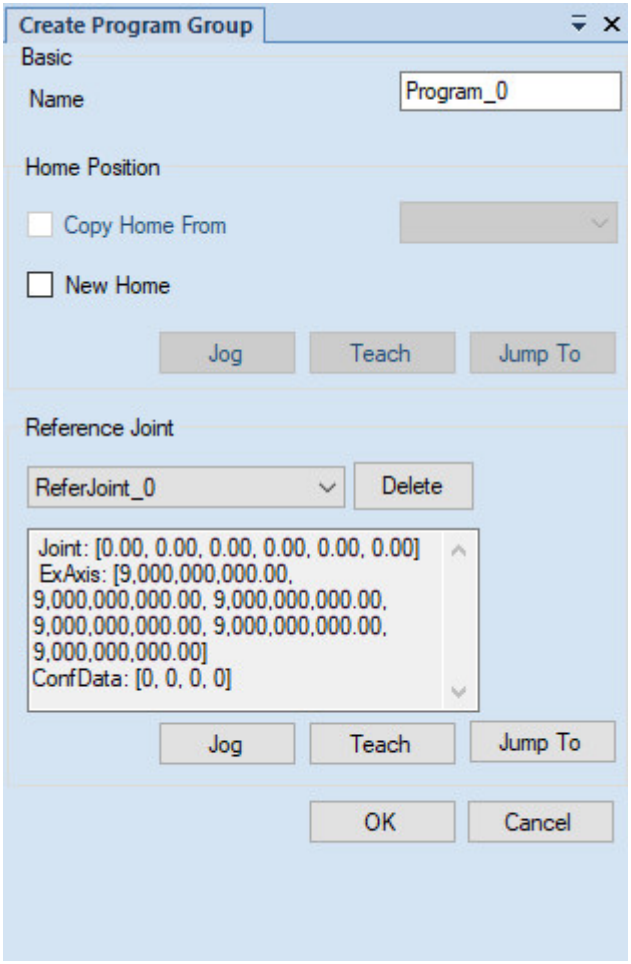
In the tool library, a row presents a tool with detailed tool data and it is possible to filter tools by tool types. For a specific tool, tool setting modification, deletion and sorting are allowed. The deletion and sorting icons are available when clicking in the first cell of a row. To modify a specific setting of a tool, double-click the corresponding cell to activate the modification. Note that, the tool shape type cannot be modified and tool name must keep unique.

4.5 Creating program group

Overview

A program group may be defined for a set of operations that will process as a group. The sequence of operations in a program group defines the machining process sequence, no matter whether the operations belong to the same geometry/tool or not. Operation sequence can be modified by simply dragging an operation node up and down under the program node.

Create Program Group window



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Group	Item	Description
Basic	Name	For specifying the name of the program group.

Continues on next page

Group	Item	Description
Home Position	Copy Home From	For specifying the home position of an existing program group for the current program group. This check box is available only when there are existing home positions. If a program group uses the home position of another program group and the position settings have been changed, the home position of this program group also changes.
	New Home	For specifying a new home position for the program group.
	Jog	For modifying the positions of each robot axis to define a home position for the program group.
	Teach	For applying the axis position settings to the home position.
	Jump To	For returning to the original axis position settings. This button is available only when a home position has been taught.
Reference Joint	ReferJoint_0	For selecting a reference joint from the list. The reference joint ReferJoint_0 is provided by default. It is the robot position where all the robot axes are at the zero position.
	Delete	For deleting the selected reference joint. The default reference joint ReferJoint_0 cannot be deleted.
	Jog	For modifying the positions of each robot axis.
	Teach	For saving the axis position settings as a new reference joint.
	Jump To	For moving the robot axes to the position specified in the selected reference joint.

Procedure

Use this procedure to create a program group.

	Action	Illustration/Note
1	Select **Create Program Group** from the **Program** category in the ribbon tab to open the program group creating window.	
2	Enter a name or remain the defaulted name for the tool in the **Name** text box.	
3	If needed, add a home position by creating new settings or using one from another program group in the **Home Position** area.	
4	If needed, select a reference joint which will be the reference robot position before the robot moves the first target of the first operation in the program group. By default, the reference joint ReferJoint_0 where all the robot axes are at the zero position is selected.	

Continues on next page

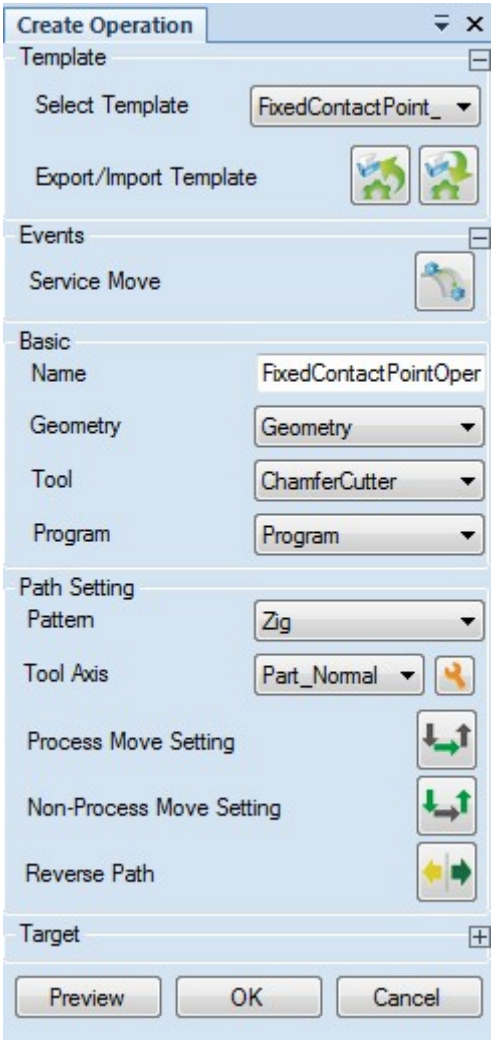
	Action	Illustration/Note
5	Click **OK** to apply the settings. A program node with the specified name is displayed in the **Program** tab page of the **Operation Navigation Tree**.	

4.6 Creating operation

Overview

An operation defines detailed settings of a certain process. Only operations in up-to-date status are able to generate paths and available for path editor and simulation. Any modification to the parent node to which an operation belongs will result in the status change from up-to-date to out-of-date. In this case, regenerate path to update settings and operation status.

Create Operation window



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Group	Item	Description
Template	Select Template	For specifying an operation template which can either be a customized template file or a default template file.
	Export/Import Template	For exporting an operation template for reuse or importing an existing operation template.

Continues on next page

Group	Item	Description
Events	Service Move	For specifying the start event and end event for the operation, and setting safe path for the operation.
Basic	Name	For specifying the name of the operation.
	Geometry	For specifying the geometry to which the operation is associated.
	Tool	For specifying the tool to which the operation is associated.
	Program	For specifying the program group to which the operation belongs.
Path Setting	Pattern	For specifying the pattern that the tool moves along the path, zig or zigzag.
	Tool Axis	For specifying the tool axis strategy, which can be the part normal or a fixed axis.
	Tool Axis setting	For setting detailed parameters of the selected tool axis strategy.
	Process Move Setting	For setting process move parameters.
	Non-Process Move Setting	For setting non-process move parameters.
	Reverse Path	For reversing the robot path direction.
Target	Target Configuration	For editing target settings.

General procedure

Use this procedure to create an operation.

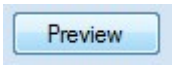
	Action	Illustration/Note
1	Select **Create Operation** from the **Operation** category in the ribbon tab to open the **Create Operation** window.	
2	Select a default template file from the **Select Template** drop-down list. There are three default options: FixedContactPoint_Default.xml, FlexibleContactPoint_Default.xml and Force_Control_Default.xml.	**Note** The operation set using the FixedContactPoint_Default.xml template does not allow the setting of contact height and tool rotation in the path editor, which are enabled only for operations using the FlexibleContactPoint_Default.xml template.
3	If customized templates exist and available for reuse, they are also listed in **Select Template**. Select the template file directly from the **Select Template** drop-down list, or click the **Import** button to import the template.	

Continues on next page

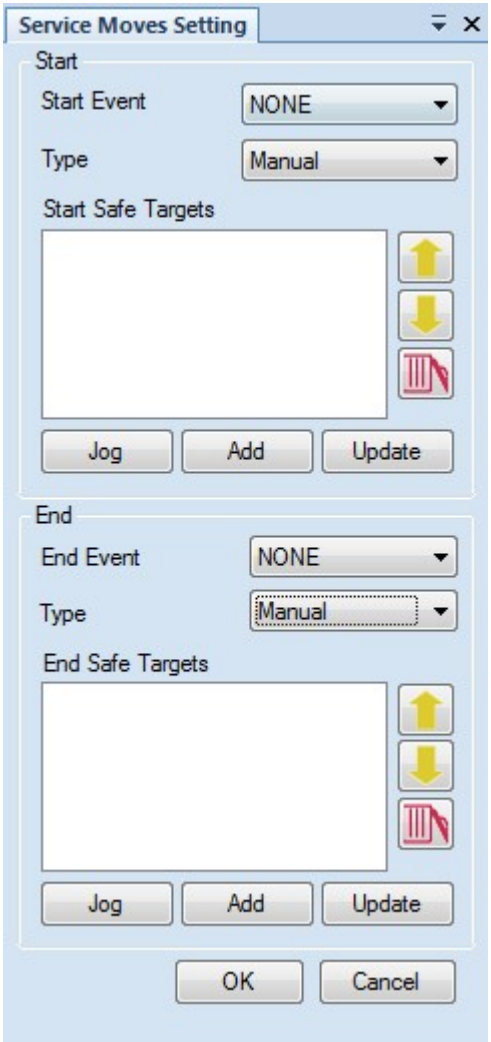
4.6 Creating operation
Continued

	Action	Illustration/Note
4	If there are RAPID programs required to be processed before or after the operation, or there are safe targets need to be moved to before or after the path, click the **Service Move** button to set start event, end event and safe path. For details, see *Service move setting on page 101*.	
5	Enter a name or remain the defaulted name for the tool in the **Name** text box.	
6	Select the geometry, tool and program group to which the operation associated.	**Note** The latest created geometry, tool and program group is set by default. The operation can also be temporarily set under the **Uncategorized Items** node. After the setting, you can simply drag the corresponding operation node to the required geometry, tool or program node.
7	Specify the pattern that the tool moves along the path. For zig pattern, the tool processes in a one-way direction with the approach each time in the same direction. For zigzag pattern, the tool processes forth and back with consecutive approach and departing.	
8	Choose the part normal or the fixed axis of a selected point as the tool axis.	
9	Click the setting button to open the **Tool Axis setting** window and set parameters as described in *Tool Axis setting on page 103*.	
10	View the rate of the estimated reachable targets.	**Note** The closer the rate approaches 100.00%, the better machining process obtains. If the rate is not 100.00%, the targets on the generated robot path may not be fully processed. You can adjust the path manually using path editor and path optimizing.
11	Set process move parameters as described in *Process move setting on page 104*.	
12	Set non-process move parameters as described in *Non-process move setting on page 106*.	
13	If needed, click the **Reverse Path** button to make the robot path direction reversed.	
14	Edit axis settings if needed. For details, see *Configuring a target on page 83*.	

Continues on next page

	Action	Illustration/Note
15	Preview the settings by clicking the **Preview** button.	
16	To save the operation settings for reuse, click the **Export** button. The template is saved as an .xml file.	
17	Click **OK** to apply the settings. An operation node with the specified name is displayed under the related program node or **Uncategorized Items** node in the **Program** tab page of the **Operation Navigation Tree**. If an associated geometry or tool is specified, the operation node is also displayed under the corresponding geometry or tool node.	

Service move setting



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Continued

Group	Item	Description
Start	Start Event	Start events can be programmed in **Preferences** and available for choosing from a list here. For details, see *Service Event Library on page 41*.
	Type	If **Auto** is selected, the safe plane settings are automatically applied for generating a safe path. If **Manual** is selected, users can specify safe targets for manually generating a safe path.
	Start Safe Targets	Available only when type **Manual** is selected. Specified start safe targets are listed. The robot moves to these targets in listed sequence from the home position (if there is) and before it moves to the first target of the path. The targets can be sorted using **Up**/**Down** button or removed using the **Delete** button.
	Jog/Add/Update	Available only when type **Manual** is selected. After clicking the **Jog** button, robot axis positions can be modified to specify safe targets. If a target is determined, click the **Add** button to add the target with specified settings in the list. If the settings of a target is modified, click the **Update** button to apply the new settings.
End	End Event	End events can be programmed in **Preferences** and available for choosing from a list here. For details, see *Service Event Library on page 41*.
	Type	If **Auto** is selected, the safe plane settings are automatically applied for generating a safe path. If **Manual** is selected, users can specify safe targets for manually generating a safe path.
	End Safe Targets	Available only when type **Manual** is selected. Specified end safe targets are listed. The robot moves to these targets in listed sequence from the end target of the path and back to the home position (if there is). The targets can be sorted using **Up**/**Down** button or removed using the **Delete** button.
	Jog/Add/Update	Available only when type **Manual** is selected. After clicking the **Jog** button, robot axis positions can be modified to specify safe targets. If a target is determined, click the **Add** button to add the target with specified settings in the list. If the settings of a target is modified, click the **Update** button to apply the new settings.

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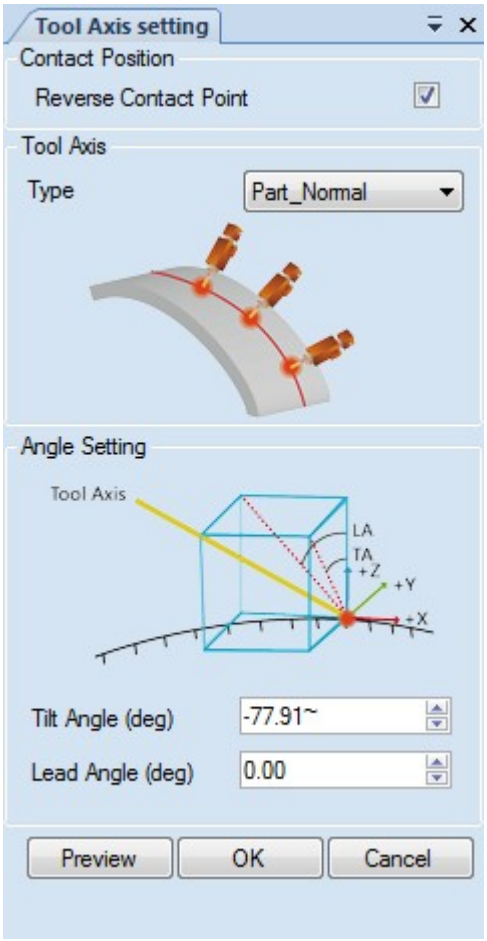
Tool Axis setting



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Group	Item	Description
Contact Position	Reverse Contact Point	If this check box is selected, the tool contact point direction will be reversed.
Tool Axis	Type	The value is the same as that selected from the **Tool Axis** drop-down list in the **Create Operation** window. If modified, the value in the **Tool Axis** drop-down list is also changed. **Note** If the tool type is belt sander and the tool axis type is Fixed_Axis, the tool may rotate slightly during actual machining process to make sure the processing tool surface is within the belt section range defined during tool creating. Detailed information about how to define the belt section used to process can be found in *Create Tool window on page 89*.
	Direction Vector (mm)	Available only to tool axis type Fixed_Axis. The setting is the same as the vector setting for a geometry.

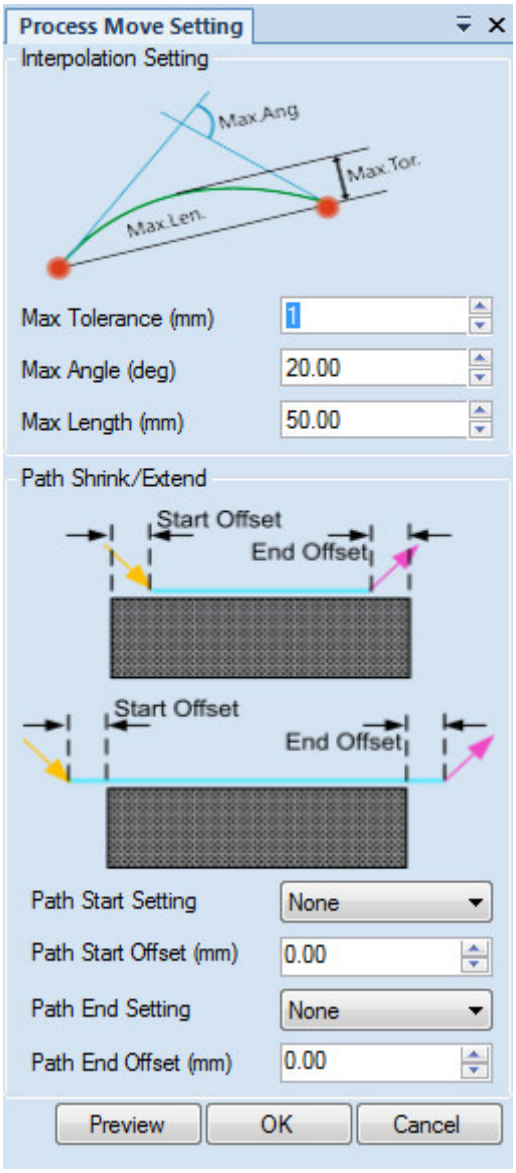
Continues on next page

4.6 Creating operation
Continued

Group	Item	Description
Angle Setting[i]	Tile Angle (deg)	The tool rotates in the specified angle along the forward direction of the path with the contact point as the center.
	Lead Angle (deg)	The tool rotates in the specified angle along the tangent direction to the forward direction of the path with the contact point as the center.

i This parameter group is available only to tool axis type Part_Normal.

Process move setting



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Group	Item	Description
Interpolation Setting	Method	The distance between two contact points will be calculated automatically based on the settings of other interpolation parameters, or always be the maximum length value. If setting to **MaxLengthOnly**, the **Interpolation Setting** checkbox in **General** tab page of the **Preferences** dialog box will be always taken as selected regardless of the actual selection status.
	Max Tolerance (mm)	A tolerance is allowed for the actual processing path to deviate from the directly connected path between two adjacent contact points within the specified value.
	Max Angle (deg)	The angle between the crossed tangent lines of two adjacent contact points must be within the specified value.
	Max Length (mm)	The distance of the path that the tool processes from one contact joint to the next contact joint must be within the specified value.
Path Shrink/Extend	Path Start Setting	The path can be shrank or extended for a defined distance at the start point or end point. The parameter specifies the path change type at the start point.
	Path Start Offset (mm)	This parameter specifies the distance that the path will shrink or extend from the start point.
	Path End Setting	The path can be shrank or extended for a defined distance at the start point or end point. The parameter specifies the path change type at the end point.
	Path End Offset (mm)	This parameter specifies the distance that the path will shrink or extend from the end point.

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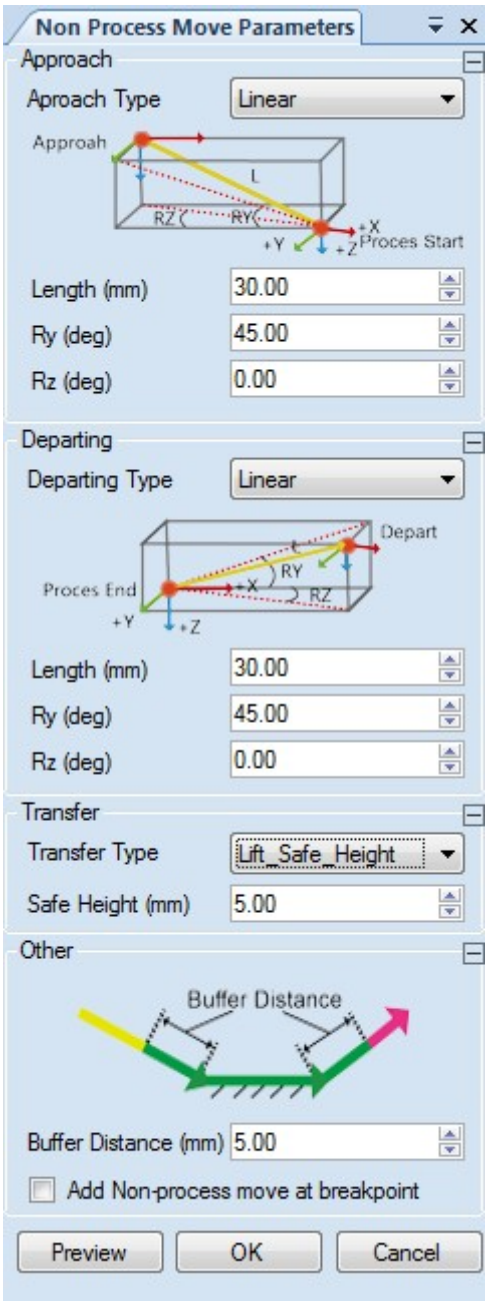
4.6 Creating operation
Continued

Non-process move setting



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Continues on next page

Group	Item	Description
Approach	Approach Type	If **Linear** is chosen, users need to set approach length and angles as required. If templates exist in **Preferences**, they will be listed and can be used directly after **Select_Template** is chosen.
	Length (mm)	Available only when **Approach Type** is **Linear**. The length defines the location where the tool starts approaching the machining part.
	Ry (deg)	Available only when **Approach Type** is **Linear**. The tool approaches the machining part with a deviation angle from the Y axis of the first machining point.
	Rz (deg)	Available only when **Approach Type** is **Linear**. The tool approaches the machining part with a deviation angle from the Z axis of the first machining point
Departing	Departing Type	**Same_as_Approach** is chosen by default, which enables the departing type to use the approach settings directly. It also allows users to customize departing settings or use a template as the approach type.
	Length (mm)	Available only when **Departing Type** is **Linear**. This parameter specifies the length that the tool departs from the machining part.
	Ry (deg)	Available only when **Departing Type** is **Linear**. The tool departs from the machining part with a deviation angle from the Y axis of the last machining point.
	Rz (deg)	Available only when **Departing Type** is **Linear**. The tool departs from the machining part with a deviation angle from the Z axis of the last machining point.
Transfer	Transfer Type	**Use_Approach_Departing** is the default option, which makes the tool moving along the path as the approach and departing type set. In addition, two more options **Lift_Safe_Height** and **Direct** are available. If **Lift_Safe_Height** is chosen, except the first and last machining points, the tool will not follow the approach and departing settings but only lifts vertically from the machining part with the specified height. If **Direct** is chosen, the tool always contacts the machining part, also except the first and last machining points, along the path during the processing. Users can click the **Preview** button to obtain a real-time view on the settings in the 3D graphics window.
	Safe Height (mm)	Available only when **Transfer Type** is **Lift_Safe_Height**.
Other	Buffer Distance (mm)	Within the buffer distance, the tool gradually adjusts its position to approach or depart the machining part, without a sudden change to the approach or departing position.
	Add Non-process move at breakpoint	If this combo box is selected, tool approach and departing are always performed at breakpoints.

4.7 Simulating robot path

Overview

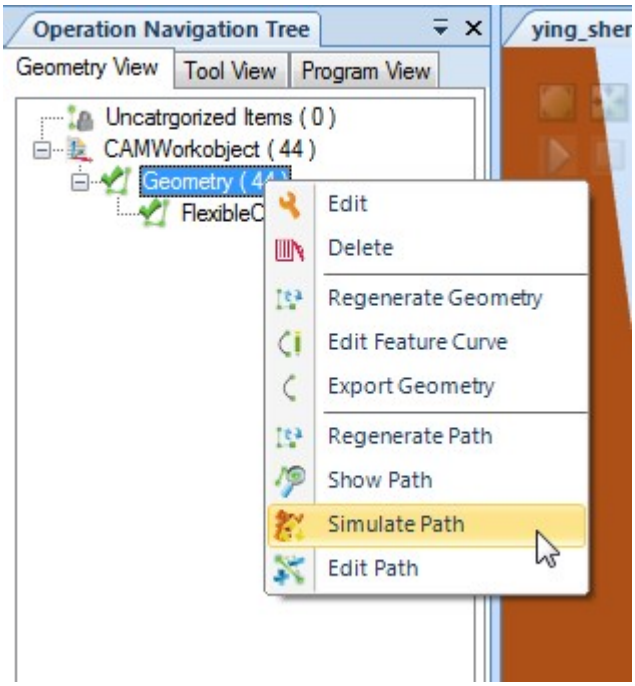
After operation creating, path editing or path optimizing, run simulation to ensure the operation run properly on the robot controller. In Machining PowerPac - Machining, the simulation can be run in either quick or VC simulation method.

Continues on next page

4.7.1 Simulation window

Entering simulation

Select **Simulate** from the **Simulation** category in the **Machining** ribbon tab to start simulation. Alternatively, you can also right-click a node in the **Operation Navigation Tree** and then choose **Simulate Path** to start the simulation. If entering from the ribbon tab, the selection of a geometry or operation is a must; otherwise, a warning message will display to prompt you to select a valid geometry or operation. If entering from the **Operation Navigation Tree** and a geometry, work object or tool has multiple operations, only the path generated by the first operation will be simulated.



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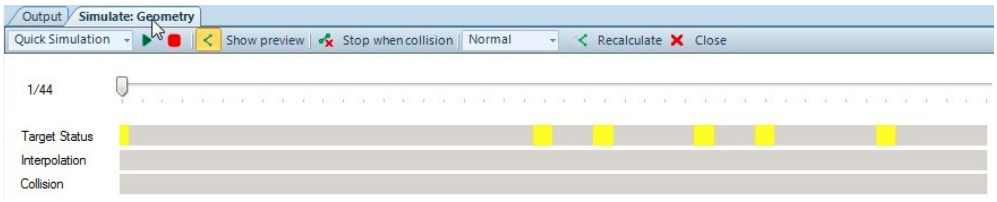
A separate **simulation control** window will appear under the 3D graphics window, as shown in the following figure.



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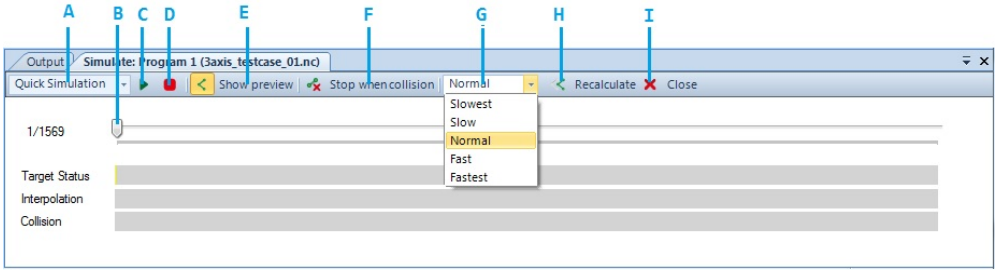
During the simulation, the tool model will be shown in the 3D graphics window, moving along the robot path. After entering the simulation, only path editor and path optimization can be performed.

Continues on next page

4.7.1 Simulation window
Continued

Simulation control

The control panel for quick simulation and VC simulation are similar. The following describes the panel for quick simulation. For the panel for VC simulation, see *Simulation with a visual controller on page 111*.



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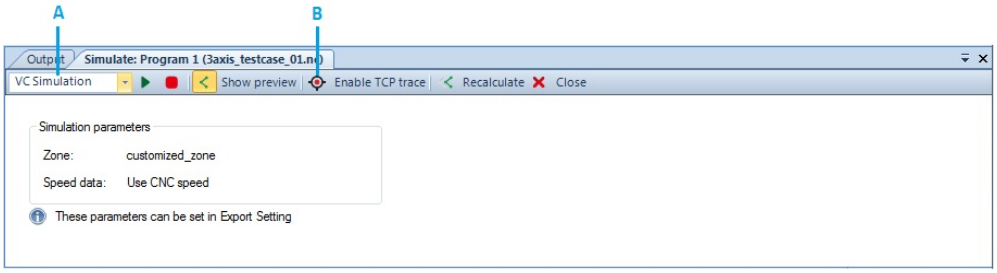
Item	Control	Description
A	Simulation method selection	Selects **Quick Simulation** for running with quick simulation. The Quick Simulation system is based on algorithms set as default by RobotStudio and cannot be modified in any way whereas running quick simulation allows customized calculation methods. **Note** Running with VC will be more precise but take more time in average.
B	Result scrollbar	The result scrollbar can be used to browse through parsed path points by dragging it along the horizontal axis. The index of current path point and the total number of path points are provided before the scrollbar.
C	Start/Pause	Starts or pauses the simulation manually.
D	Stop	Stops the simulation manually.
E	Show preview	Shows robot path when running simulation.
F	Stop when collision	Stops the simulation when collision occurs. This can only function when running quick simulation.
G	Speed selection	Five speed types are available.
H	Recalculate	When the robot path is modified by path editor or path optimization, the robot path need to be recalculated. If it is a program is modified, after clicking **Recalculate**, the discontinuity between robot joints and between external axes will be compensated automatically.
I	Close	Uses the X icon to exit simulation mode.
-	Target Status bar[i]	Displays target information.
-	Interpolation bar[i]	Displays interpolation targets during simulation.
-	Collision bar[i]	Displays collision status.

i The color of target status, interpolation and collision bars change according to the current status. When moving the cursor over a bar, a popup message will display with corresponding color information.

Continues on next page

Simulation with a visual controller

Selecting **VC Simulation** from the simulation method selection drop-down list box will run the simulation with a visual controller. The **Enable TCP trace** button will appear on the control panel, instead of the **Stop when collision** button.



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Item	Control	Description
A	Simulation method selection	Selects **VC Simulation** for running VC simulation.
B	Enable TCP trace	Enables tool path tracing. When this option is checked, the tool will leave a trace behind.

Note

Make sure the controller is ready before VC simulation.

If the controller is not ready, or the controller do not load the right RAPID file, there will be errors.

4.7.2 Simulating robot path

Procedure

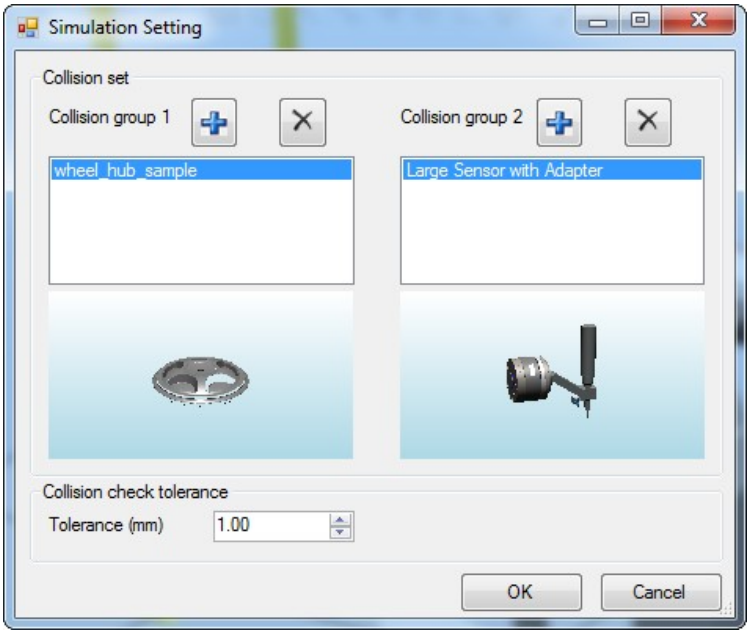
Use this procedure to simulate a robot path.

	Action	Illustration/Note
1	Open the simulation window.	**Note** If clicking **Simulate** but without a geometry or operation selected, a message window will appear.
2	In the simulation control panel, click **Start** to start the simulation. The simulation will run at the given speed.	See *Simulation control on page 110* for reference.
3	Click **Pause** button to pause the simulation, or click **Stop** to stop it. Resume a simulation by clicking **Start** button again.	
4	Use the result scrollbar in the simulation control panel to toggle among path points. The preview on a path point will display in the 3D graphics window upon the toggling on the point.	
5	To exit simulation, click the X icon in the panel.	

4.7.3 Setting collision set for simulation

Overview

A collision set contains two groups, collision group 1 and collision group 2, in which you place objects to detect any collisions between them. When any object in group 1 collides with any object in group 2, the collision is displayed in the 3D graphical view and logged in the output window. You can have several collision sets in a station, but each collision set can only contain two groups.



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Group	Item	Description
Collision Set	Collision group 1 and 2	The collision set component A and B.
	3D graphic view window	The selected parts in collision set are displayed in these windows.
Collision check toleration	Tolerance (mm)	For some pressure processes, the collision between the tool and part is allowed. In this case, you can specify a tolerance value so that the system will ignore all small collision checks within the tolerance during the simulation. You can focus on those poor collision checks.

Procedure to create collision set

Use this procedure to create a collision set.

	Action	Illustration/Note
1	Choose **Simulation Setting** from the **Simulation** category in the ribbon tool to open the simulation setting dialog box.	

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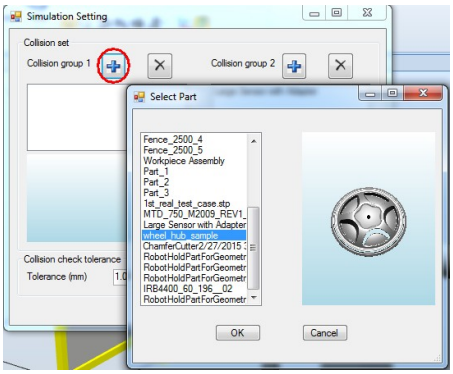
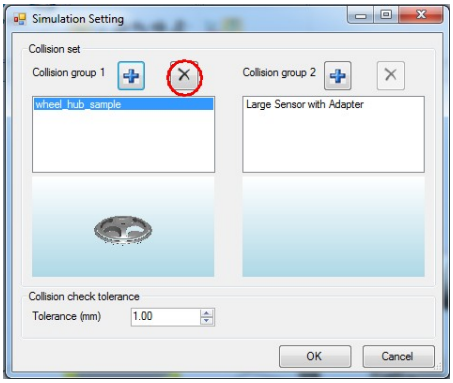
4.7.3 Setting collision set for simulation

Continued

	Action	Illustration/Note
2	Click the + button to expand the collision set. A dialog box displays for you to select parts.	 xx1500000186
3	Select a part you want to use for collision check by clicking it. The CAD model of the selected part is displayed on the right. Proceed by clicking **OK**.	
4	You can add multiple parts in each group for collision check, but each time you can choose only one part.	
5	If needed, remove a part by selecting it and then clicking the **x** button.	 xx1500000187
6	Enter a value in the **Tolerance (mm)** text box or click the up/down arrows to choose a value.	 xx1500000469
7	Click **OK** to apply the settings.	

4.8 Path Editor

4.8.1 About the path editor

Overview

The Path Editor is used to manually edit path targets after path generation and displays the targets by representing them as instruction nodes in a list. These targets can be modified by using commands from the shortcut menu or the commands in the **Modify** ribbon tab that displays after nodes are chosen. In order to run Path Editor, users may run into path editor in both of the following cases.

- Path edit without simulation
- Path edit with simulation

From the simulation result window, pick a path point to edit. See *Simulating robot path on page 108* for more information on simulation.

The Path Editor has these features:

- Shows the position and rotation based on the active work object.
- Shows how current robot joints.
- Edits a single or multiple points manually to obtain a more precise processing path.

Contact path and contact point

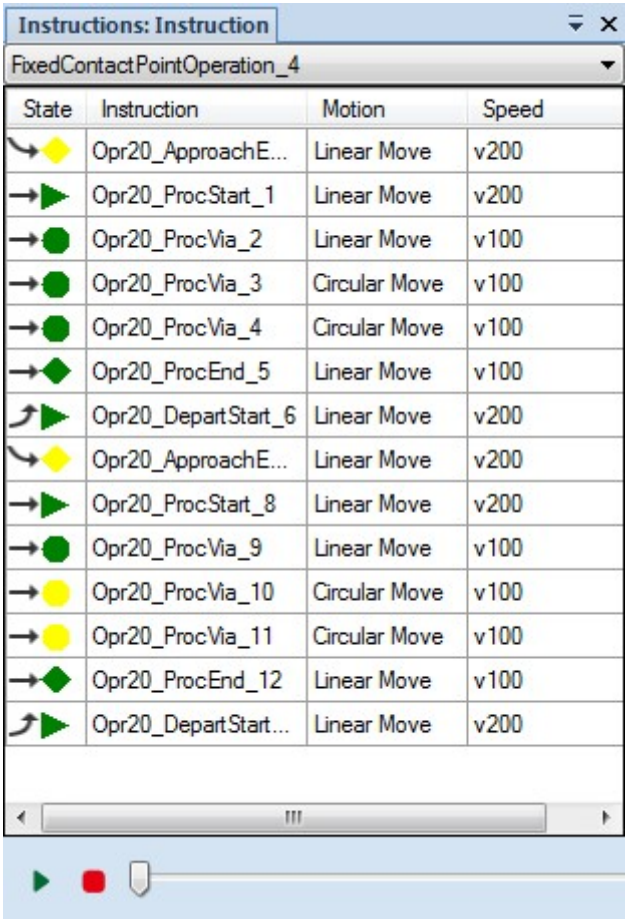
A robot path, also known as TCP path, is generated based on the setting of a specific tool. The robot path represents the moving tragectories of the tool, which is not the actual processing path on the machining part. The tool processes on the part at a certain point, that is called contact point, and the trace of contact points is defined as the contact path. In path editor, all functions working on contact points are available only when the tool is defined to side machining.

4.8.2 Entering path editor

Entering methods

Select **Path Editor** from the **Path Editor** category in **Machining** ribbon tab. You can also right-click any node in the **Operation Navigation Tree** and select **Edit path** from the shortcut context menu.

If you enter the path editor from the ribbon tab, a geometry or operation must be selected first. If the path editor is entered from a geometry node that has multiple operation nodes, the robot instructions of only the first operation under the geometry node will be listed. After entering the path editor, only simulation function is available in the ribbon tab for use.



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4.8.3 Working with instruction list

Instruction list

The **Instructions** window is displayed at the right pane and list all instructions. There are four columns: **State**, **Instruction**, **Motion** and **Speed**.

Every row in the list view represents an instruction node. Each node has a unique name that follows the naming rules set in **Preference** dialog box but still enables modification by double-clicking. For naming rule setting, see *Instruction Name on page 43*. The node name is displayed next to the target point in the 3D graphics window when the corresponding node is selected.

Icons and states

In the **State** column of the instruction list, arrows and graphs are used together to indicate the process phase of a robot instruction, each of which has three patterns:

- Arrows directing to southeast indicate instructions related to approach, those directing to northeast indicate instructions related to departing, and right arrows indicate the process.
- Right-directed triangles represent start instructions, diamonds represent end instructions, and rounds are course instructions.

In addition, graphs of different colors indicate different process states as described below:

Color	Description	Error Type
Red	Error	Singularity/Out of range/Outside reach
Yellow	Warning	Large joint change/Wrist flip
Green	Normal	No error
Blue	Dynamic Error	Collision

Motion

In the **Motion** column of the instruction list, the motion type of each instruction is displayed as **Linear Move**, **Circular Move**, or **Joint Move**, representing MoveL, MoveC, and MoveJ in RAPID code respectively.

Generally, an instruction is carried out in linear motion type and can be converted to joint motion type by selecting **Convert to Joint**/**Linear** from the context menu, to make the robot perform joint movement between targets. An instruction in joint motion type also exists when a safe plane has been set.

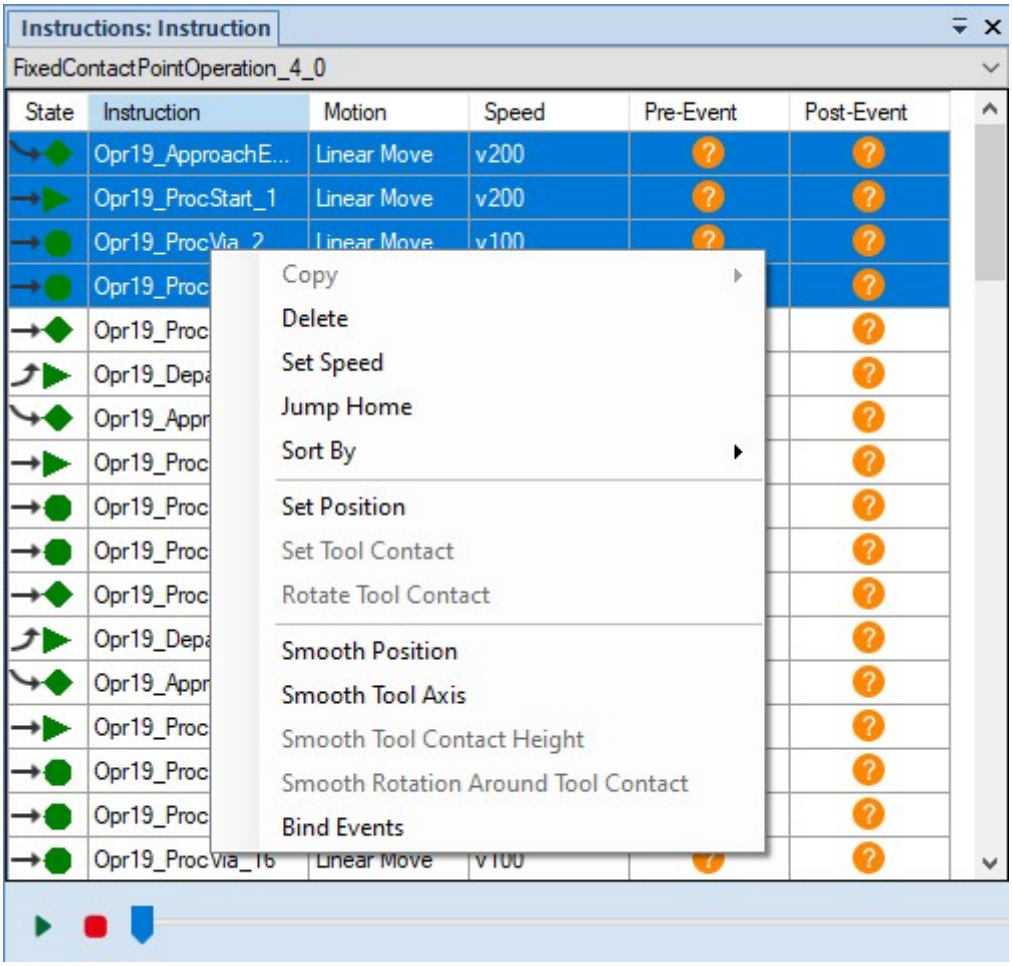
If the generated path is a circle or circular arc, the instruction will be automatically carried out in circular motion type. Because the circular motion can only be used for open circular arcs, two instruction nodes will be listed when the path is a closed circle, each of which represents a half circle. Different from the instructions in linear motion type, which has one target point, an instruction in circular motion type has two target points, the mid-point and the end point. When selecting an instruction node with **Circular Move**, the mid-point of the corresponding circular arc is previewed in the 3D graphics window.

Continues on next page

4.8.3 Working with instruction list
Continued

Context menu for instruction nodes

Instruction nodes in the list can be selected for operating more functions. It is also possible to select multiple nodes using **Ctrl** and **Shift**. Right-clicking the selected node(s) in the **Instructions** window would display a context menu for target. The following figure shows the available functions.



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	Menu Item	Description
1	Copy/Insert Above	Copies the selected robot instruction node and inserts above. **Note** The copy menu item is enabled when only one instruction selected. When user selects more than one instruction, the menu item will be disabled.
2	Copy/Insert Below	Copies the selected robot instruction node and inserts below.
3	Delete	Deletes the selected instruction(s).
4	Convert to Joint/Linear[i]	Converts the motion type of the selected instruction, joint movement or linear movement. For a joint target, the robot performs a joint movement from the previous target; otherwise, the robot runs in linear.

Continues on next page

	Menu Item	Description
5	Set Speed	The **Set Speed** window will be shown in the left pane. Modifies the speed data of the target.
6	Jump Home	When the robot hides the robot path preview, users can click this menu item to make the robot jump to home position (zero position).
7	Sort By/Instruction Sequence	Lists the instruction nodes in the original instruction sequence.
8	Sort By/Speed Data	Lists the instruction nodes based on the speed data. If nodes are sorted by speed data, only **Set Speed** will be available in the context menu.
9	Set Position	The **Set Position** window will be shown in the left pane. Path editor reuses the set position tool of RobotStudio, so users can operate it easy. Sets the position and orientation based on the specified reference frame for the selected instruction. If multiple instructions have been selected, the position and orientation of the first instruction need to be set and other instructions will have a relative displacement. If the instruction is in circular motion type, users can further select **Cir Point**, **To Point**, or **Both** to set the position and orientation of the mid-point, end point, or both points, respectively.
10	Set Position/Cir Point	Submenu of the **Set Position** command. Valid when the instruction is in circular motion type and displays the **Set Position** window for setting the position and orientation of the mid-point of the instruction.
11	Set Position/To Point	Submenu of the **Set Position** command. Valid when the instruction is in circular motion type and displays the **Set Position** window for setting the position and orientation of the end point of the instruction.
12	Set Position/Both Point	Submenu of the **Set Position** command. Valid when the instruction is in circular motion type and displays the **Set Position** window for setting the position and orientation of both mid-point and end point of the instruction. If **Local** is selected from the **Reference** drop-down list in the **Set Position** window, the set value(s) are the increment to the original position/orientation values. If **World** is selected, the position and orientation of both mid-point and end point of the instruction will be modified to the set values; in this case, the mid-point and end point coincide with each other.
13	Set Tool Contact[ii]	The **Set Tool Contact** window will be shown in the left pane. Modifies the contact point for one or more specified targets. For details, see *Setting tool contact on page 122*.
14	Rotate Tool Contact[ii]	The **Rotate Tool Contact** window will be shown in the left pane. Rotates the tool for one or more specified targets with the contact point unchanged. The Y axis of the contact point is used as the center during the tool rotation around the point.
15	Smooth Position[iii]	The **Set Position Smooth** window will be shown in the left pane. Selects one or more targets between a start and end target to adjust target positions for obtain a smooth position change. For details, see *Smoothing position on page 123*.
16	Smooth Tool Axis[iii]	The **Smooth Tool Axis** window will be shown in the left pane. Adjusts the tool axis of one or more targets to obtain a smooth tool axis change between targets. For details, see *Smoothing tool axis on page 124*.

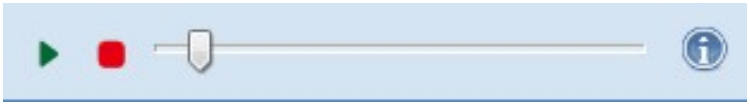
Continues on next page

4.8.3 Working with instruction list
Continued

	Menu Item	Description
17	Smooth Tool Contact Height[iv]	The **Set Tool Contact Smooth** window will be shown in the left pane. Smooths the change from the contact point of one target to that of another. For details, see *Smoothing tool contact height on page 125*.
18	Smooth Rotation Around Tool Contact[iv]	The **Rotate Tool Contact Smooth** window will be shown in the left pane. Smooths the tool rotation from one target to another. For details, see *Smoothing rotation around tool contact on page 126*.
19	Smooth BeltSander Angle[v]	The **Smooth BeltSander Angle** window will be shown in the left pane. Smooths the processing angle of the belt sander from one target to another. For details, see *Smoothing beltsander angle on page 127*.
20	Bind Events	The **Bind Events** dialog box will be displayed. Binds events to the selected target/target group. For details, see *Binding events on page 128*. **Note** The bind events exist and take effect only in the RAPID programs that are exported using the Mach_*XX* export template.

i Available only for one-node selection.
ii Available only when operation type enables contact point change, tool type is cutter and tool side is used for machining.
iii Available only when three or more instruction nodes are selected.
iv Available only when operation type enables contact point change, tool type is cutter, tool side is used for machining, and three or more instruction nodes are selected.
v Available only when tool type is belt sander, and three or more instruction nodes are selected.

Path player



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It looks like a simple audio player, but it plays with the robot instruction nodes.

1. Click the **Start** button (green) to start the player

   When the player starts, the button will be changed to the Pause icon, the selected node in list view will change one by one quickly.
2. Click the **Pause** button

   The quick preview will be paused.
3. Click the **Stop** button (red) to stop the player

   The quick preview will be stopped and the cursor will be reset to zero-position.

If you hover the mouse cursor over the information icon, some tool tips for the Path Editor are shown.

4.8.4 Editing a path

General procedure

Use this procedure to edit a robot path.

Note

For path editor to work, you need to have a geometry or operation selected in the **Operation Navigation Tree**.

	Action	Illustration/Note
1	Open the path editor.	**Note** If no geometry or operation is selected, a message "Please select valid operation or geometry first!" will pop up. After path editor is activated, nodes in the **Operation Navigation Tree** are disabled.
2	Select instruction nodes in the instruction list view. Left-click mouse device to select one node. Multi-select by left-clicking and dragging mouse device or left-clicking mouse device with **Ctrl**/**Shift** pressed.	**Note** If no geometry or operation is selected, a message "Please select valid operation or geometry first!" will pop up. After path editor is activated, nodes in the **Operation Navigation Tree** are disabled.
3	Right-click on selected instruction nodes and select required command from the shortcut context menu.	
4	The settings will be displayed in real time in the 3D graphics window or you can have a dynamic preview for some certain commands.	**Tip** Always have a preview before accepting the setting. Accepted settings cannot be reversed.
5	After setting, click the **Start** button to view the processing movement along the path. Alternatively, view the path by simulating it in the **Simulation** window.	
6	**Note** Do not regenerate the path after editing it using the path editor; otherwise, the settings are withdrawn.	

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4.8.4 Editing a path
Continued

Setting tool contact

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Either tool axis or normal axis can be used as the fixed axis, based on which the setting applies.

In the setting window, to have an intuitive view of setting adjustment, a diagram is represented to show target indexes at X axis and height at Y axis. The original contact height on the tool is displayed with a green line and modified height with a red line. The height adjustment take effect for all targets if multiple instruction nodes have been selected.

To modify the height, drag the scrollbar to obtain a required value. The adjustable height range is the specified contact height for tool. Alternatively, you can use up/down arrow buttons on the keyboard to add/reduce the value by 1 each time. **Dynamic Preview** enables a preview on the settings. Always preview before applying the settings because they are irreversible.

Ensure that the tool always contacts the machining part during the contact height setting. Otherwise, a warning will be displayed to prompt you to modify the setting.

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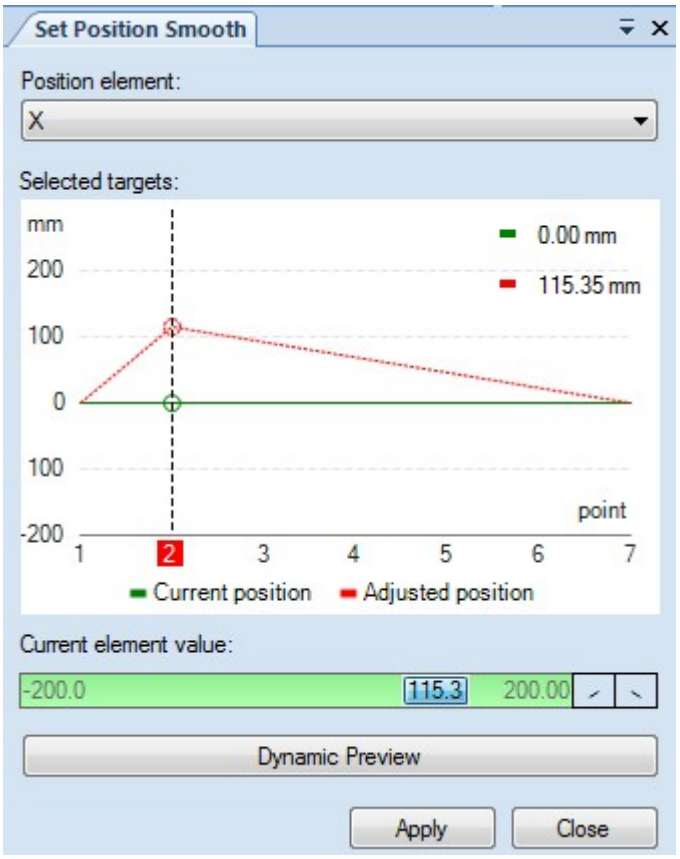
Smoothing position



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Positions of several targets can be adjusted based on the X/Y/Z axis of either original position or orientation to obtain a smooth position change between targets. If the contact height of a target changes, the target becomes a key target being circled. The key target can also be converted to a normal target by right-clicking the circle and choosing **Delete Key Node**. Note that modified value of the target keeps until the setting is all done.

The operation for smoothing position is similar to that for setting tool contact. Before applying the adjustment, use **Dynamic Preview** to preview the settings. A target can deviate from its original position by a maximum of 200 mm.

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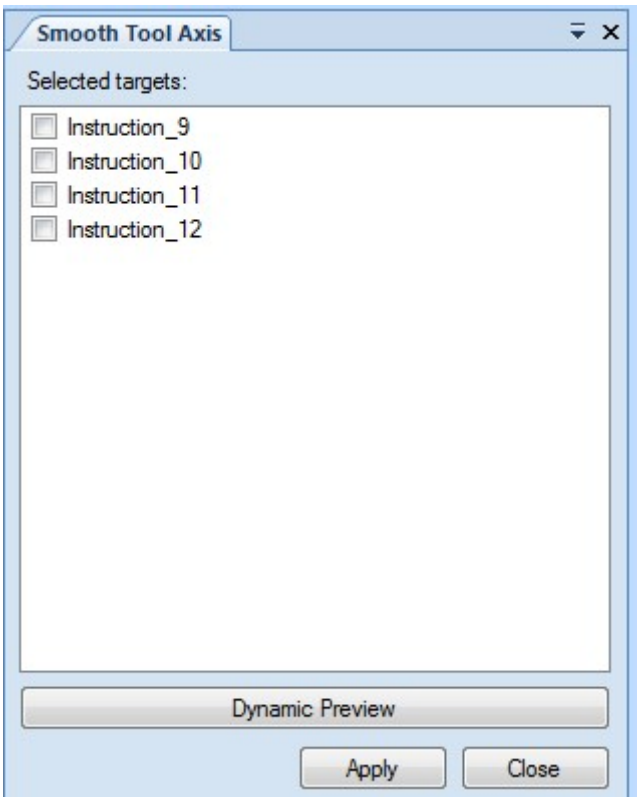
4.8.4 Editing a path
Continued

Smoothing tool axis



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Check boxes are available for selecting one or more targets to obtain tool axis smoothness. Only tool axes of unselected targets will change to ensure smooth path from one selected target to its next selected target. However, the tool axes of the first and last targets never change. **Dynamic Preview** is also available.

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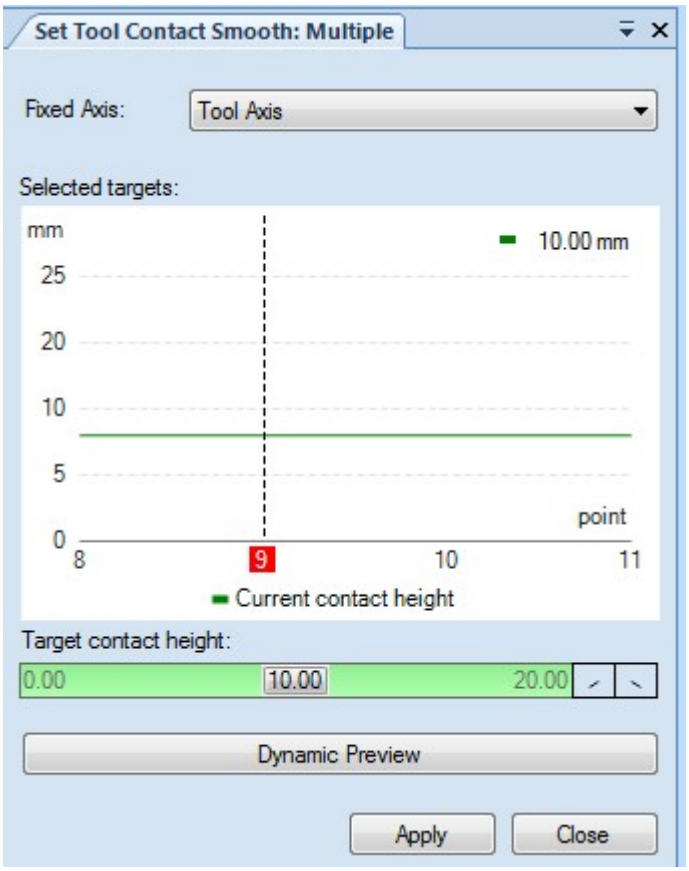
Smoothing tool contact height



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You can select one or more targets between a start and end targets and set their contact height in a similar way of setting the height of a single target. After setting, smoothness will be applied between contact heights of two targets. **Dynamic Preview** is also available.

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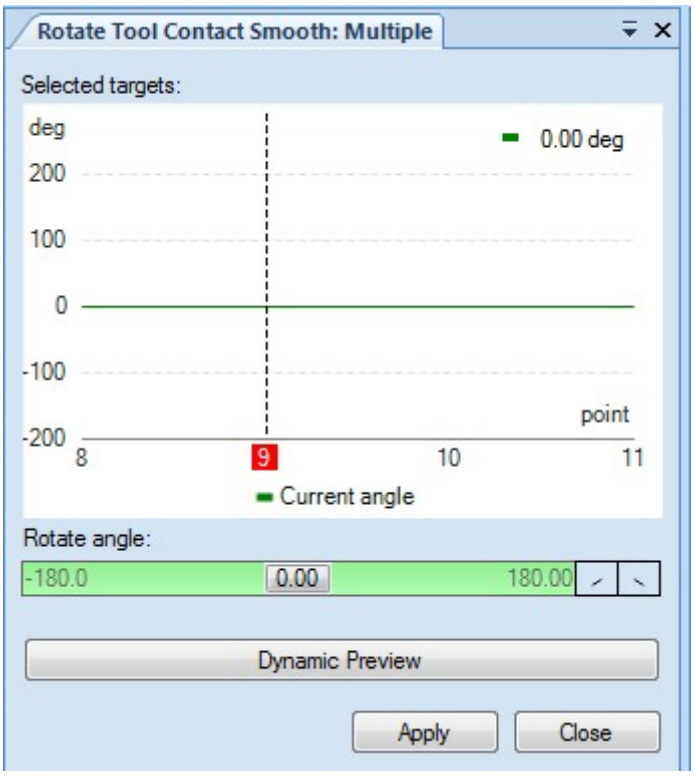
4.8.4 Editing a path
Continued

Smoothing rotation around tool contact



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The tool changes its pose to achieve the rotation around the contact point of specified targets. With a similar way of setting tool contact, the tool will smoothly rotate from the pose at one target to the pose at another target after the setting using this function. **Dynamic Preview** is also available.

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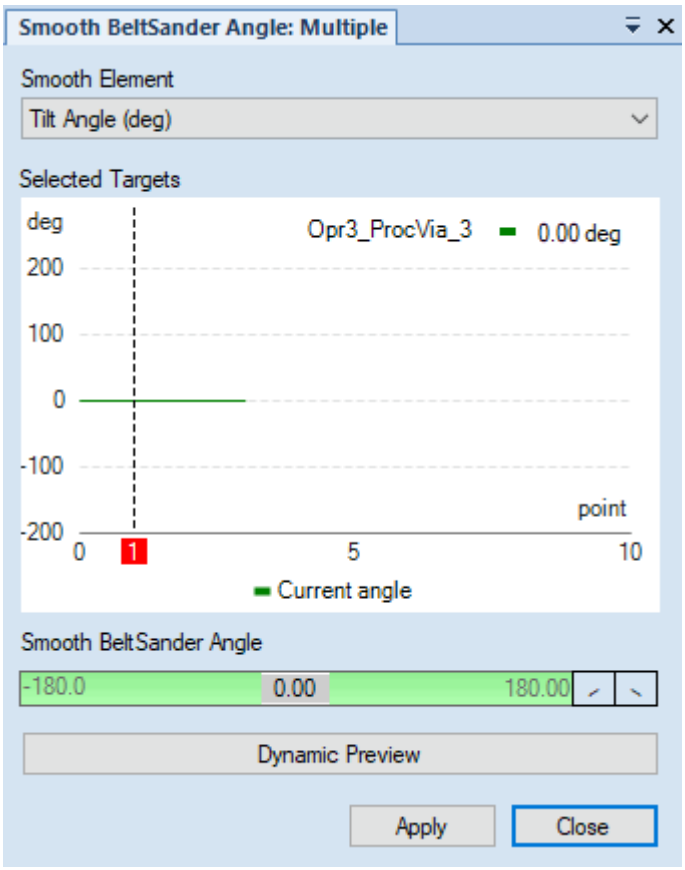
Smoothing beltsander angle



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You can select three or more targets and set the processing angle of the belt sander at each target.

In the setting window, modify the smooth element as required. If **Tilt Angle (deg)**, **Lead Angle (deg)** or **Rot Angle (deg)** is selected, the belt sander changes its angle to process by rotating around the X axis, Y axis and Z axis of the processing point on the belt, respectively. If **Rotation Around TCP-Z (deg)** is selected, the belt sander changes its processing angle by rotating around the Z axis of the TCP. Other operations of smoothing beltsander angle are similar to those of setting tool contact for a cutter-type tool.

After the setting, the belt sander will smoothly adjust its processing angle from one target to another. **Dynamic Preview** is also available.

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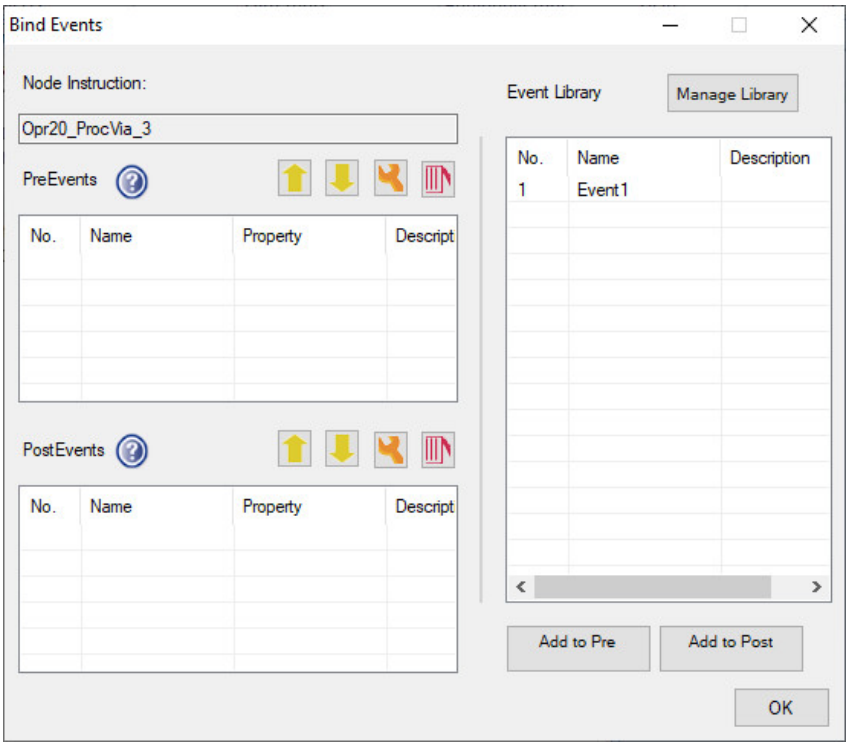
4.8.4 Editing a path
Continued

Binding events



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An event, which could be a RAPID program or a signal trigger, can be added before or after the selected target/target group as the start event or end event, respectively. Events bound to targets/target groups are also allowed to be sorted, modified and deleted.

To manage all the available events or add a new event, clicking **Manage Event** to open the **Event Library** dialog box.

Note

The bind events exist and take effect only in the RAPID programs that are exported using the Mach_*XX* export template.

4.9 Path Optimizing

4.9.1 Automatic path optimizing

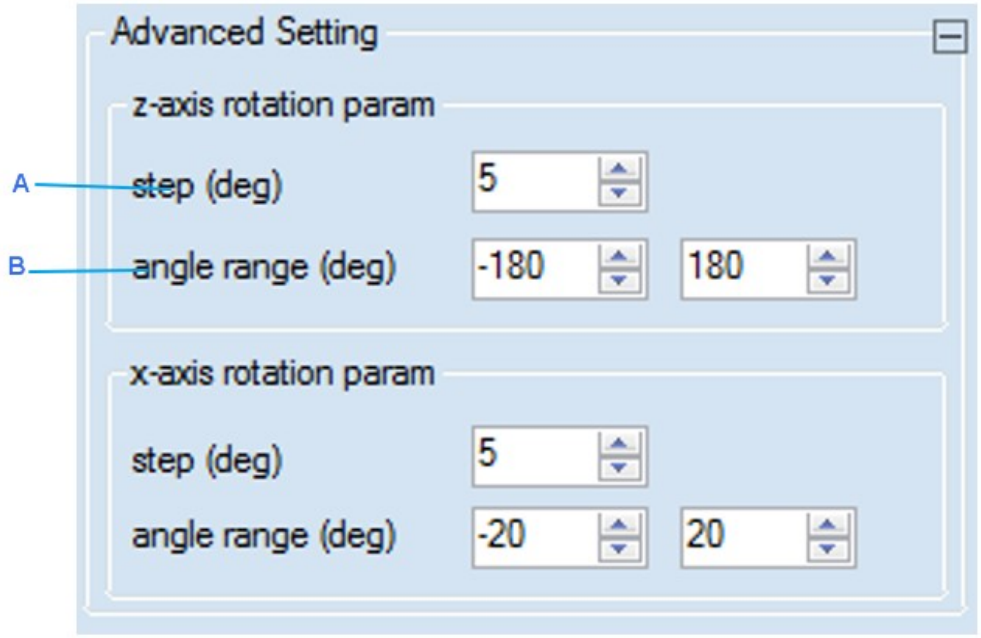
Overview

Automatic path optimizing will automatically rotate the robot targets to find error free solution. This function is active only for geometries and only modifies the orientation of targets.

> **Note**
>
> To enable automatic path optimizing, make sure that in the **Path Optimizer** page in the **Preferences** dialog box, **Automatic Optimizer** is selected from the **Default Path Optimizer** drop-down list. See *Path Optimizer on page 44*.

Advanced setting

The advanced setting is default collapsed. You can modify the settings for specific requirement.



xx1400002315

Item	Control	Description
A	Step	Optimization tries to find the error-free solution step by step. Step specifies the step value that changed every time.
B	Angle range	Axis angle range limitation of robot targets.

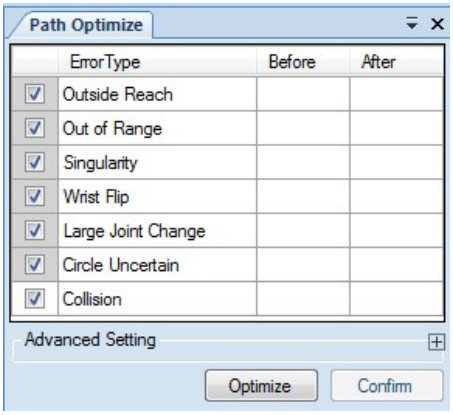
Continues on next page

4.9.1 Automatic path optimizing

Continued

Procedure

Use this procedure to optimize targets.

	Action	Illustration/Note
1	Select a geometry in the **Operation Navigation Tree**.	
2	Choose **Target Optimize** from the Path Editor category in the ribbon tab to open the path optimizing window.	 xx1500000198 *Figure 4.1: Path Optimize window*
3	Toggle on or off the **Collision** check.	**Note** Other error types are always validated in optimization.
4	Click **Optimize** button to start the optimization and the result will be displayed in the table above. The **Before** column displays the number of error targets before optimization, and the **After** column displays the number of error targets after optimization.	
5	Click **Confirm** button to apply the optimization result into robot targets.	**Note** After clicking **Optimize**, the result will not be apply into robot targets automatically until you confirm it. A message shows after clicking **Confirm** to make sure that you want to confirm the optimization result.
6	Close target optimize window to exit this function.	The robot targets will be updated. In addition, the process bar in simulation (if simulation window displays), the list view in path editor and the robot path will all be updated.

4.9.2 Manual path optimizing

About manual path optimizing

Overview

Manual path optimizing is used to manually edit the orientations of path targets after path generation to find an error-free solution. The function is available to a single geometry, operation, or program group.

> **Note**
>
> To enable manual path optimizing, make sure that in the **Path Optimizer** page in the **Preferences** dialog box, **Manual Optimizer** is selected from the **Default Path Optimizer** drop-down list. See *Path Optimizer on page 44*.

Manual path optimizing has these features:

- Shows the working angle of a specific robot joint at a specific target.
- Shows all static errors, dynamic errors, and collisions in a graphic view and the specific targets that have these errors.
- Edits targets by simply dragging a Bezier curve to obtain error-free path.

Error types

The following error types can be shown for manual path optimizing:

- Dynamic error

  If the path has a dynamic error at a specific target, it means the target is still reachable but the robot may experience a sudden wrist flip. This may be caused by a large angle change between two adjacent targets or a large working angle change of the joint.
- Static error

  If the path has a static error at a specific target, it means the target is unreachable.
- Collision

  If a collision error is presented at a specific target, the robot collides with other parts during machining at this target.

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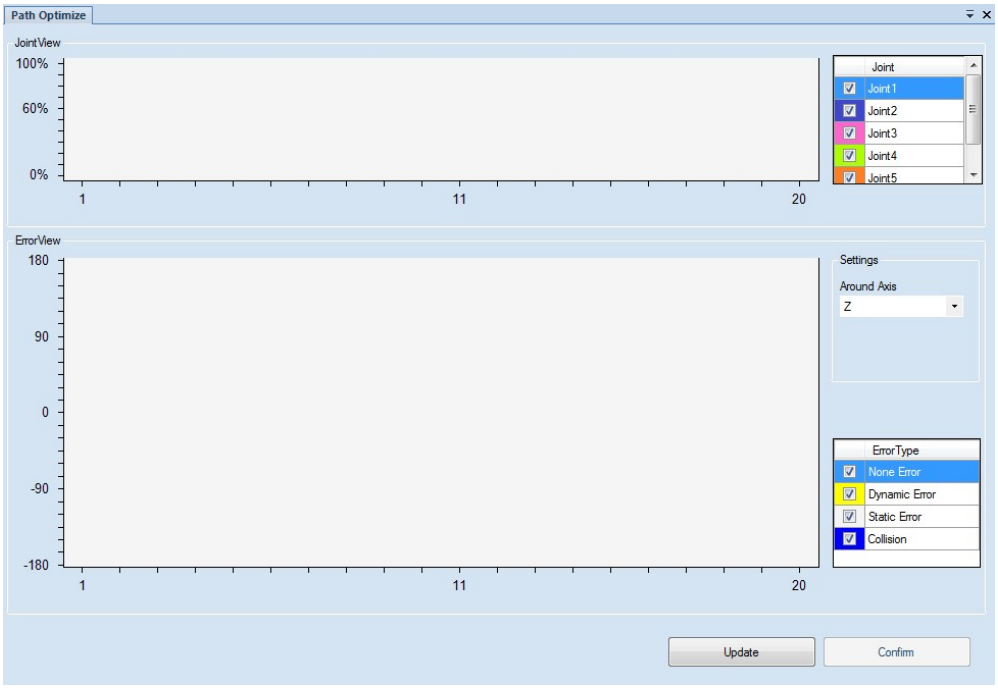
4.9.2 Manual path optimizing
Continued

Path Optimize window

General



xx1600001204

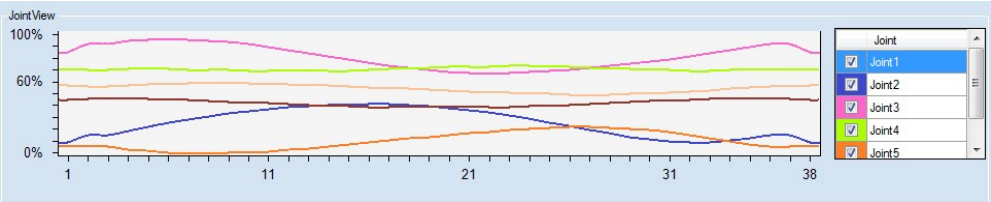
Area	Item	Description
JointView	Horizontal axis	Specifies the targets that the path has. Each scale mark represents a target.
	Vertical axis	Specifies the working angle of a robot joint in percent. The value is calculated based on the allowed working range of the joint.
	Joint list	Lists all the joints of the robot. Users can select one or more joints to show. By default, all joints are selected. Selected joints will be displayed in different colors in the graphic view.
ErrorView	Horizontal axis	Specifies the targets that the path has. Each scale mark represents a target.
	Vertical axis	Specifies the angle that the target rotates. **Tip** The actual displayed angle range depends on the selection from the **Default Axis range** drop-down list in the **Path Optimizer** page in the **Preferences** dialog box, which can be **+180 to -180** or **+360 to -360**. See *Path Optimizer on page 44*.
	Error Type	Lists all the error types that a path may have. By default, all types are selected. Users can remove any selection to ignore the errors in that type.
Settings	Around Axis	Specifies the axis around which the target rotates.

Continues on next page

Area	Item	Description
-	Update	For displaying or updating the graphic views in the **JointView** and **ErrorView** areas. **Note** Clicking this button will not make the path adjustments take effect on the geometry, operation and program group.
-	Confirm	For confirming the adjustments on the path. The modifications take effect only after clicking this button.

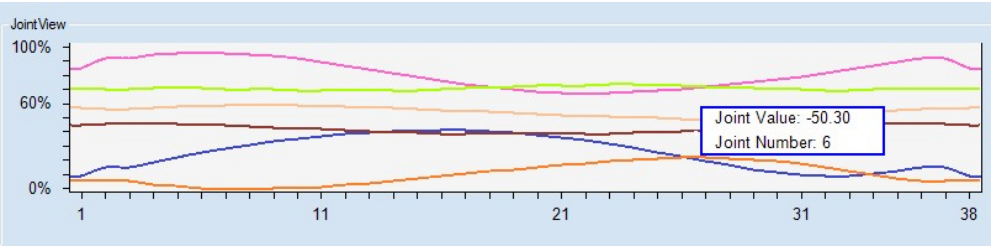
Graphic view in **JointView** area

In the **JointView** area, lines in different colors are used to represent the working ranges of robot joints at different targets. Users can choose the lines to be displayed by selecting or removing the check boxes in the **Joint** list.



xx1600001199

To show the working angle of a specific joint at a specific target, you can click on the corresponding line and move the mouse to the target. In this way, a message box is displayed, as shown in the following figure. The value in the message box changes when you move the mouse to another target or another line. You can click the blank area to close the display.



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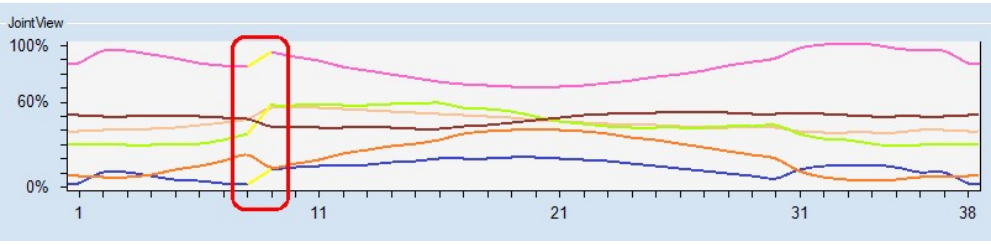
If one or more sections of a line become yellow, it means the robot joint will have a large working angle change from one target to the next target.



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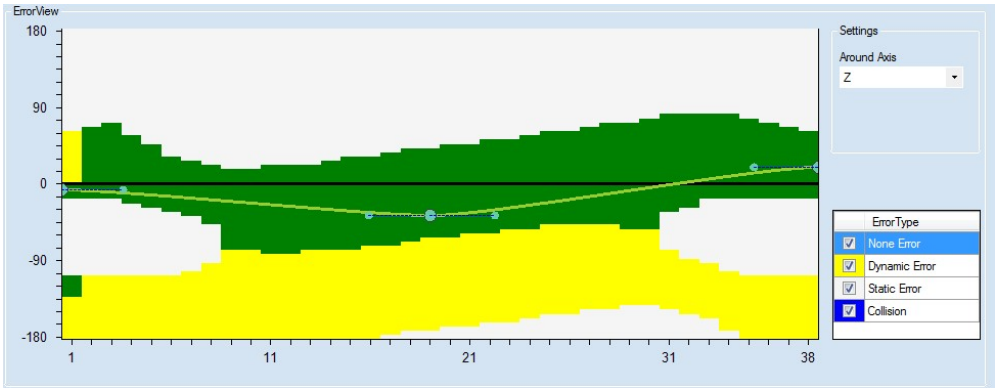
4.9.2 Manual path optimizing
Continued

Graphic view in **ErrorView** area

In the **ErrorView** area, color blocks are used for indicating whether the path has an error or not at different targets. The green, yellow, grey, and blue blocks indicate no error, dynamic error, static error, and collision, respectively. The black line represents the current path. The graphic view in the **ErrorView** area allows to be zoomed in and out.



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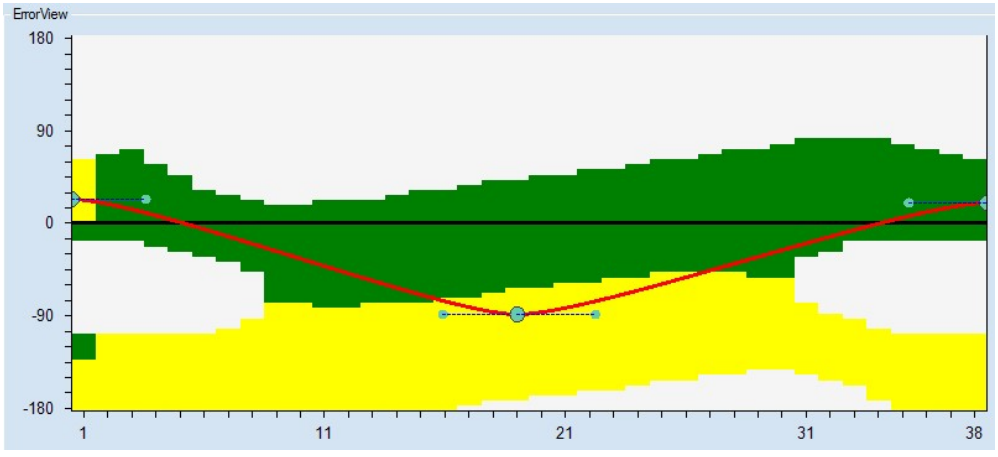
An adjustable curve is displayed to perform path optimizing. By default, three points, that is, the first target, middle target and end target of the path, are defined on the adjustable line. You can right-click the curve to add a new point for the required target. Every point has three sub-points. If you drag the center sub-point, only the orientation of its represented point is modified. If you drag the other two sub-points, the orientations of all the targets falling in the section between the two sub-points are smoothly modified. The adjustable curve becomes green only when all the targets are in the green area; otherwise, it is red, indicating you that the path still has errors at some targets.



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You can click the **Update** button to have a real-time display of the adjusted path, and click the **Confirm** button to accept the adjustment. After the adjustment is updated or confirmed, the adjustable curve replaces the current path and becomes black.

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Optimizing a path

Use this procedure to optimize a path.

> **Note**
>
> For manual path optimizing to work, you need to have a geometry, operation or program group selected in the **Operation Navigation Tree**.

	Action	Illustration/Note
1	Select **Path Optimize** from the **Path Editor** category in the ribbon tab to open the **Path Optimize** window.	**Note** If no geometry or operation is selected, a message "Please select geometry first!" will pop up. After path optimizing is activated, nodes in the **Operation Navigation Tree** are disabled.
2	Click **Update** to generate graphic views in the **JointView** and **ErrorView** areas.	**Note** If a geometry is selected, the horizontal axes of the graphic views show all the targets of the operations belonging to the geometry. If an operation is selected, the horizontal axes of the graphic views show the targets of the operation.
3	If required, in the **JointView** area, click the line of a required axis to view the working angle of the robot joint at different targets. **Tip** The value changes when the mouse moves to another target. Click the blank area to close the pop-up message box.	
4	In the **ErrorView** area, drag the points on the adjustable curve to adjust the target orientations until a green curve is obtained. If required, click the curve to add more points for adjusting.	**Note** During the adjustment, if the axis in the **Around Axis** drop-down list is to be modified and the adjusted path is not confirmed, a message box is displayed to prompt you to confirm the adjustments.
5	Click **Update** to display the adjusted path.	
6	If yellow sections exist in the lines in the **JointView** area, adjust the path again.	
7	If required, open the simulation window to verify that the path has no errors or meets the requirement.	
8	Click **Confirm** to accept the adjustment.	

4.10 Calibrating

Overview

The calibration function is designed to calibrate positions that are created offline in real cell. In Machining PowerPac - Machining, robot-hold work object and fixed work object are supported, with which users can simply create calibration modules. If all your targets refer to work objects, you only need to calibrate the work objects when using the program in real cell. To calibrate work objects, 5 points calibration method is recommended.

The setting window is similar for robot-hold work objects and fixed work objects (presented as robot-hold tools on GUI), with only work object list different.

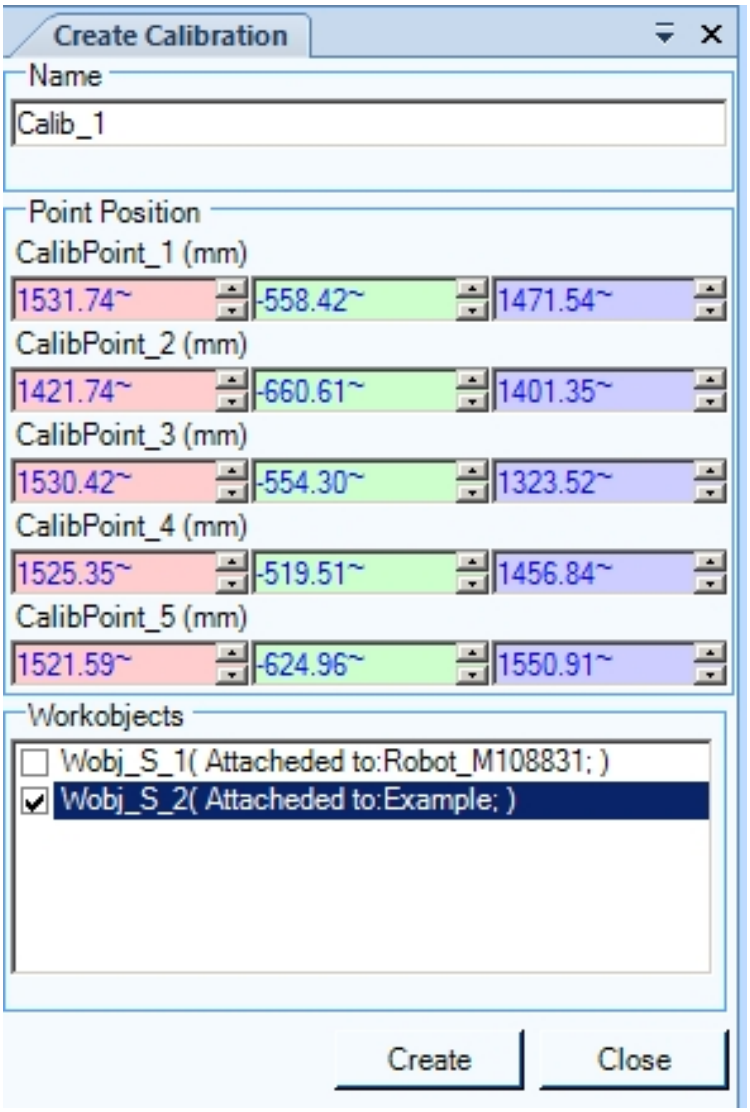

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Figure 4.2: Create Calibration window

Group	Item	Description
Name	-	For specifying the calibration process name.

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Group	Item	Description
Point Position	Calib Point	For setting the coordinate of calibration points. The coordination setting of five points is available.
WorkObject	-	For selecting work objects.

Continues on next page

4.10.1 Creating calibration data

Procedure

Use this procedure to create a calibration item:

	Action	Illustration/Note
1	Choose **Create Calibration (Robot Hold Tool)** or **Create Calibration (Robot Hold WorkObject)** as required from the **Calibration** category in the **Machining** ribbon tab. The **Create Calibration** window displays on the left pane of the screen.	
2	Enter a name or remain the default name for the calibration process.	
3	In the **Point Position** group, click in a combo box to activate the setting. Then, click a point in the 3D graphics view to transfer values to the calib point. Repeat setting for other points.	**Note** After selecting a point to set the calib point value, the combo boxes of the next calib point activates automatically for setting so that you can select the second point directly in the graphics window. Note that the reference frame is *wobj0*.
4	In the **WorkObjects** list, select the check box of the work object you want to calibrate.	
5	Click **Create**.	**Note** If the **Calibrations** window opens, the new calibration data will be displayed in the window and Machining PowerPac - Machining generates a RAPID procedure for this calibration.

Calibration list

The calibration list provides all calibration processes and enables users to modify some settings. Enter the calibration list by choosing **Calibration List** from the **Calibration** category in the ribbon tab. Then, the **Calibrations** window displays on the right pane of the screen.

Users can right-click a node in the calibration list and choose a command from the shortcut context menu to perform a specific function. The table below shows the available commands.

Node	Command	Description
Calibrations (root node)	Create Calibration (Robot Hold Tool)	Opens the setting window for creating robot-hold tool (fixed work object) calibration.
	Create Calibration (Robot Hold Wobj)	Opens the setting window for creating robot-hold work object (fixed tool) calibration.

Continues on next page

Node	Command	Description
Calibration process	Rename	For renaming the process.
	Delete	For deleting the process, including all child calibration points and work objects.
Calibration point	Properties	Opens the **CalibPoint** window. User can modify the point position and then click **Apply** to apply the modification.
Work object	Delete	For deleting the work object.

Exporting calibration tasks

Choose **Export** from the **Calibration** category in the ribbon tab to export the calibration tasks. All calibration processes in the calibration list will be automatically exported as .mod files to a default folder. You can click **Open Location** to open the folder directly.

4.10.2 Calibrating in real world

Procedure

Use this procedure to calibrate a work object in real cell:

> **Note**
>
> After calibrating, the work object is updated. If you want to re-calibrate, set the work object back to it's original value, otherwise the calibration result will be incorrect.

1. Download the program to your real controller.
2. On the **ABB** main menu of the **FlexPendant**, tap **Program Editor**.
3. Tap **Module**.

   All the modules in the current program are listed here.
4. Tap **Calibdata**, then tap **Show Module**.
5. Tap a calibration data you created in Machining PowerPac - Machining.
6. Tap a calibration point, for example, **CalibPoint_1_c**.

   The point with a suffix *_c* is the real cell calibration point.
7. On the **ABB** main menu, tap **Jogging**.

   To jog the robot, the system must be in manual mode.
8. For robot-hold tool calibration, make sure the work object is *wobj0* in the **Jogging** window. For robot-hold work object calibration, make sure the work object is *Workobject_RobotHold*. Then jog the TCP to a position the same as **CalibPoint_1** in Machining PowerPac - Machining.
9. Go back to the program editor for modifying calibdata. Tap **Modify Position**, and tap **Modify** in the confirmation dialog to transfer the values to the point.
10. Repeat this procedure for the other four calibration points.
11. Move the program pointer to the calibration routine, and press the **Start** button to run the routine.

    The work object is calibrated.

4.11 Exporting RAPID file

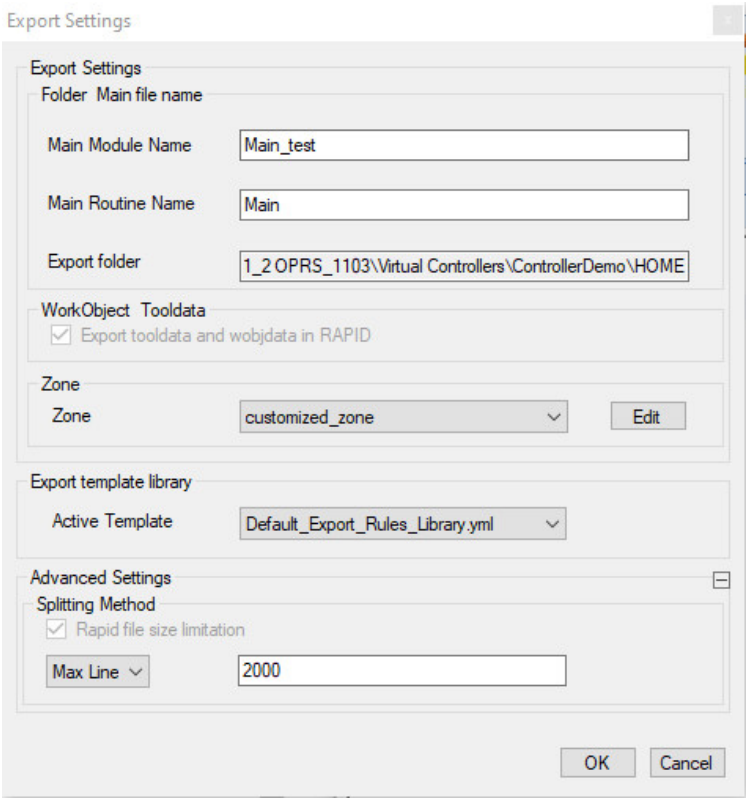
Overview

When the simulation is running well in Machining PowerPac - Machining, you can export your work as a RAPID file or an RW MFC file, and later download it to a robot controller to run.

> **WARNING**
>
> After download of the RAPID module file to a real controller, a validation must be done in Manual Reduced Speed mode.

In the **Machining** ribbon tab, the **Export** group has three functions: **Export Settings**, **Export Rapid** and **Export RW MFC**.

Export Settings window



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Group	Area	Item	Description
General Settings	Folder&Main file name	Main Module Name	For specifying a desired module name in the textbox.
		Main Routine Name	For specifying a desired routine name in the textbox. The output file will be named as: User input Module Name.
		Export folder	For specifying the directory where the exported file save. It is not allowed to be set at present.
	Export template library	-	Tool data and work object data are exported in RAPID files when this check box is selected.
	Zone	Zone	For selecting a zone. Click the drop-down list and select among z0, z1, z5, z10, z15, z20, z30, z40, z50, z60, z80, z100, z150, z200, and any user-defined zone. Each number behind z corresponds to the TCP path in mm, except z0, which is set at 0.3 mm. For details about the values set for different zones, see *Operating manual - RobotStudio*.
Export template library	-	Active Template	For selecting the template of the exported RAPID files. See *Export templates on page 142*.
Advanced Settings	Splitting Method	Rapid file size limitation	The export function will create RAPID code which will be stored in files, so this split method means the limit for this file. They are two ways to limit the file size, one is maximum code line limit and another is file size limit.

Export templates

Template types

Different types of export templates are available for users to export data in required formats to meet different application situations.

Template	Description
Default_*XX*	Default export template, common data such as targets, tool data, work object data and instructions in the program will be exported.
Export_*XX*	The programs exported using the **Export**_*XX* template will include more arguments such as tilt angle and lead angle.
Force_*XX*	The programs exported using the **Force**_*XX* template will include instructions specific to force control applications.
Welding_*XX*	The programs exported using the **Welding**_*XX* template will include instructions specific to welding applications.

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Template	Description
Large_*XX*	This template is valid only when all of the following requirements are met: • Machining Software (previously known as Machining Shop-floor HMI) in advanced version Machining Premium (option 877-3 for IRC5 and 3418-2 for OmniCore) is installed. • Add T_large task in group More than 2000 instructions under the option Machining Premium is selected. • Option Multitasking is selected. It is recommended to use this template for data export when an operation contains more than 2000 target points. Information of every 200 target points will be grouped and exported. For more details, see *Multiple instruction exporting on page 144*.
Mach_*XX*	This template is valid only when the Machining Software is installed.

Exported file types

If the **Default**_*XX*, **Export**_*XX*, **Force**_*XX* and **Welding**_*XX* templates are set, the program will be exported in the following files:

- Main_test_*ProgramID*.mod
- Group_*ProgramID_OperationID*_000.mod
- TargetDefGroup_*ProgramID_OperationID*_000.mod

If the **Mach**_*XX* template is set, in addition to the previous three files, an extra ProcessDefGroup_*ProgramID_OperationID*_000 file that includes the machining process data will also be exported. The machining-type files contains instructions and data types specific to machining applications. For details about the machining instructions and data types, see *RAPID instructions on page 147* and *RAPID data types on page 153*.

If the **Large_XX** template is set, the program will be exported in the following files:

- BackgroundCalibData.mod
- BackgroundMain.mod
- MotionCalibData.mod
- MotionMain.mod
- Instruction_LN_*IndexNumber*.mod
- Target_LN_*IndexNumber*.mod
- Arguments_LN_*IndexNumber*..mod
- Process_LN_*IndexNumber*.mod

If there are start events or end events defined, the EventDefGroup_*ProgramID*.mod and MotionEventDefGroup.mod file will also be exported when the **Mach**_*XX* and **Large_XX** template is set, respectively.

File loading to controller

When loading the files generated using the **Default**_*XX*, **Export**_*XX*, **Force**_*XX*, **Welding**_*XX* and **Mach**_*XX* templates, only the Main_test_*ProgramID* file is required to be imported to the T_ROB1 task of the controller. Data in other files will be automatically called by the main module.

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When loading the files generated using the **Large_*XX*** template, the following procedure is required to ensure successful file loading:

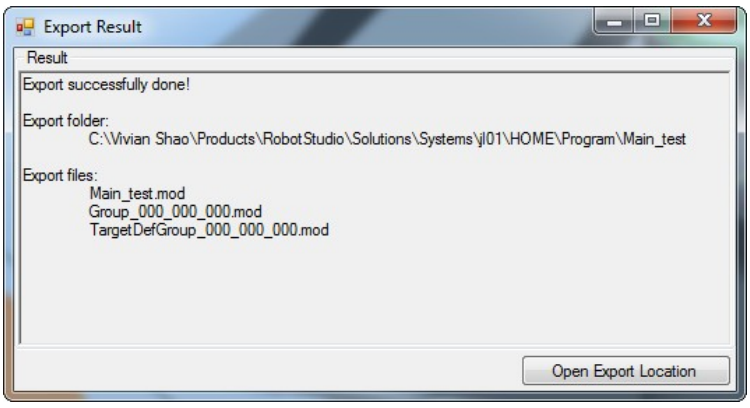
1. Import the BackgroundCalibData.mod and BackgroundMain.mod files to the T_Large task.
2. Import the MotionCalibData.mod, MotionEventDefGroup.mod and MotionMain.mod files to the T_ROB1 task.
3. Set the program pointer to the Proc line in the main module of the T_Large task.
4. In the **RAPID** tab of the RobotStudio, remove the selection of the T_ROB1 task in the **Selected Tasked** list in the **Test and Debug** group.
5. Run the program to start code compiling.

   A corresponding binary file will be generated for the Instruction_LN_*IndexNumber*.mod, Target_LN_*IndexNumber*.mod, Arguments_LN_*IndexNumber*..mod and Process_LN_*IndexNumber*.mod files.
6. Set the program pointer to the Main module.
7. Select the T_ROB1 task in the **Selected Tasked** list.
8. Run the program to test.

Export result

Choose **Export Rapid** or **Export RW MFC** from the **Export** category to export a specified program group. Files in .mod format will then be created in the designated export folder. Note that a program group is necessary for the export.

These files will be listed in the result window. You can click **Open Export Location** to enter the export folder directly.



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Multiple instruction exporting

Introduction

If the targets in a program is more than 2000, it is recommended to enable the multiple instruction exporting function. With the function enabled, every 200 instructions will be grouped and included in a separate module in the T_Large task. The modules in the T_Large task will be further called by the main routine in the T_ROB1 task. This facilitates program programming and reading.

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The multiple instruction exporting function is supported only by Machining Software in advanced version (option Machining Premium). To enable the function, make sure the Multitasking option is selected and then select option Machining Premium > More than 2000 instructions > Add T_large task in the **Modify Installation** dialog.

Working with multiple instruction exporting function

1. Open RobotStudio.
2. In the Add-Ins tab, click **Machining 202*X.X***.
3. In the **Machining** tab, choose **Export Settings** from the **Export** list in the **Path Tools** group.
4. In the displayed **Export Settings** window, choose **Large_Export_Rules_Library.yml** from the **Active Template** drop-down list in the **Export template library** area, and then click **OK**.
5. In the **Program** tab page on the left pane of the window, right-click the required program and choose **Export RAPID** from the shortcut menu.
   - Information of every 200 targets is included in an LN file. If less than 200 targets are left for the last file, default data will be added to make sure 200 target items are included in the file.
   - The LN files are named with suffix "_LN_{index}", in which "index" refers to the file number.
   - The LN files are generated and exported to directory `$HOME/LN{ProgramName}/Opr_{ProgramID}_{Operation_ID}`.
6. Click the **Controller** tab and, in the **RAPID** category in the **Controller** navigation tree in the displayed window:
   - Right-click the T_Large task, choose **Load Module** from the shortcut menu and load modules `BackgroundCalibData.mod` and `BackgroundMain.mod`.
   - Right-click the T_ROB1 task, choose Load Module from the shortcut menu and load modules `MotionCalibData.mod`, `MotionMain.mod` and, if any, `MotionEventDefGroup`.
7. Click the **RAPID** tab and remove the selection of the T_ROB1 task from the **Selected tasks** list in the **Test and Debug** group.
8. Set the program pointer to the GenerateModules_Opr routine in the T_Large task.
9. Run the program to start RAPID compiling.

   Corresponding binary files are generated for the LN files in the same directory.
10. Click the **RAPID** tab and select the T_ROB1 task from the **Selected tasks** list in the **Test and Debug** group.
11. Set the program pointer to the main routine in the T_ROB1 task.
12. Run the program.

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5 Reference information

5.1 RAPID instructions

5.1.1 MachL - Moves linearly

Usage

In machining programs, `MachL` is used to move the tool center point (TCP) linearly to a given destination.

This instruction can only be used in the main task `T_ROB1` or, if in a MultiMove System, in Motion tasks.

Arguments

`offset`

Data type: `pose`

`offset` is used to add an offset to the robot position in the object coordinate system.

`RelEuler`

Data type: `MachiningPose` (See *MachiningPose - Coordinate transformations in machining programs on page 153*)

`RelEuler` is used to add a displacement and/or a rotation, expressed in the active tool coordinate system, to a robot position.

`ToPoint`

Data type: `robtarget`

`ToPoint` defines the destination point of the robot and external axes.

`\RCS`

Data type: `pose`

`RCS` defines the coordinate system for machining the contact point. The Z-axis direction is the same as the normal vector. The value of the this argument is generated automatically in Machining PowerPac and not allowed to be changed.

`\ID`

Data type: `identno`

The argument `\ID` is mandatory in the MultiMove systems, if the movement is synchronized or coordinated synchronized. This argument is not allowed in any other case. The specified id number must be the same in all the cooperating program tasks. By using the id number the movements are not mixed up at the runtime.

`Speed`

Data type: `speeddata`

The speed data that applies to movements. Speed data defines the velocity for the tool center point, the tool reorientation, and external axes.

Continues on next page

5.1.1 MachL - Moves linearly
Continued

`Zone`

Data type: `zonedata`

Zone data for the movement. Zone data describes the size of the generated corner path.

`Tool`

Data type: `tooldata`

The tool in use when the robot moves. The tool center point is the point moved to the specified destination position.

`\WObj`

Data type: `wobjdata`

The work object (coordinate system) to which the robot position in the instruction is related.

This argument can be omitted and if so then the position is related to the world coordinate system. If, on the other hand, a stationary tool or coordinated external axes are used then this argument must be specified to perform a linear movement relative to the work object.

`\Corr`

Data type: `switch`

Correction data written to a corrections entry by the instruction CorrWrite will be added to the path and destination position if this argument is present.

The RobotWare option Path Offset is required when using this argument.

`\TLoad`

Data type: `loaddata`

The `\TLoad` argument describes the load attached to the tool flange of the robot.

`process`

Data type: `MachineProcess` (See *MachineProcess - Process definitions in machining programs on page 154*)

The `process` argument describes the required process parameters and other necessary information for machining applications.

5.1.2 MachJ - Moves using joint movement

Usage

In machining programs, `MachJ` is used to move quickly from one point to another when that movement does not have to be in a straight line.

The robot and external axes move to the destination position along a non-linear path. All axes reach the destination position at the same time.

This instruction can only be used in the main task `T_ROB1` or, if in a MultiMove system, in Motion tasks.

Arguments

`offset`

Data type: `pose`

`offset` is used to add an offset to the robot position in the object coordinate system.

`RelEuler`

Data type: `MachiningPose` (See *MachiningPose - Coordinate transformations in machining programs on page 153*)

`RelEuler` is used to add a displacement and/or a rotation, expressed in the active tool coordinate system, to a robot position.

`ToPoint`

Data type: `robtarget`

`ToPoint` defines the destination point of the robot and external axes.

`\RCS`

Data type: `pose`

`RCS` defines the coordinate system for machining the contact point. The Z-axis direction is the same as the normal vector. The value of the this argument is generated automatically in Machining PowerPac and not allowed to be changed.

`\ID`

Data type: `identno`

The argument `\ID` is mandatory in the MultiMove systems, if the movement is synchronized or coordinated synchronized. This argument is not allowed in any other case. The specified id number must be the same in all the cooperating program tasks. By using the id number the movements are not mixed up at the runtime.

`Speed`

Data type: `speeddata`

The speed data that applies to movements. Speed data defines the velocity for the tool center point, the tool reorientation, and external axes.

`Zone`

Data type: `zonedata`

Continues on next page

5.1.2 MachJ - Moves using joint movement
Continued

Zone data for the movement. Zone data describes the size of the generated corner path.

`Tool`

Data type: `tooldata`

The tool in use when the robot moves. The tool center point is the point moved to the specified destination position.

`\WObj`

Data type: `wobjdata`

The work object (coordinate system) to which the robot position in the instruction is related.

This argument can be omitted and if so then the position is related to the world coordinate system. If, on the other hand, a stationary tool or coordinated external axes are used then this argument must be specified to perform a linear movement relative to the work object.

`\TLoad`

Data type: `loaddata`

The `\TLoad` argument describes the load attached to the tool flange of the robot.

`process`

Data type: `MachineProcess` (See *MachineProcess - Process definitions in machining programs on page 154*)

The `process` argument describes the required process parameters and other necessary information for machining applications.

5.1.3 MachC - Moves circularly

Usage

In machining programs, `MachC` is used to move the tool center point (TCP) circularly to a given destination. During the movement the orientation normally remains unchanged relative to the circle.

This instruction can only be used in the main task `T_ROB1` or, if in a MultiMove system, in Motion tasks.

Arguments

`offset`

Data type: `pose`

`offset` is used to add an offset to the robot position in the object coordinate system.

`RelEuler`

Data type: `MachiningPose` (See *MachiningPose - Coordinate transformations in machining programs on page 153*)

`RelEuler` is used to add a displacement and/or a rotation, expressed in the active tool coordinate system, to a robot position.

`CirPoint`

Data type: `robtarget`

The circle point of the robot. The circle point is a position on the circle between the start point and the destination point.

`\RCS_Cir`

Data type: `pose`

`RCS` defines the coordinate system for circle point.

`ToPoint`

Data type: `robtarget`

`ToPoint` defines the destination point of the robot and external axes.

`\RCS_To`

Data type: `pose`

`RCS` defines the coordinate system for destination point.

`\ID`

Data type: `identno`

The argument `\ID` is mandatory in the MultiMove systems, if the movement is synchronized or coordinated synchronized. This argument is not allowed in any other case. The specified id number must be the same in all the cooperating program tasks. By using the id number the movements are not mixed up at the runtime.

Continues on next page

5.1.3 MachC - Moves circularly
Continued

`Speed`

Data type: `speeddata`

The speed data that applies to movements. Speed data defines the velocity for the tool center point, the tool reorientation, and external axes.

`Zone`

Data type: `zonedata`

Zone data for the movement. Zone data describes the size of the generated corner path.

`Tool`

Data type: `tooldata`

The tool in use when the robot moves. The tool center point is the point moved to the specified destination position.

`\WObj`

Data type: `wobjdata`

The work object (coordinate system) to which the robot position in the instruction is related.

This argument can be omitted and if so then the position is related to the world coordinate system. If, on the other hand, a stationary tool or coordinated external axes are used then this argument must be specified to perform a linear movement relative to the work object.

`\TLoad`

Data type: `loaddata`

The `\TLoad` argument describes the load attached to the tool flange of the robot.

`process`

Data type: `MachineProcess` (See *MachineProcess - Process definitions in machining programs on page 154*)

The `process` argument describes the required process parameters and other necessary information for machining applications.

5.2 RAPID data types

5.2.1 MachiningPose - Coordinate transformations in machining programs

Usage

Data of the type `MachiningPose` describes how a coordinate system is displaced and rotated.

Components

x

Data type: `num`

The displacement in X-axis position of the coordinate system.

y

Data type: `num`

The displacement in Y-axis position of the coordinate system.

z

Data type: `num`

The displacement in Z-axis position of the coordinate system.

Rx

Data type: `num`

The orientation in X-axis position of the coordinate system.

Ry

Data type: `num`

The orientation in Y-axis position of the coordinate system.

Rz

Data type: `num`

The orientation in Z-axis position of the coordinate system.

5.2.2 MachineProcess - Process definitions in machining programs

Usage

Data of the type `MachiningProcess` describes parameters specially used during machining process.

Components

`EngageDistance`

Data type: `num`

The pressure amount with which the tool will move a further distance towards to the work object.

`TiltAngle`

Data type: `num`

The angle (inclined right or left) that the tool will rotate along the forward direction of the machining path.

`LeadAngle`

Data type: `num`

The angle (inclined forward or backward) that the tool will rotate along the tangent direction to the forward direction of the machining path.

`PreRoutine`

Data type: `string`

The component `PreRoutine` defines the event that is executed before a motion instruction.

`PostRoutine`

Data type: `string`

The component `PostRoutine` defines the event that is executed after a motion instruction.

6 Troubleshooting

6.1 Version upgrade failure

Trouble description

When upgrading the Machining PowerPac - Machining from 6.02 to 6.02.01 or from 6.03 to 6.03.01, users may experience the following failures:

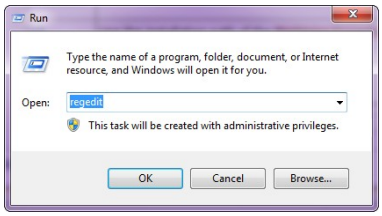
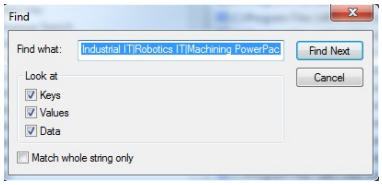
- The Machining PowerPac - Machining in the new version cannot be started.
- An internal error message is displayed in the **Output** window.
- Some new functions of the Machining PowerPac - Machining cannot be activated.

Problem cause

The .dll files cannot be removed when the old version of the Machining PowerPac - Machining is uninstalled and also cannot be replaced by the new .dll files when the new version of the Machining PowerPac - Machining is installed.

Solution

Use the following procedure to manually remove the old .dll files before installing the new version of the Machining PowerPac - Machining.

	Action	Note
1	On the PC, click the **Start** button, and then point to **Run**.	
2	Type **regedit** in the **Open** text box and then click **OK**.	 xx1600001266
3	In the displayed **Registry Editor** window, choose **Edit** > **Find**, or press the shortcut key combination **Ctrl+F**.	
4	Use the installation path of the Machining PowerPac - Machining as the keyword and type it in the **Find what** text box. Then, click **Find Next**.	 xx1600001267
5	Delete all the displayed .dll files.	
6	Remove the **Bin** subfolder from the installation folder of the Machining PowerPac - Machining.	

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Index

A
approach, 107

B
buffer distance, 107

C
CAD model, 48
calibrating, 136
contact area, 13
contact diameter
  CD, 90
contact height, 13
  CH, 90
contact path, 13
controller world coordinate system, 17
coordinate systems, 15

D
departing, 107

E
end event for operations, 42
end event for path targets, 45
export
  RAPID file, 141
external axis
  linear track, 84
  positioner, 86

F
feature curve, 13
frames, 15

G
geometry, 34, 54
  customized curve, 13, 81
  edge curve, 13, 79
  intersection geometry, 13, 74
  projection geometry, 13, 64
  UV curve, 13, 77
global speed setting, 40

H
holder diameter
  HD, 90
holder lenght
  HL, 90
home path
  home position, 14, 96

N
non-process move, 41, 107

O
operation, 34, 98
  end event, 14
  start event, 14
optimizing
  automatic optimizing, 129
Optimizing
  manual optimizing, 131
overlapping calculation, 65, 67, 74

P
path editor, 115–116, 121
  contact path, 115
  contact point, 115
  set tool contact, 122
  smooth beltsander angle, 127
  smooth position, 123
  smooth rotation around tool contact, 126
  smooth tool axis, 124
  smooth tool contact height, 125
process move, 105
program group, 35, 95

R
robot path, 13

S
safe height, 107
safe path, 102
  end safe target, 14, 102
  start safe target, 14, 102
safe plane, 14
service move
  end event, 102
  start event, 102
simulation, 108, 112
  collision set, 113
  quick simulation, 110
  VC simulation, 111
start event for operations, 42
start event for path targets, 45
station world coordiante system, 15

T
TCP, 15
tip diameter
  TD, 90
tip length
  TL, 90
tool, 35, 89
tool axis, 104
Tool Center Point coordinate system, 15
tool library, 94
transfer, 107

U
UCS, 20
user coordinate system, 20

V
view
  geometry view, 13
  program view, 13
  tool view, 13

W
WorkObject, 20
work object, 34, 50–51
world coordinate system, 15

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