



## Collaborative Mode

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ENG. Tory 2018.01.31 V1.0

# Briefly

## ➤ Purpose

When the TM Robot operates in the man-machine cooperation mode, it will run at a slower speed and a smaller axial torque according to the user's setting. At this time, the robot's light signal will add with a purple light for the user to distinguish whether the robot enters Man-machine collaboration mode.

### 1. Safety IO collaborative mode -

According to the safety IO trigger, the project will be switched from full speed mode to man-machine cooperation mode.

### 2. Collaborative Mode –

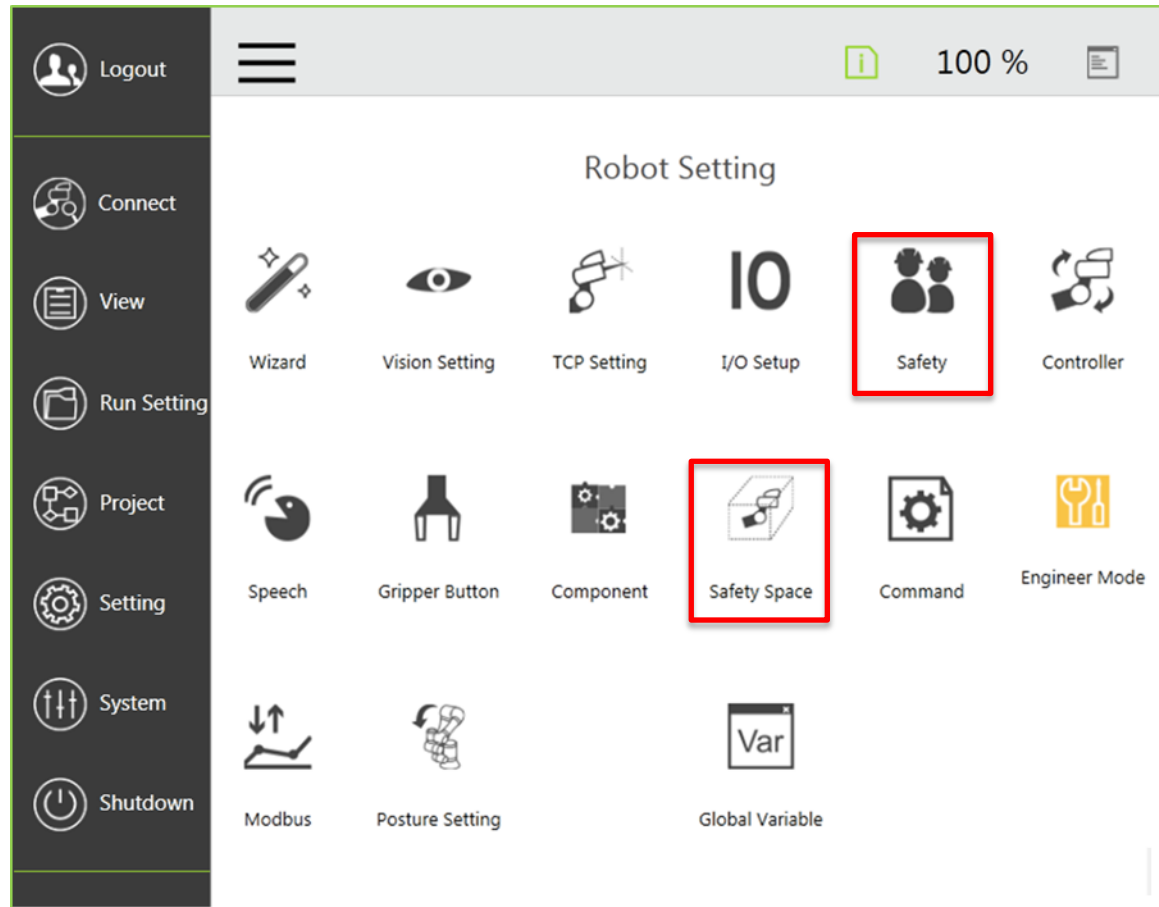
The cooperative mode and parameter setting in the safety settings depend on the arm may reach different human body parts to calculate the arm speed and adjust the security settings.

### 3. Safety Space –

Create a plane or a space, when the arm into the plane or space, it will achieve safe man-machine collaboration. If set to stop mode, it is like setting up invisible fence.

## ➤ Equipment

TM5 HMI 1.64.1010

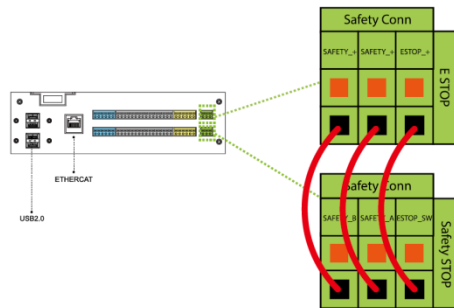


# Safety IO collaborative mode & Collaborative Mode & Safety Space



## Safety IO collaborative mode

Safety

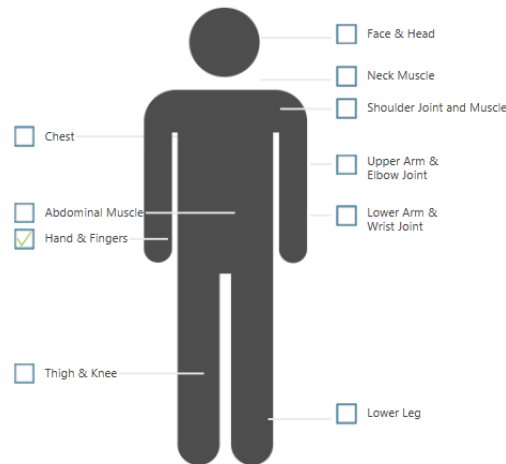


Depending on the safety IO trigger (external safety devices can be connected, such as rasters, laser scanners and other safety-compliant devices trigger), Switch the project speed from full speed mode to man-machine collaboration mode.



Safety

## Collaborative Mode

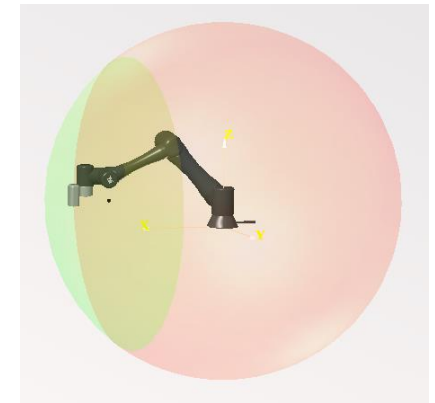


According to ISO / TS 15066 parts of the body can bear the power and pressure of the medical report to calculate the robot speed, force size of the force adjustment, the force area and project speed.



Safety Space

## Safety Space



Create a flat or a space by hand-guiding points. When the arm enters this plane or space, it will comply with Collaborative Mode's safety settings and safe project running speed to achieve safe man-machine collaboration. It is also possible to set this plane or space to a mode that is out of operation, just like creating invisible fences, safe spaces.



# Safety IO collaborative mode

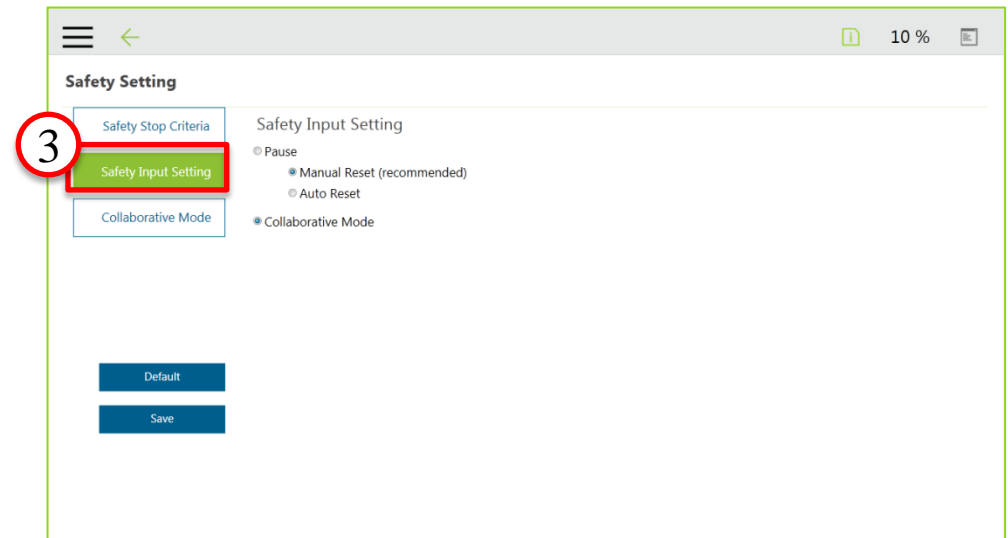
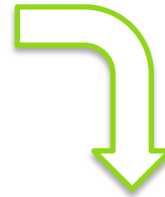
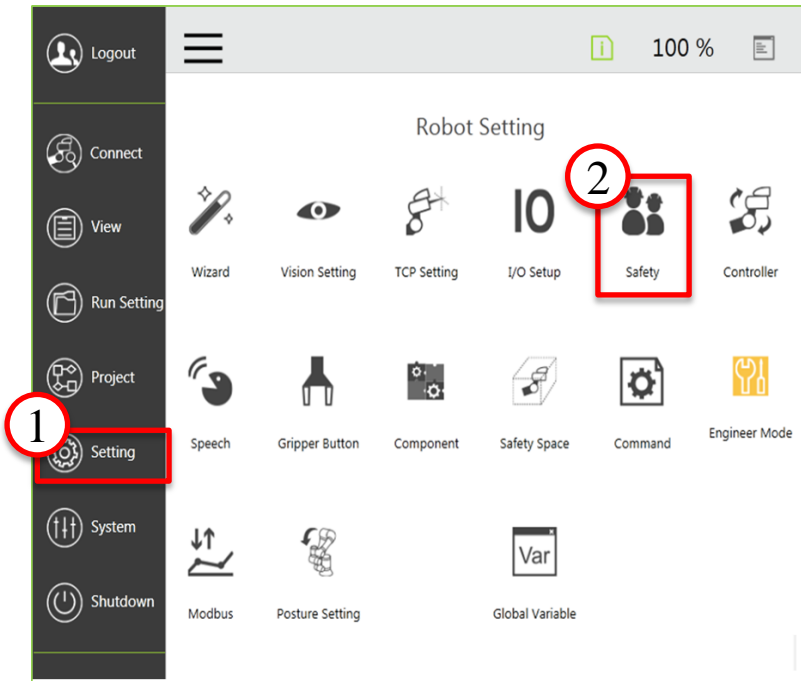
Safety



# Safety IO collaborative mode

Enter the step

- ① setting
- ② Safety
- ③ Safety Input Setting option





## Safety IO collaborative mode

Safety IO settings: The safety IO settings are divided into "pause" and "collaborative mode". The user can decide whether to operate the collaborative mode or pause the project from the IO trigger status.

**Safety Setting**

Safety Stop Criteria

Safety Input Setting

Collaborative Mode

Pause

Manual Reset (recommended)

Auto Reset

Collaborative Mode

Default

Save

Collaborative mode: After the risk assessment, the user can switch the project from full-speed mode to man-machine collaborative mode according to the safety IO trigger.



Safety

# Collaborative Mode



# Collaborative Mode

Safety



Please note that the functions described in this SOP are only for assisting the user to set the parameters and settings for human-machine collaboration more conveniently. The user should still conduct a complete risk assessment according to the environment and conditions of the robot before using the robot. TM Robot states the following significant residual risks that may exist: the risk of a robot hitting the human body at full speed due to improper use of secure space to set up or run a wrong project.



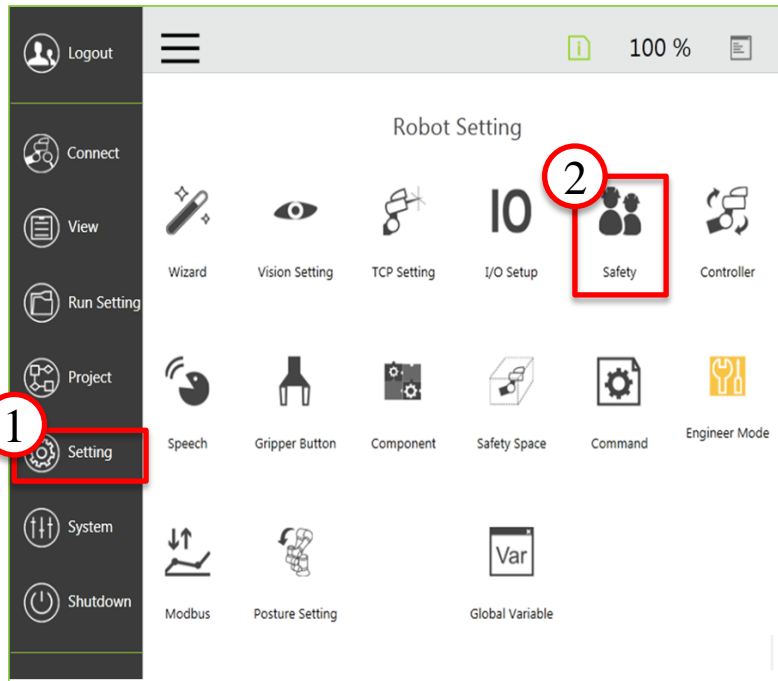
If using the TM Flow Compliance function in a safe area, the Compliance instruction is not controlled by the man-machine cooperation mode. The robot will still execute the Compliance function according to the strength you have set. If you want to use the Compliance function in the man-machine cooperation mode, Complete a complete risk assessment and set appropriate strength values.





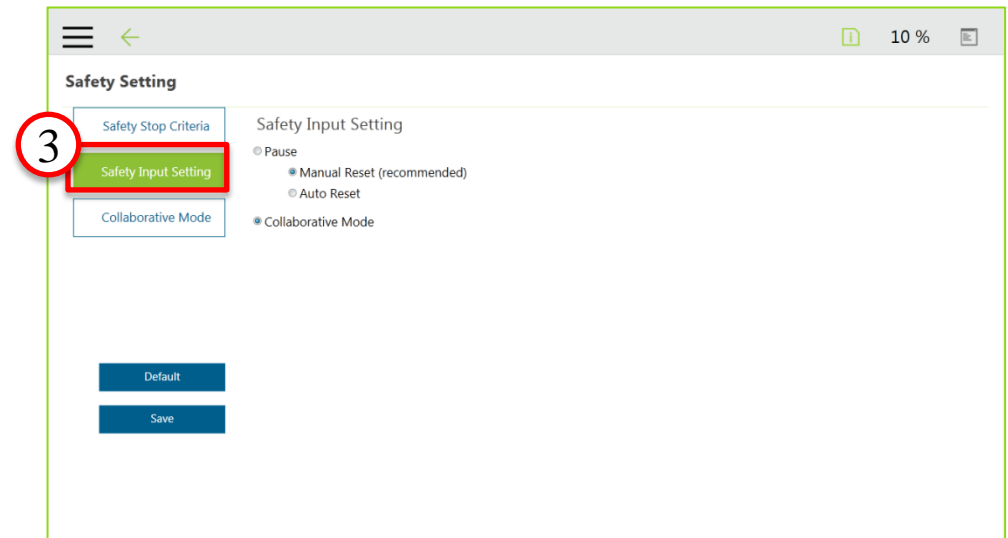
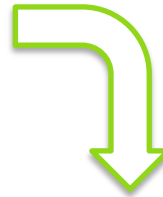
# Collaborative Mode

Safety



## Step

- 1 setting
- 2 Safety
- 3 Safety Input Setting option





# Collaborative Mode

Safety

TM Robot man-machine collaborative mode parameter settings can be divided into the risk part settings and the upper limit setting.

Body region risk setting

More Limit setting

10 %

Safety Setting

Safety Stop Criteria

Safety Input Setting

Collaborative Mode

Default

Save

Body Region Risk SettingX

More Limit Setting X

1.Please set body regions that could be contacted by the robot in the collaborative workspace

Face & Head

Neck Muscle

Shoulder Joint and Muscle

Upper Arm & Elbow Joint

Lower Arm & Wrist Joint

Lower Leg

Thigh & Knee

Hand & Fingers

Abdominal Muscle

Chest

2.Result

When robot enters the collaborative workspace, the path motion set with 100% speed will be automatically changed into  
180 mm/sec

When robot enters the collaborative workspace, the PTP motion set with 100% speed will be automatically changed into  
8.1 %

Please check the minimum possible contact area between any equipment installed on the robot and human body is lower than  
0.74 cm x cm

☒ Enable G-Sensor

☐ I have checked the minimum possible contact area between any equipment installed on the robot and human body is lower than the value listed above

This feature is designed to auto adjust the speed of robot in Collaborative Mode following the biomechanical limits of each body region listed in ISO/TS 15066. User should consider more and take responsibility for human body region which is not listed in the graph by himself, and make sure the robot does not have any chance to contact with any dangerous body region like spine and hindbrain.



Safety

# Collaborative Mode-Body region risk setting

**Safety Setting**

Safety Stop Criteria  
Safety Input Setting  
Collaborative Mode

Body Region Risk SettingX More Limit Setting X

**1.Please set body regions that could be contacted by the robot in the collaborative workspace**

☐ Face & Head  
☐ Neck Muscle  
☐ Shoulder Joint and Muscle  
☐ Upper Arm & Elbow Joint  
☐ Lower Arm & Wrist Joint  
☐ Lower Leg  
☐ Thigh & Knee  
☒ Hand & Fingers  
☐ Abdominal Muscle  
☐ Chest

**2.Result**

When robot enters the collaborative workspace, the path motion set with 100% speed will be automatically changed into  mm/sec

When robot enters the collaborative workspace, the PTP motion set with 100% speed will be automatically changed into  %

Please check the minimum possible contact area between any equipment installed on the robot and human body is lower than  cm x cm

☒ Enable G-Sensor  
☐ I have checked the minimum possible contact area between any equipment installed on the robot and human body is lower than the value listed above

This feature is designed to auto adjust the speed of robot in Collaborative Mode following the biomechanical limits of each body region listed in ISO/TS 15066. User should consider more and take responsibility for human body region which is not listed in the graph by himself, and make sure the robot does not have any chance to contact with any dangerous body region like spine and hindbrain.

Default  
Save

Risk part of the set part of the user according to their needs, set the robot in man-machine collaborative space may come into contact with the risk parts of human body, the interface on the right side of the operation results show the robot in man-machine collaborative mode speed, to be used After confirmation, the user can save the setting value. The calculation result includes the values of the speed of the path automatically converted into the man-machine collaborative zone, the value of the automatically moving speed of the point-to-point movement, the area of contact between the robotic arm and the human body, and the user should check the lower right corner before storing the set value Confirm the field, self-confirmation robot peripheral equipment and human exposure to the area are greater than or equal to the area to confirm the value.



# Collaborative Mode-Body region risk setting

Safety

- 1 Select the risk of collision with the arm site, you can check, except the face and head.
- 2 Check to confirm that the contact area between the arm-mounted apparatus and the human body is less than or equal to the above value (the contact area of different parts is different).
- 3 Save settings.

☰

←

ⓘ 10 %

☰

### Safety Setting

Safety Stop Criteria

Safety Input Setting

Collaborative Mode

Default

Save

Body Region Risk SettingX More Limit Setting X

1. Please set body regions that could be contacted by the robot in the collaborative workspace

☐

Face & Head

☐

Neck Muscle

☐

Shoulder Joint and Muscle

☐

Upper Arm & Elbow Joint

☐

Lower Arm & Wrist Joint

☐

Lower Leg

☐

Thigh & Knee

☐

Abdominal Muscle

☐

Chest

☒

Hand & Fingers

2. Result

When robot enters the collaborative workspace, the path motion set with 100% speed will be automatically changed into  mm/sec

When robot enters the collaborative workspace, the PTP motion set with 100% speed will be automatically changed into  %

Please check the minimum possible contact area between any equipment installed on the robot and human body is lower than  cm x cm

☒ Enable G-Sensor

☐ I have checked the minimum possible contact area between any equipment installed on the robot and human body is lower than the value listed above

This feature is designed to auto adjust the speed of robot in Collaborative Mode following the biomechanical limits of each body region listed in ISO/TS 15066. User should consider more and take responsibility for human body region which is not listed in the graph by himself, and make sure the robot does not have any chance to contact with any dangerous body region like spine and hindbrain.



Safety

## Collaborative Mode-Body region risk setting

If the option of face and head is checked, a warning window will pop up. Caution: According to ISO / TS 15066, the man-machine cooperation space is forbidden to set face and head position, please reset the relevant position.

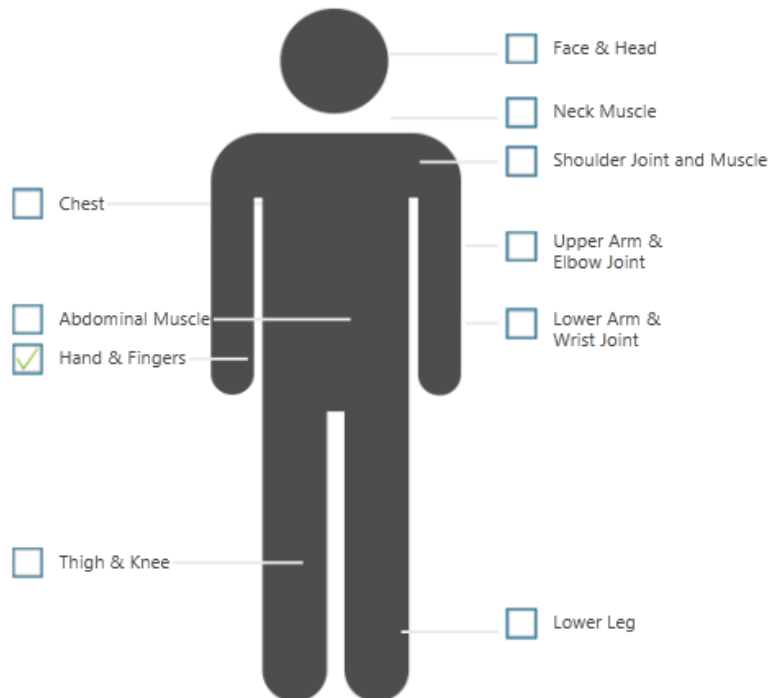




Safety

# Collaborative Mode-Body region risk setting

## 1. Please set body regions that could be contacted by the robot in the collaborative workspace



## 2. Result

When robot enters the collaborative workspace, the path motion set with 100% speed will be automatically changed into  mm/sec

When robot enters the collaborative workspace, the PTP motion set with 100% speed will be automatically changed into  %

Please check the minimum possible contact area between any equipment installed on the robot and human body is lower than  cm x cm

☒ Enable G-Sensor

☐ I have checked the minimum possible contact area between any equipment installed on the robot and human body is lower than the value listed above

This feature is designed to auto adjust the speed of robot in Collaborative Mode following the biomechanical limits of each body region listed in ISO/TS 15066. User should consider more and take responsibility for human body region which is not listed in the graph by himself, and make sure the robot does not have any chance to contact with any dangerous body region like spine and hindbrain.

If you select more than one part, the value will be the minimum part of the site as a standard, to ensure safety.



Safety

## Collaborative Mode-Body region risk setting

### 2.Result

When robot enters the collaborative workspace, the path motion set with 100% speed will be automatically changed into

180 mm/sec

Converts the path movement speed automatically from 100% to (value in Gray box) mm / sec

When robot enters the collaborative workspace, the PTP motion set with 100% speed will be automatically changed into

8.1 %

Converts point-to-point movement speed automatically converted from 100% (value in gray box)%

Please check the minimum possible contact area between any equipment installed on the robot and human body is lower than

0.74 cm x cm

The area that the robot's external equipment may touch with the human body is less than or equal to the area confirmed value (this value can not be changed).



Safety

## Collaborative Mode-Body region risk setting

Whether to start force detection

☒ Enable G-Sensor

☐ I have checked the minimum possible contact area between any equipment installed on the robot and human body is lower than the value listed above

This feature is designed to auto adjust the speed of robot in Collaborative Mode following the biomechanical limits of each body region listed in ISO/TS 15066. User should consider more and take responsibility for human body region which is not listed in the graph by himself, and make sure the robot does not have any chance to contact with any dangerous body region like spine and hindbrain.



危險

This function computes the robot speed according to the ISO / TS15066 medical reports of forces and pressures that may be exerted on various parts of the human body. Except for the parts shown in the figure, the rest such as the dangerous parts such as the spine and the cerebrum, the user should consider the risk of collision and avoid any possible Crashes happen.

Although the result of the calculation of the risk part can be corrected, it can only be set smaller. If you need to set more detailed parameters, please go to "More limit Setting Page" to make correction.





# Collaborative Mode-More Limit setting

Safety

More limit Setting page can be set for the arm's momentum, power, axis speed, shaft torque, etc., but note that the setting value of this section should be smaller than the setting value of the standard mode to be confirmed by the user After the set value can be stored.

☰

←

ⓘ 10 %

Safety Setting

Safety Stop Criteria

Safety Input Setting

Collaborative Mode

Default

Save

More limit Setting

Body Region Risk SettingX More Limit Setting X

Robot

Momentum10Kg.m/sec

Power200watt

Joint Speed

J1:100deg/sec

J2:100deg/sec

J3:100deg/sec

J4:100deg/sec

J5:100deg/sec

J6:100deg/sec

TCP

Speed0.2m/sec

Force130N

Joint Torque

J1:35Nm

J2:35Nm

J3:35Nm

J4:8Nm

J5:8Nm

J6:8Nm



Safety Space

# Safety Space



# Safety Space



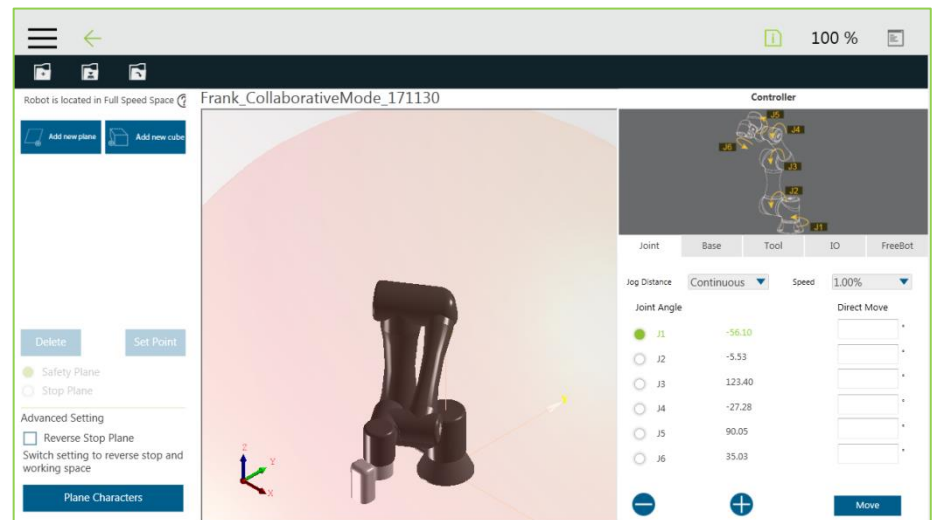
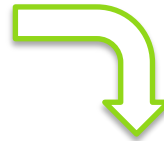
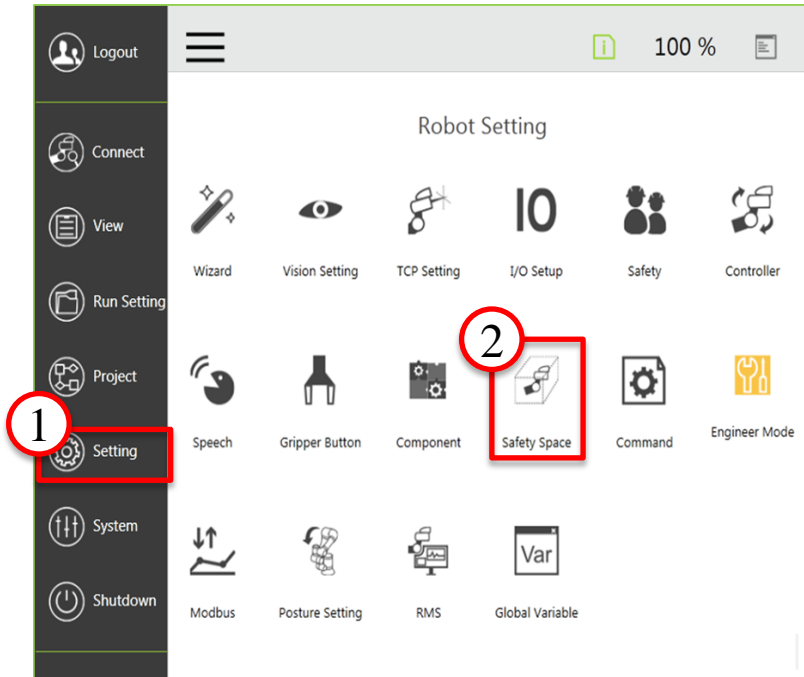
In addition to setting the global status as a man-machine collaboration space, this function can not be used alone as a safety function. The user must conduct a comprehensive risk assessment according to the environment and conditions of use, and configure safety standards such as gratings and laser scanners Equipment, with safety IO settings, the external device triggers the pause mode or collaboration mode, the correct setting of the operating environment, or through other appropriate safety design, to prevent personnel from entering the robot full speed zone. This function is only for assisting the user to understand the concept of space more easily during teaching and programming. The man-machine cooperation plane / space function should only be used in the teaching process to know the man-machine cooperation area and the full-speed operation area instead of being used alone Switching between man-machine cooperation mode and full-speed mode is mistakenly considered as a safety function; this application can not be used alone when application stops plane / space during teaching and avoids setting points or movement across prohibited areas The purpose of the space limit, and was mistaken for security features. TM Robot identifies significant residual risks that may exist as a result of improper use of the safety space to set up or run the wrong project, causing the robot to hit the human body at full speed.



# Safety Space

## Steps

- ① setting
- ② Safety Space

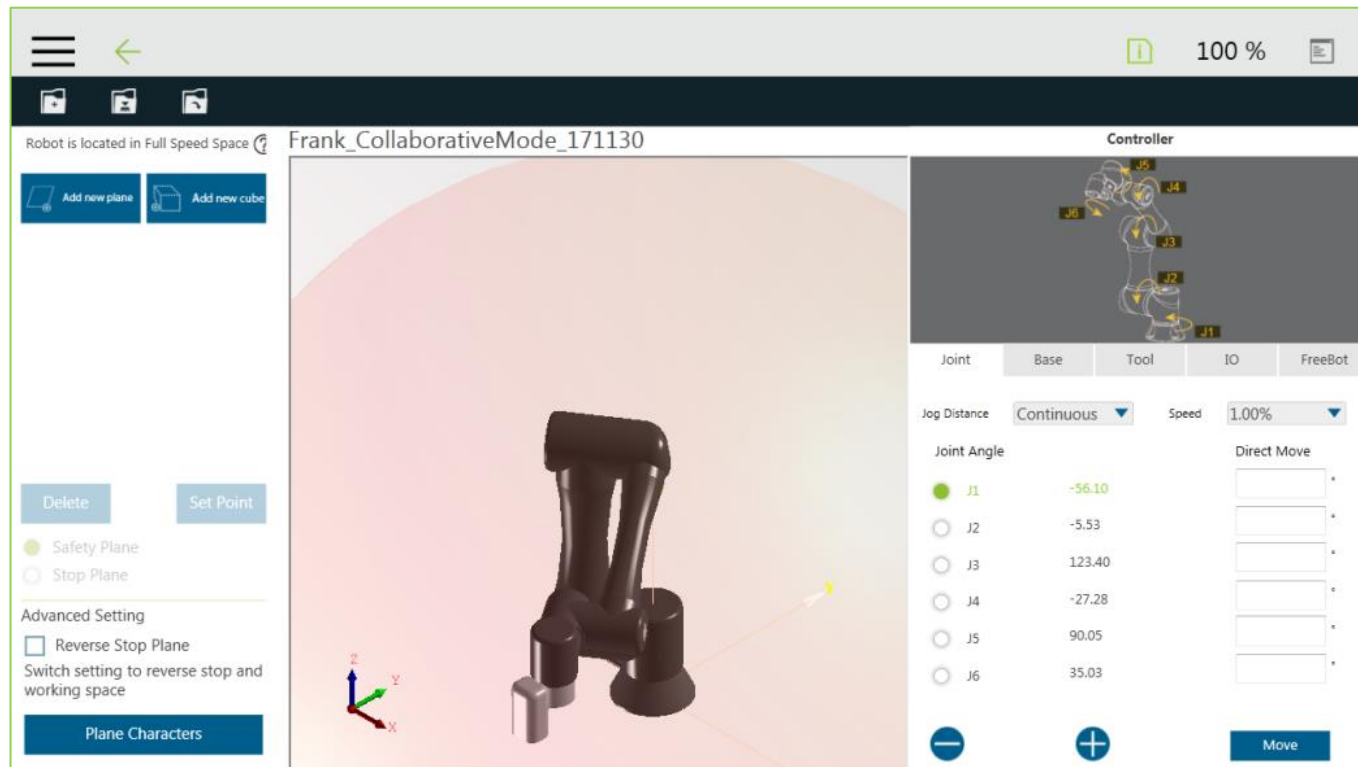




Safety Space

# Safety Space

TM Robot provides two spatial features of plane and hexahedron for the establishment of a safe space environment. When the robot enters the safe space during operation, the robot enters the man-machine cooperation mode. Plane feature allows users to set the safety plane and stop plane two properties, hexahedron provides only the establishment of safe space.



The left side of the page provides collaboration space settings, the middle is the virtual robot interface, the right side is the controller interface.



Safety Space

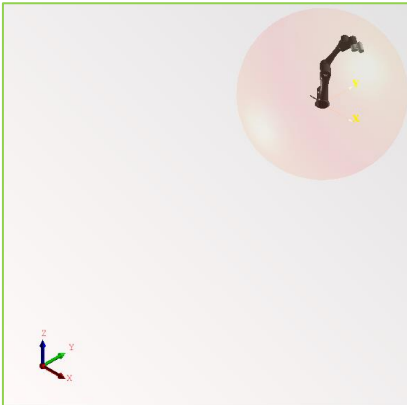
# Safety Space-3D simulation Page operating instructions



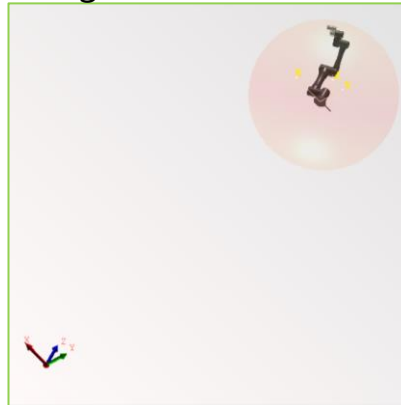
The original picture



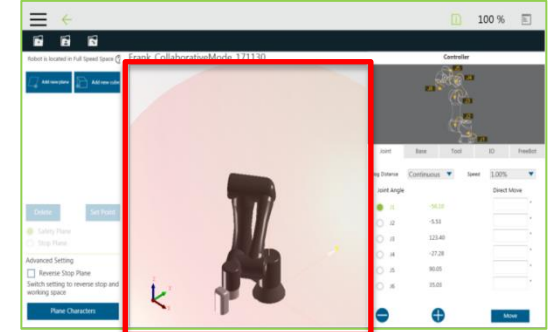
Zoom in, zoom out  
ctrl + left mouse button +  
drag mouse



move  
ctrl + mouse wheel  
button



Rotate the angle of view  
ctrl + right mouse button

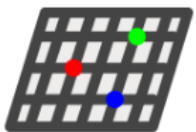




# Safety Space-Safety Space Setting

Add new plane

建立平面



1st Point 2nd Point 3rd Point

Add new cube

Build hexahedral space

(Only to create a safe space)



Please set the first point

1st Point 2nd Point 3rd Point  
4th Point

Robot is located in Full Speed Space

Add new plane

Add new cube

plane1

Delete

Set Point

Safety Plane

Stop Plane

Advanced Setting

Reverse Stop Plane

Switch setting to reverse stop and working space

Plane Characters

- Create a Safety Space project
- Save Safety Space project
- Open Safety Space project

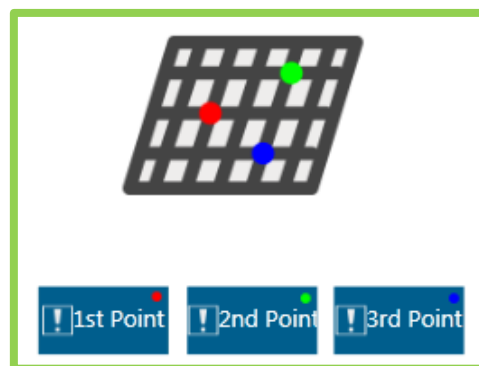
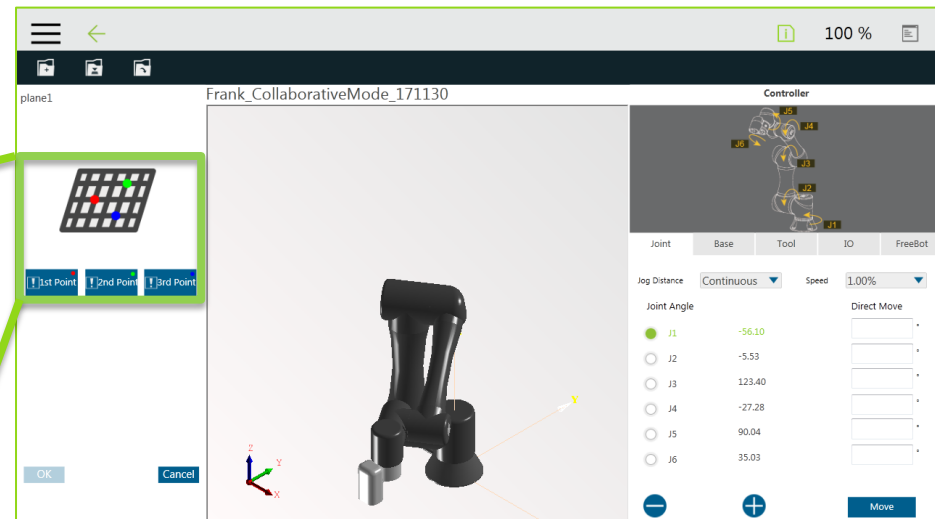
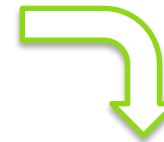
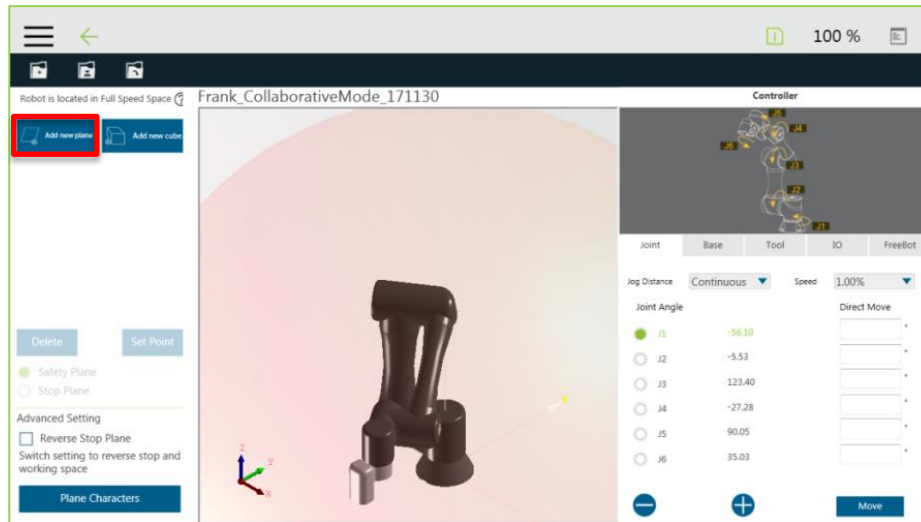
- Select Safety Plane (set according to Collaborative Mode)
- Select the stop plane (stop immediately after the arm enter)

Reverse stop plane  
Select Back Stop Plane workspace



# Safety Space

Click the button to add a new plane or select the plane features click on the reset feature button to enter the new / modify the page.



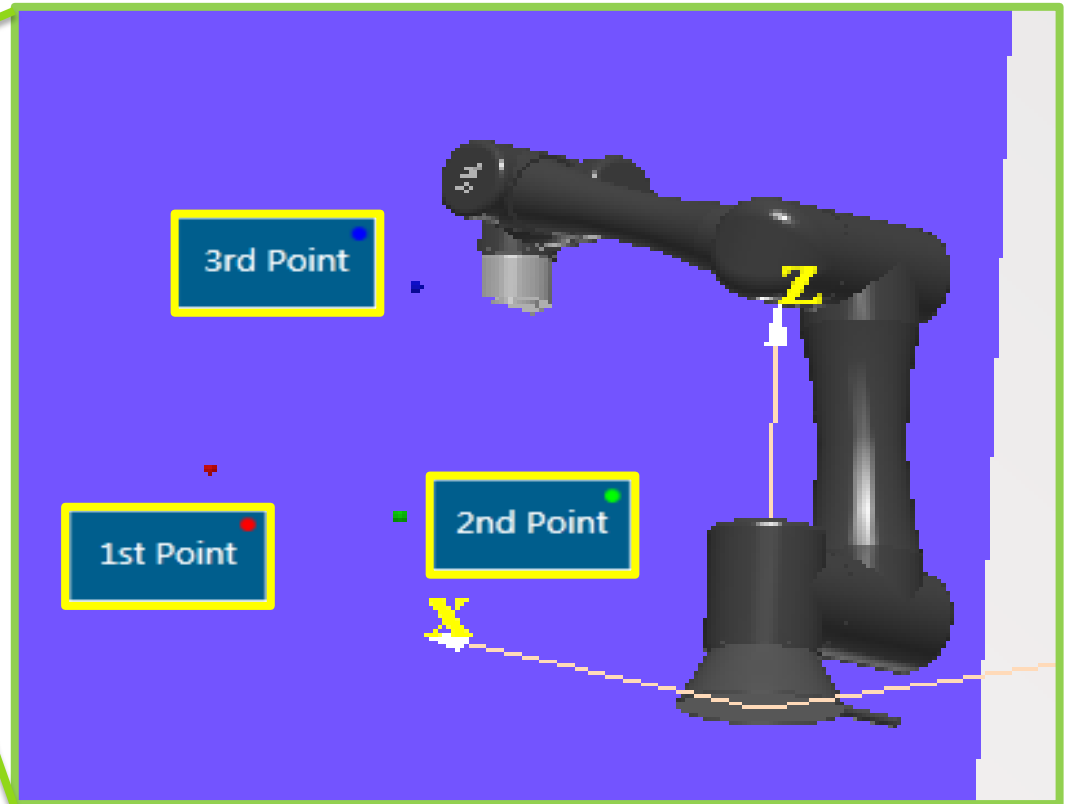
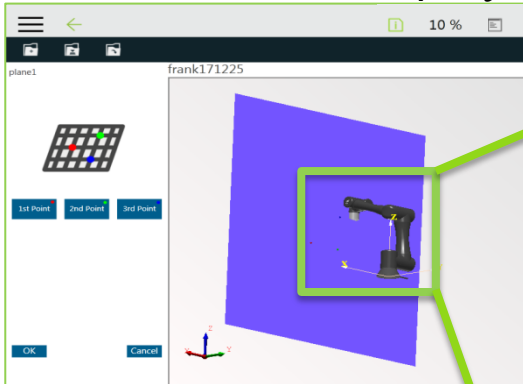




Safety Space

# Safety Space

In this page, the user can set up a plane by setting three points by TCP. The setting order of the three points can be random, and the robot virtual interface will be displayed with the corresponding chromosphere.

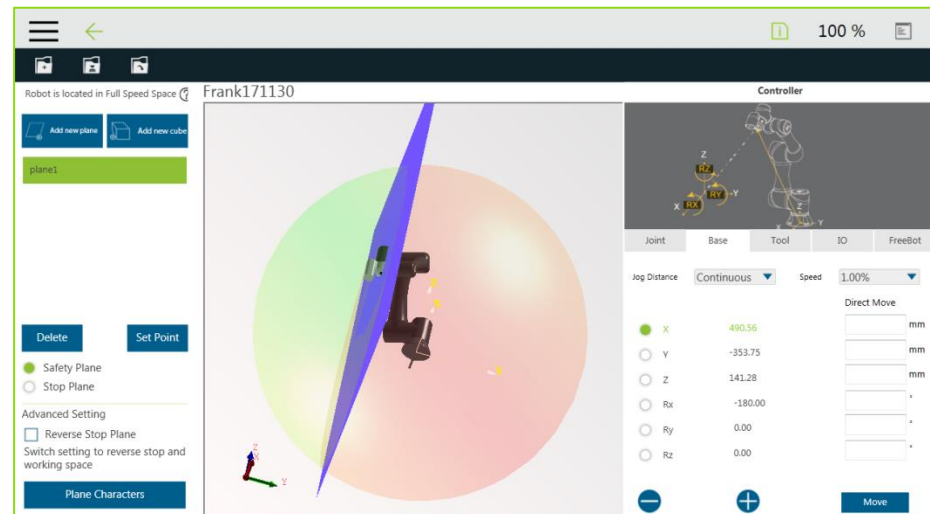
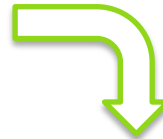
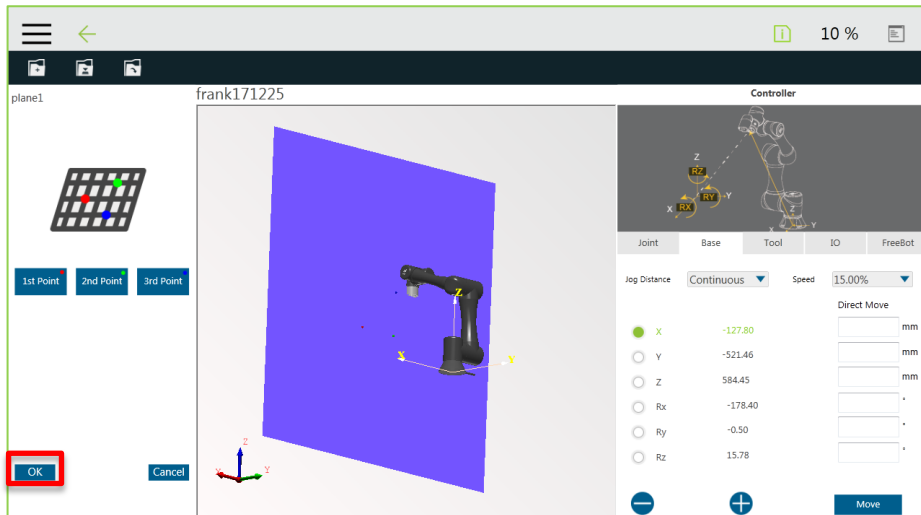




Safety Space

# Safety Space

After the three points are set up, a transparent blue virtual plane will appear. Now you can click the OK button to build the plane. Note that when there is a phenomenon such as common point or collinearity, you will not be able to set up this virtual plane.





Safety Space

# Safety Space

By clicking the button to add a new hexahedral or hexahedron feature and click the reset feature button to enter the new / modify the hexahedron page, this page users can set the TCP A point to establish a hexahedron, four points can be set in random order, the robot virtual interface will be the corresponding color ball display.

Robot is located in Full Speed Space

Frank\_CollaborativeMode\_171130

Controller

Add new plane

Add new cube

Delete

Set Point

Safety Plane

Stop Plane

Advanced Setting

Reverse Stop Plane

Switch setting to reverse stop and working space

Plane Characters

Please set the first point

1st Point

2nd Point

3rd Point

4th Point

OK

Cancel

Joint

Base

Tool

IO

FreeBot

Jog Distance

Continuous

Speed

1.00%

Joint Angle

J1

-56.10

J2

-5.53

J3

123.40

J4

-27.28

J5

90.05

J6

32.00

Direct Move

Move

Please set the first point

1st Point

2nd Point

3rd Point

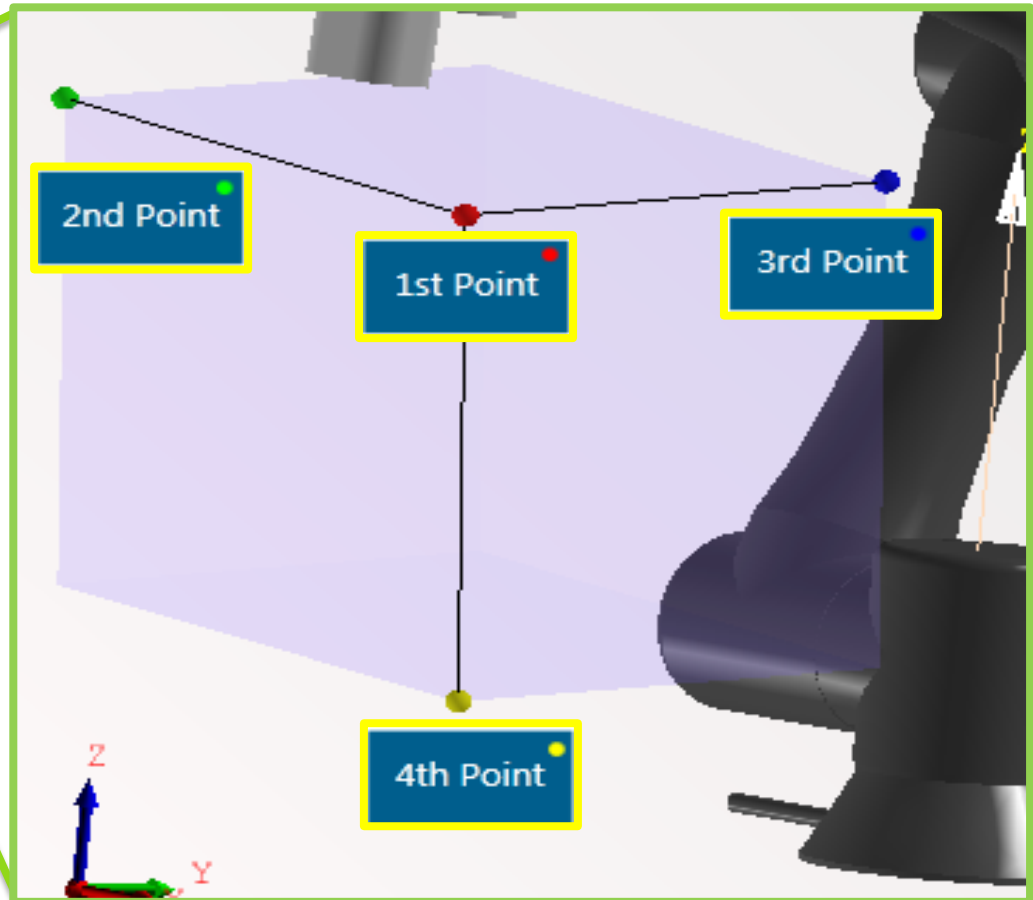
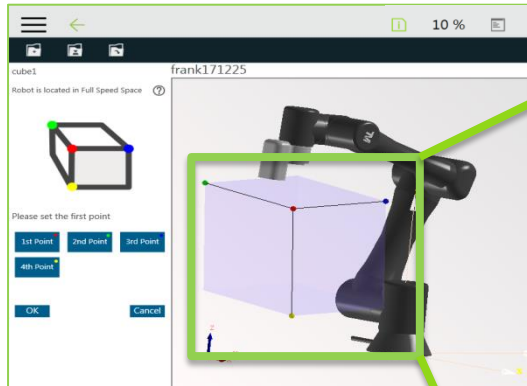
4th Point



Safety Space

# Safety Space

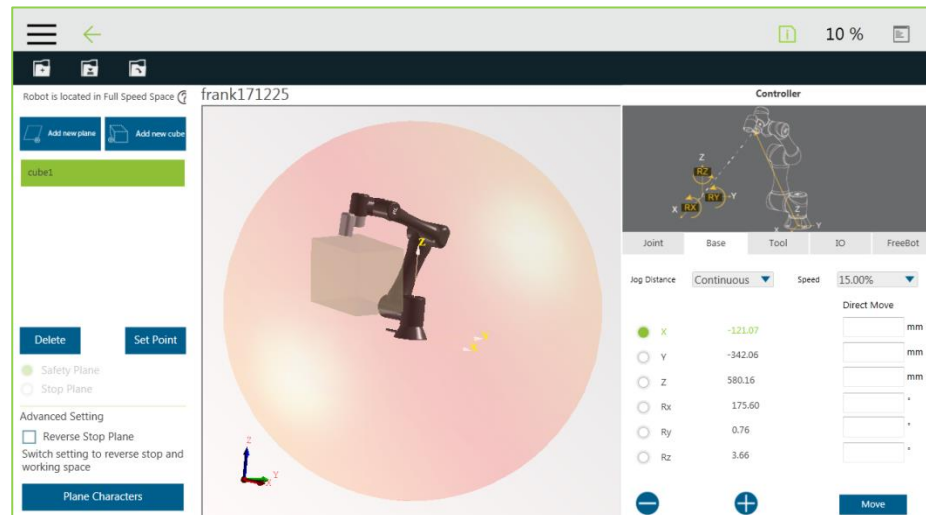
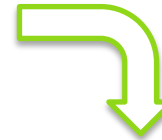
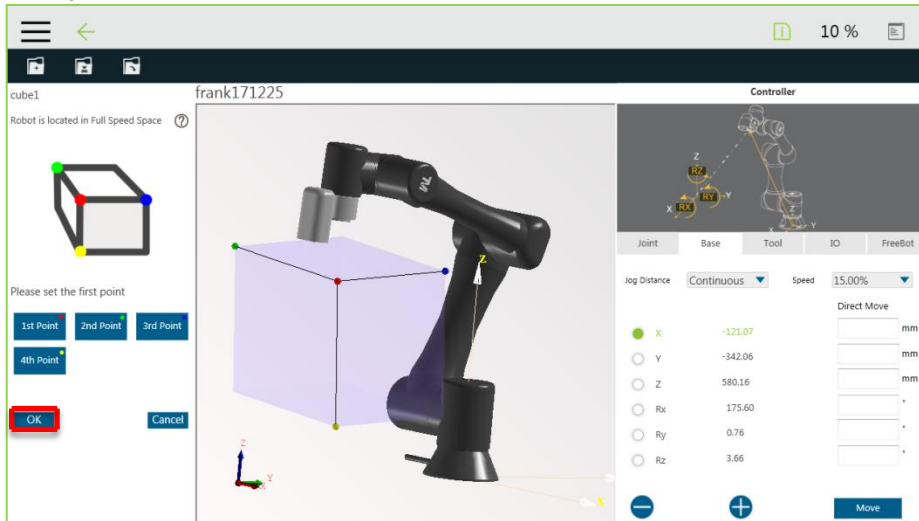
In this page, users can set up a hexahedron with four points by TCP. The order of the four points can be set randomly. The robot virtual interface will be displayed with the corresponding chromosphere.





# Safety Space

When the four points are set, there will be a transparent blue virtual hexahedron, then click the OK button to build hexahedron, it should be noted that there is a total point, collinear and other phenomena will be Can not build this hexahedron.

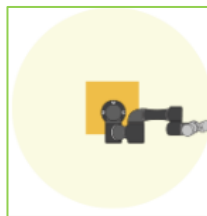
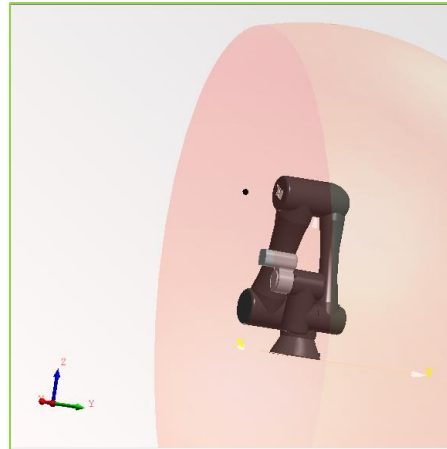
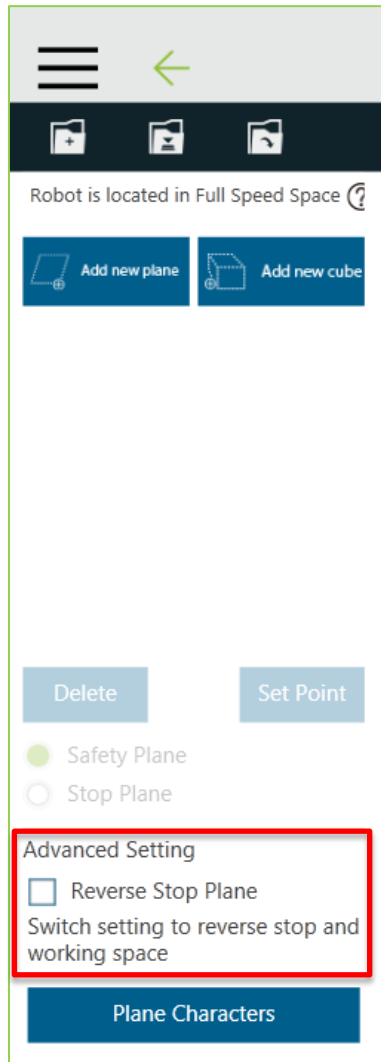




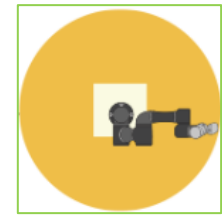
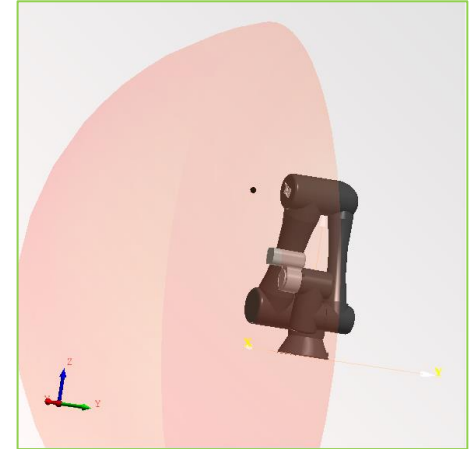
## Safety Space

# Reverse stop plane

Select Reverse Stop Plane workspace



Before click



After click

After click, the arm will immediately beep twice to warn the user that the arm is currently in the stop space.

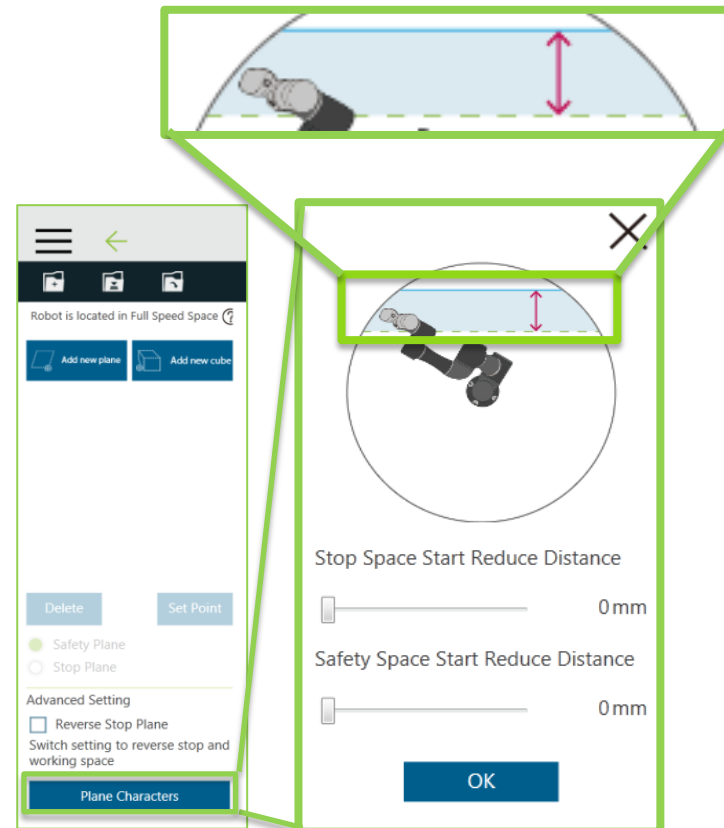
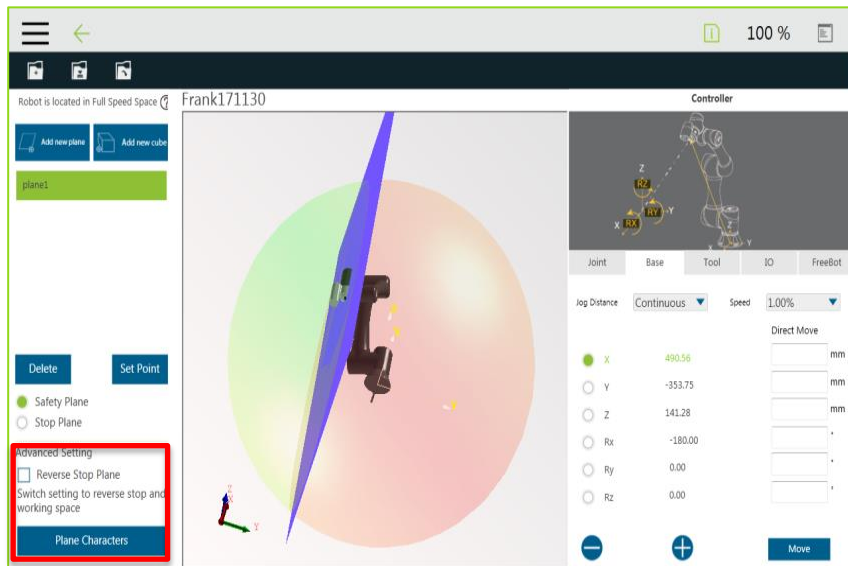


Safety Space

# Safety Space

Clicking the Plane Characters button will bring up the setting window, in which the user can set the starting deceleration distance for the cooperation area and the stop area. When the robot enters the man-machine cooperation area, it is the ready deceleration area, and the robot will start to decelerate, but the status of the light ring will not change at this moment.

Pre-deceleration area, the robot began to slow down in this area, but this time the light ring state unchanged.

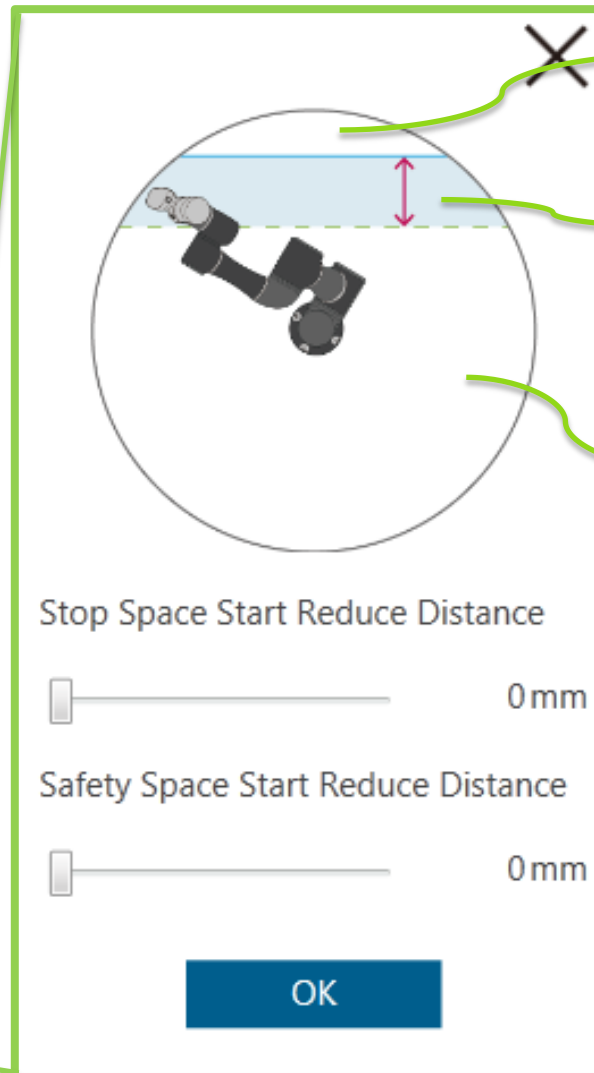
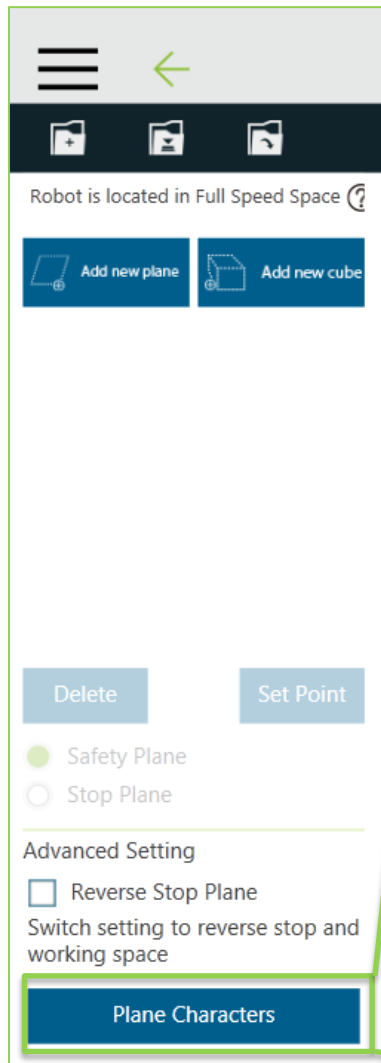




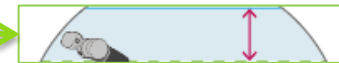
Safety Space

# Safety Space

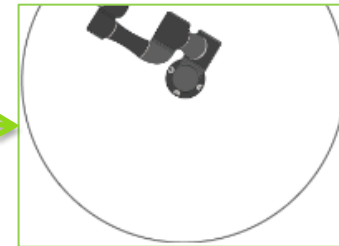
## Plane Characters



Safe area or stop area



Pre-deceleration area



Full speed area

Stop Space Start Reduce Distance



0 mm

Safety Space Start Reduce Distance



0 mm

OK

Stop plane start reduce distance  
Adjustable value: -10 ~ 350mm

The safety plane starts to reduce  
Adjustable value: -10 ~ 350mm

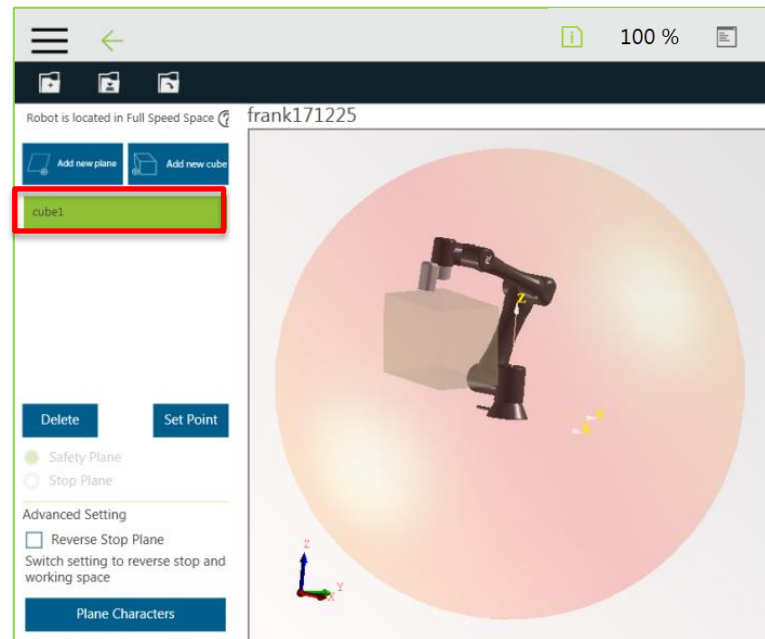
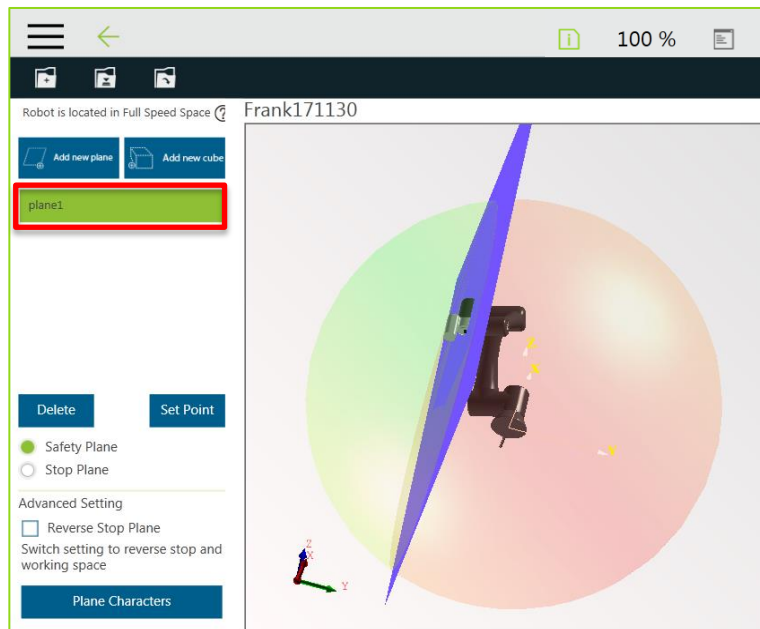




Safety Space

# Safety Space

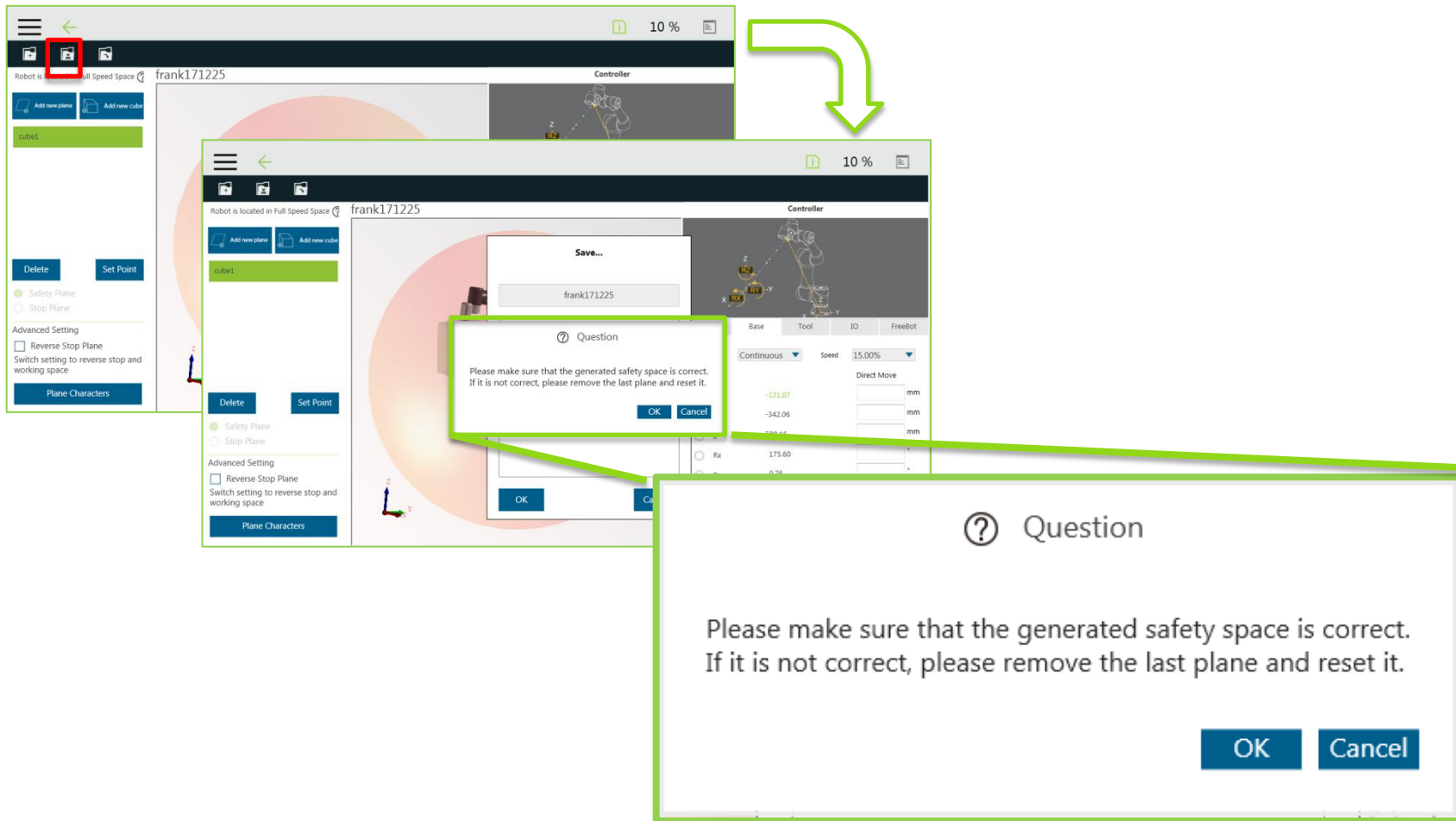
The list shows all the features that have been set up. When the user clicks on the features in the list, the robot virtual interface in the middle will display the selected features in a clear blue color, and the user will be able to select the selected features Delete, reset and other settings. Note! The hexahedron only provides safe space.





# Safety Space

After the safety space is set up, please save it and the files are stored separately in the externally set Safety Space.





# Safety Space

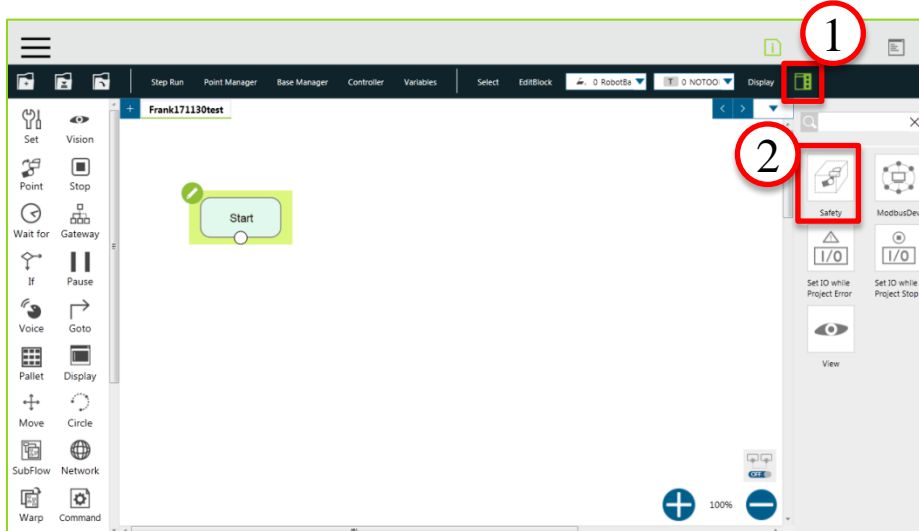


Convenient setting of the safe space is achieved by the complex spatial geometry algorithm. It may cause the user to unexpectedly split the space in some specific setting conditions. The user should fully view the result of the spatial sphere in the 3D picture before saving the setting. As expected, the risk of the robot hitting the human body at full speed conditions occurs as a result of improper use of secure space to set up or run erroneous projects.



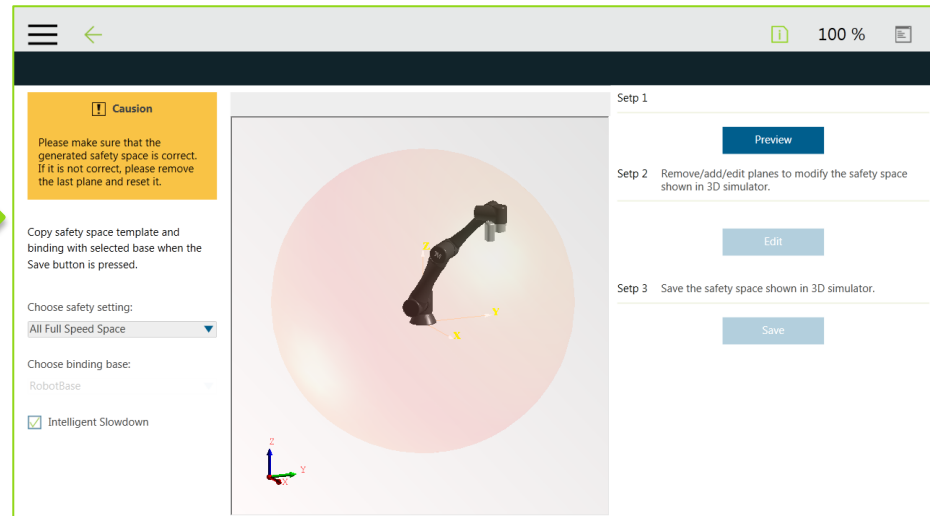
# Safety Space

After setting up the security plane, the user can enter the project page, fold the layout on the right, and click Safety to enter the security settings page.



## Steps

- ① setting
- ② Safety Space

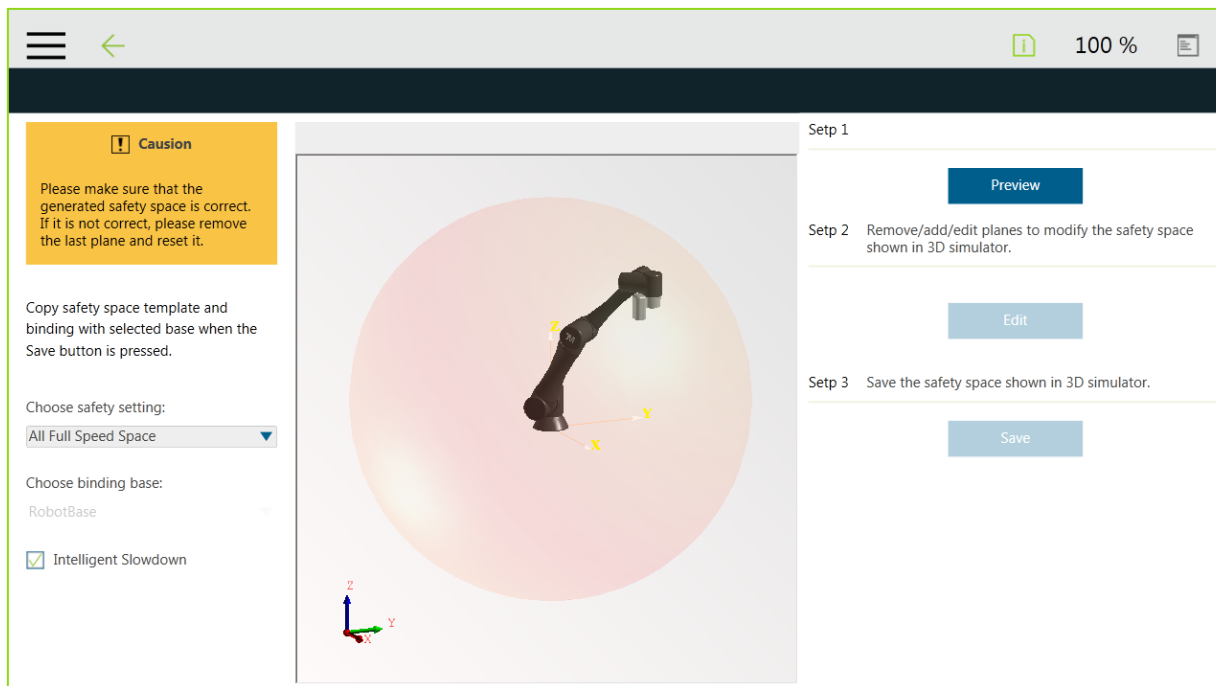




Safety Space

# Safety Space





After entering, press the preview key, the safety plane selected by Choose safety setting and the base coordinate system set by Choose binding base are combined with each other and displayed on the 3D simulator. To modify the safety space, the setting button can be used to modify the selected safety setting. Before storing, it is the user's responsibility to check the safety of the displayed space and to maintain its own safety. If the generated safety space is not correct, click the edit button and remove the last safety plane to reset. Press to save After that, the system will store the safe space displayed in the 3D simulator.






Safety Space

# Safety Space

100 %

**Caution**

Please make sure that the generated safety space is correct. If it is not correct, please remove the last plane and reset it.

Copy safety space template and binding with selected base when the Save button is pressed.


1

Choose safety setting:  
All Full Speed Space

2

Choose binding base:  
RobotBase

☒ Intelligent Slowdown



Choose a safe plane

Select base you want to use

Setp 1

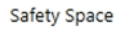
Preview

Setp 2 Remove/add/edit planes to modify the safety space shown in 3D simulator.

Edit

Setp 3 Save the safety space shown in 3D simulator.

Save



Select the just set safe space from the preset full speed area.










Safety Space

# Safety Space

The red box shows the security space settings are bound in this project. At this time, the security space settings can be modified, edited, and finally stored in this project. The external security space configuration files will not be modified.

10 %

**Caution**

Please make sure that the generated safety space is correct. If it is not correct, please remove the last plane and reset it.

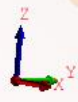

Copy safety space template and binding with selected base when the Save button is pressed.

Choose safety setting:  
frank171225 ▼


Choose binding base:  
RobotBase ▼

☒ Intelligent Slowdown


frank171225\_Binding




Setp 1



Setp 2 Remove/add/edit planes to modify the safety space shown in 3D simulator.



Setp 3 Save the safety space shown in 3D simulator.







# Safety Space

## Setp 1

---

Preview

Setp 2 Remove/add/edit planes to modify the safety space shown in 3D simulator.

---

Edit

Setp 3 Save the safety space shown in 3D simulator.

---

Save

Preview

The resulting safety space is displayed on the 3D simulator.

Edit

Enter the safety space editing interface.

Save

Save safety space set in this project. (Changes here do not affect the external safety profile)



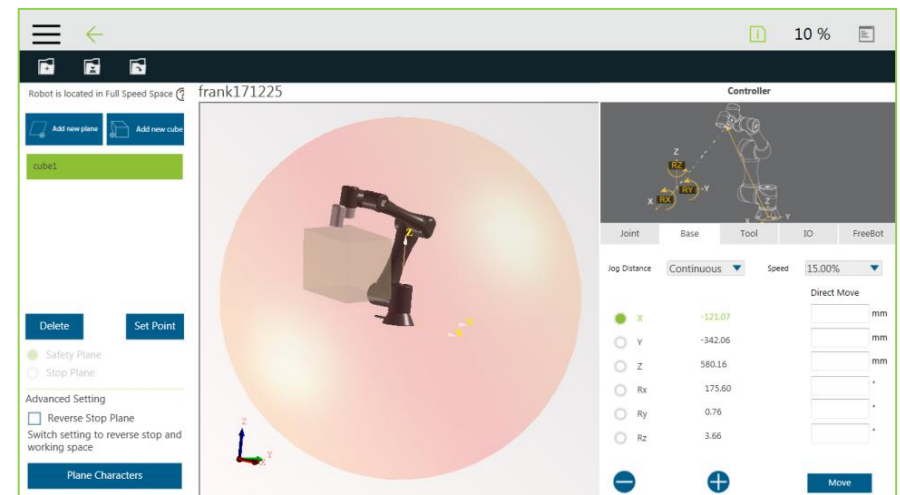
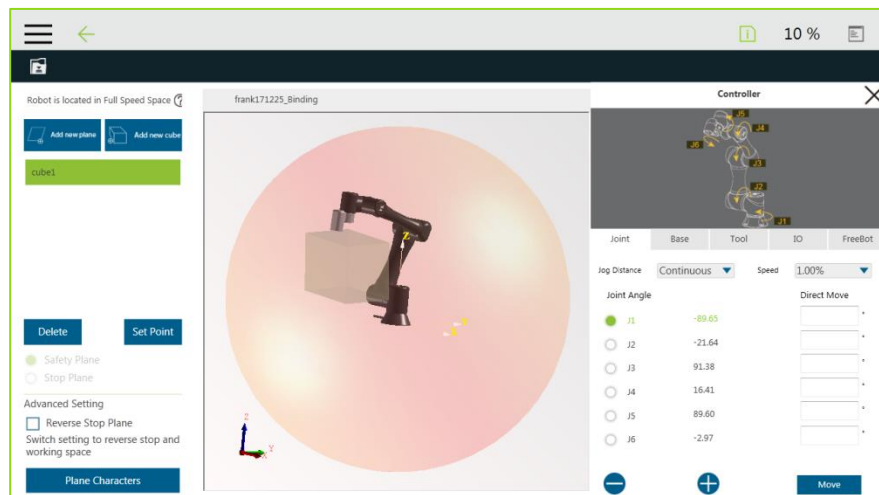
# Safety Space

Edit

into the safe space editing interface.



External safety space editing interface



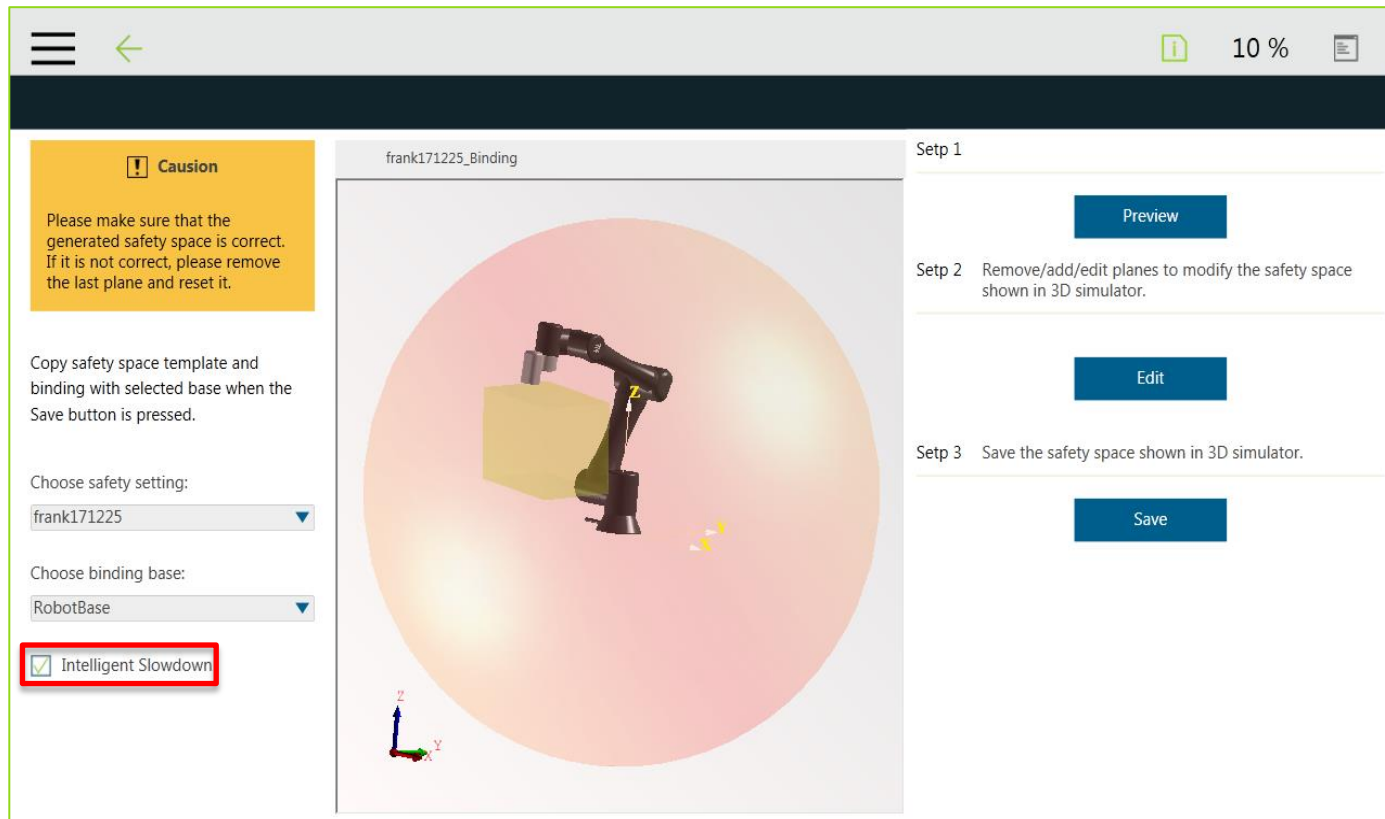
兩編輯介面操作方法一樣，詳見前述說明頁面。



Safety Space

# Safety Space

Intelligent slowdown, this feature provides the ability of TM ROBOT to decelerate before leaving full speed. According to the position feedback of TCP on the coordinate system, the robot judges whether the robot enters the man-machine cooperation area from the full-speed area and sets the speed according to the selected path and the corresponding operation result.





# Safety Space



The robot Intelligent slowdown function only judges whether the initial position and the end point of the robot TCP in the coordinate system enter the cooperation area from the full speed area. Therefore, if the initial position and the end point are located in the full speed area and the TCP position enters the cooperation area during operation, Function does not start.



Safety Space

# Safety Space

After all the settings are completed, the window will be displayed again when saving.

The screenshot shows the 'Safety Space' configuration window. On the left, there is a 'Caution' box with a warning icon and text: 'Please make sure that the generated safety space is correct. If it is not correct, please remove the last plane and reset it.' Below this, instructions state: 'Copy safety space template and binding with selected base when the Save button is pressed.' There are two dropdown menus: 'Choose safety setting:' with 'frank171225' selected, and 'Choose binding base:' with 'RobotBase' selected. A checkbox for 'Intelligent Slowdown' is checked. The main area displays a 3D simulator with a large orange safety space and a coordinate system (X, Y, Z). A white dialog box with a green border and a question mark icon is centered over the 3D view. The dialog text reads: 'Question Please make sure that the generated safety space is correct. If it is not correct, please remove the last plane and reset it.' It has 'OK' and 'Cancel' buttons. Numbered callouts are present: '2' points to the dialog box, '3' points to the 'OK' button, and '1' points to the 'Save' button on the right. The right panel shows 'Setp 1' with a 'Preview' button, 'Setp 2' with the text 'Remove/add/edit planes to modify the safety space shown in 3D simulator.', an 'Edit' button, and a 'Save' button. The 'Save' button is highlighted with a red box and a red circle with the number '1'. The top bar of the window shows a menu icon, a back arrow, an information icon, '10 %', and a document icon.

**END**