rethink robotics

baxter™

user guide

for intera 3.2 software

Welcome!

Thank you for purchasing Baxter, the world's first collaborative robot for manufacturing.

This user guide is designed to provide you with an overview of the robot's features, help support you through the setup process, instruct you on training Baxter for tasks, and outline some basic troubleshooting measures should you need them.

The latest and most detailed information is available on our Intera MFG Wiki page at: mfg.rethinkrobotics.com

Safety Statement

Complying with ISO 10218-2 requires performing a risk assessment of each application to determine the needed safety performance and safeguarding. ANSI RIA R15.06-2012 is a U.S.-national adoption of ISO 10218-1 & 2.

Users should exercise caution while training Baxter and practicing its motions. The risk of injury is increased when using custom end-effectors, off-vertical motions, and potentially hazardous work pieces.

Rethink Robotics recommends the use of safety glasses when interacting with Baxter, as with other equipment used in industrial environments.

For additional information, reference Baxter's Safety Documentation: http://www.rethinkrobotics.com/resources/safety/

Baxter's maximum transit speed is now controlled to 2 meters per second. (2 m/s).

Disclaimer

Every effort is made to ensure that the information in this manual is accurate. This publication could include technical or typographical errors or other inaccuracies. Rethink Robotics, Inc® may make changes to the product described in this publication or to this publication at any time, without notice.

A newer version of this document may be available here: mfg. rethinkrobotics.com/wiki/Support_Resources

Typographical conventions and notes used in this guide

IMPORTANT	Calls out essential information that must be followed to prevent injury to the operator or damage to the robot.
Note	Calls out key conceptual information.
Tip	Provides hints or other helpful information when training or operating Baxter.
Bold	When used in-line, bold text indicates a specific named element, like a physical button or button on the screen. For example, "Rotate the **knob** to scroll through the saved tasks."
<Italics>	Used to indicate: a *new term*, or name of another document.

Quick Start

Performing a Pick and Place in Just a Few Minutes

Follow the steps in this section to get up and running with Baxter quickly. The bulk of this User Guide explains Baxter in more detail its parts, terminology, how to perform various tasks, create paths, etc., but to get a very basic idea of how to operate Baxter, start here.

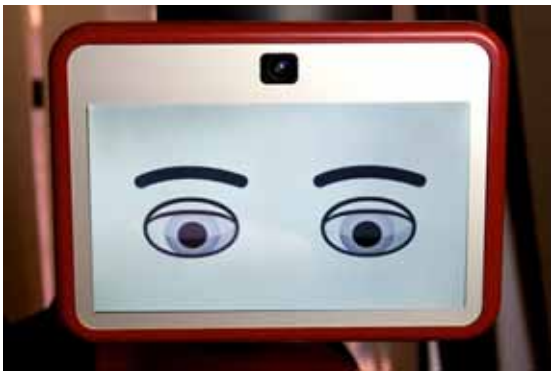
NOTE: For Baxter to perform properly, it should be calibrated (see “Calibrating the Arms” on page 138), and its grippers attached (per the instructions in the gripper kit) and configured (see “Appendix A: Configuring Grippers” on page 143) before you train a Pick and Place task. Otherwise, Baxter’s arm may pull or miss Picks when performing tasks.

Power On Baxter

To turn Baxter on, press and release the white power button on the lower left back of the robot (See “Back View” on page 14 for the location.)

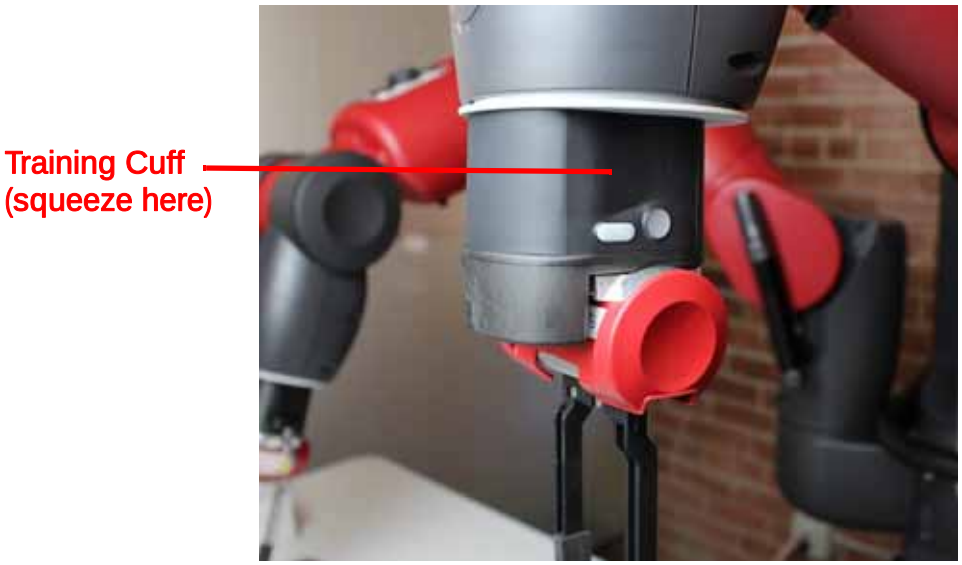
IMPORTANT: Do not hold the power button down when powering on. It could damage the robot.

The lights on the head turn on, and the display shows a neutral face.



1. Move the Arm

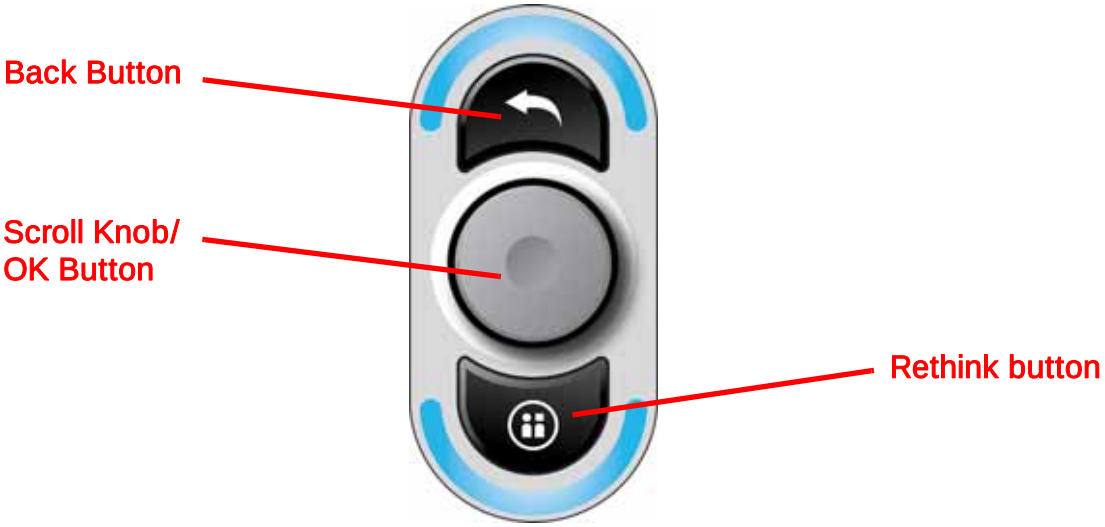
Grab anywhere along Baxter's arm and push and pull on it slightly to feel its resistance. Now, grab the indented portion of the *training cuff,* the part between Baxter's wrist and grippers, and squeeze it just above the buttons on either side. Baxter is now in "Zero G" mode and you can now move the arm easily.



Release the training cuff and the arm becomes (semi-) rigid again. Note that the arm stays in the location and orientation it was in when you stopped squeezing the training cuff. The location and orientation of the arm (its shoulder, elbow, wrist, and so on) is called its *pose*.

THE NAVIGATOR

On both of Baxter's arms, and on either side of Baxter's torso, is the Navigator, a set of buttons and a knob you use to make selections on Baxter. The selections you make on the Navigator are shown on Baxter's display.



2. Create a New Task

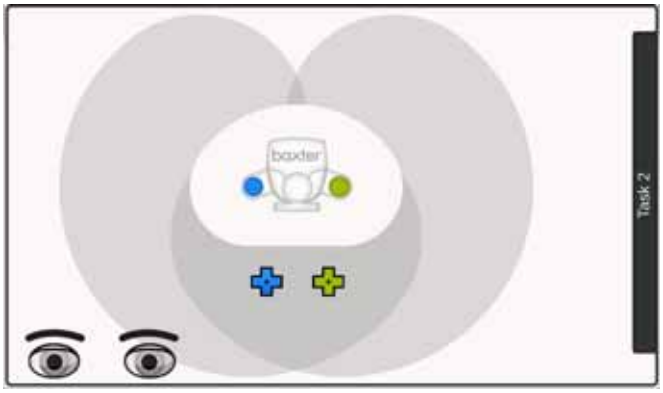
The work you train Baxter to perform is called a *task*. A task can be very simple, like the pick and place you're about to create, or much more complicated, involving both of Baxter's arms moving in a coordinated fashion to and from multiple pick and place locations, holding a variety of poses, and sending and receiving signals from other machines and devices.

You can both scroll the knob to move through options on Baxter's display, or press it to make a selection. We refer to pressing the scroll knob to make a selection as "pressing the **OK** button" or sometimes, "press **OK** on the Navigator."

Generally you press the **Back** button on the Navigator when you want to return to the previous screen.

Scroll the knob to reveal the main button bar and stop scrolling when you reach the New Task icon (as shown here).

Press **OK** on the Navigator. Baxter displays the *Task Map.*



For now you just need to know that the blue icon on the display represents Baxter's right arm, the green icon represents the left arm, and the shaded area is where the arms can reach.

Squeeze the training cuff and move one of Baxter's arms. Watch as the appropriate icon moves on screen in response to the movement of the arm.

3. Grasp an Object

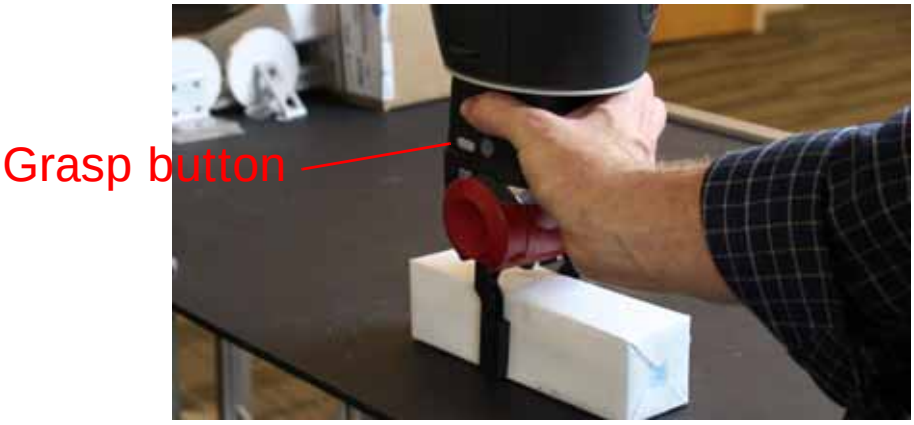
NOTE: If the end effectors have not already been configured, configure them now, otherwise the gripper may not work. See "Appendix A: Configuring Grippers" on page 143.

Place an object on the work surface for Baxter to grasp.

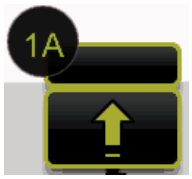
Remember: For you to train a pick and place, Baxter must have at least one arm with a properly working gripper attached. If not, follow the gripper kit instructions and install a gripper now.

If your Baxter has parallel electric grippers installed, make sure the grippers are open, then position the fingers on either side of the object. If you're using the vacuum grippers, position the object just touching the vacuum cup.

Press the Grasp button on the training cuff.

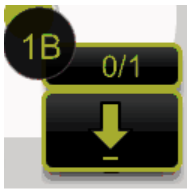


Baxter grabs the object and nods its head acknowledging your instruction. If you look at Baxter's display, you'll see an icon for a Pick, plus a sub-task number and letter. (For details, see "Tasks, Sub-tasks, and Actions" on page 28.)



Still squeezing the training cuff, move the arm to the location where you want Baxter to place the object, then press the Grasp button again to release the object. Baxter nods and releases the object.

The Task Map displays the icon for a Place (along with sub-task number and letter).



Reset the object to its original position, select **Run** or **Reset**, and watch Baxter perform the task.

You just trained your first task using Baxter.

Getting to Know Baxter

Setting Up Baxter

To prepare for the arrival and setup of Baxter, read the *Baxter Pre-Delivery Guide*. The document arrives in an email prior to the delivery of your order.

To set up Baxter:

- Locate the installation card that ships with the robot. Follow the instructions to assemble the pedestal (if ordered), and attach Baxter to the pedestal or alternate work surface.
- Follow the instructions included with the gripper kit to install a gripper.

If you misplace these documents, refer to our wiki:
mfg.rethinkrobotics.com/wiki/Support_Resources

Accessories

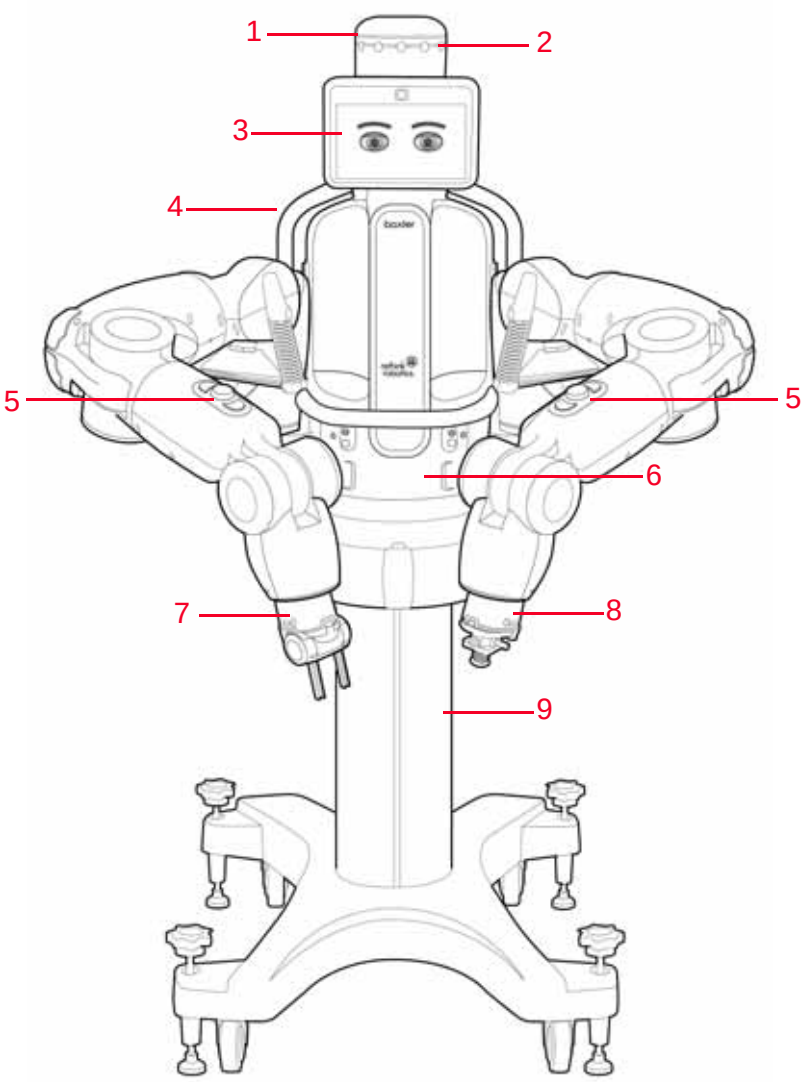
Included accessories:

- Power cord
- E-stop button and 10-foot cable

Optional accessories:

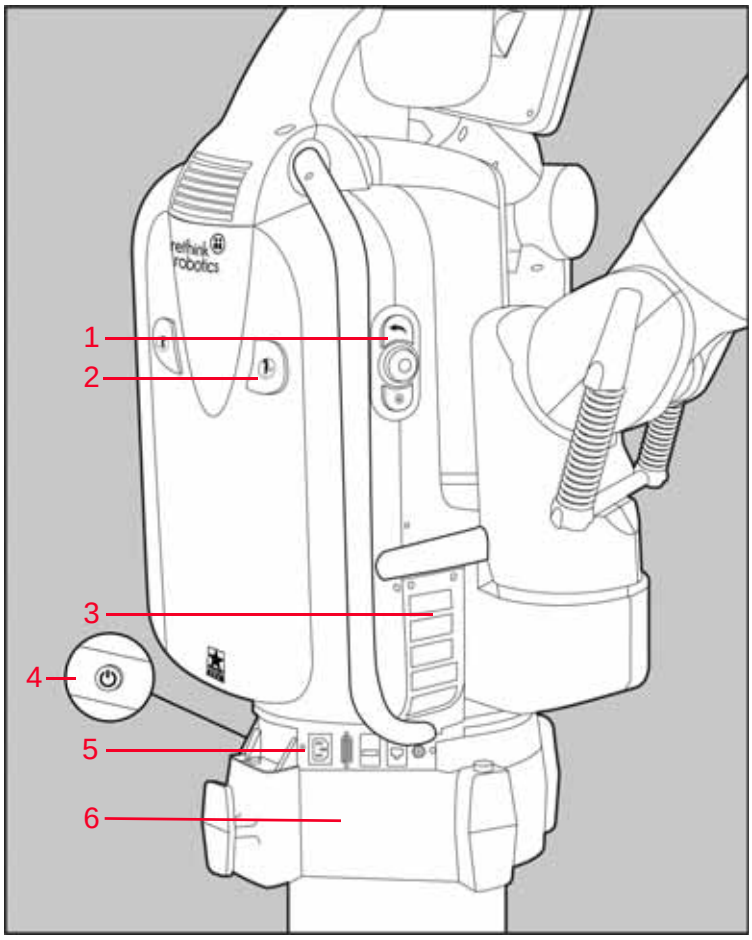
- Rethink Robotics Electric Parallel Gripper Kit
- Rethink Robotics Vacuum Cup Gripper Kit
- Baxter pedestal

Front View



1. Condition ring
2. Attention ring
3. Display
4. Torso
5. Navigator (one on each forearm)
6. Lower front panel
7. Training cuff (shown with parallel gripper)
8. Training cuff (shown with vacuum gripper
9. Pedestal (optional)

Back View



1. Navigator (one on each side)
2. Non-active (button for future use)
3. Air filter (one on each side)
4. Power button
5. Power and I/O panel (with DB15, USB, and Ethernet Ports)
6. Pedestal (optional)

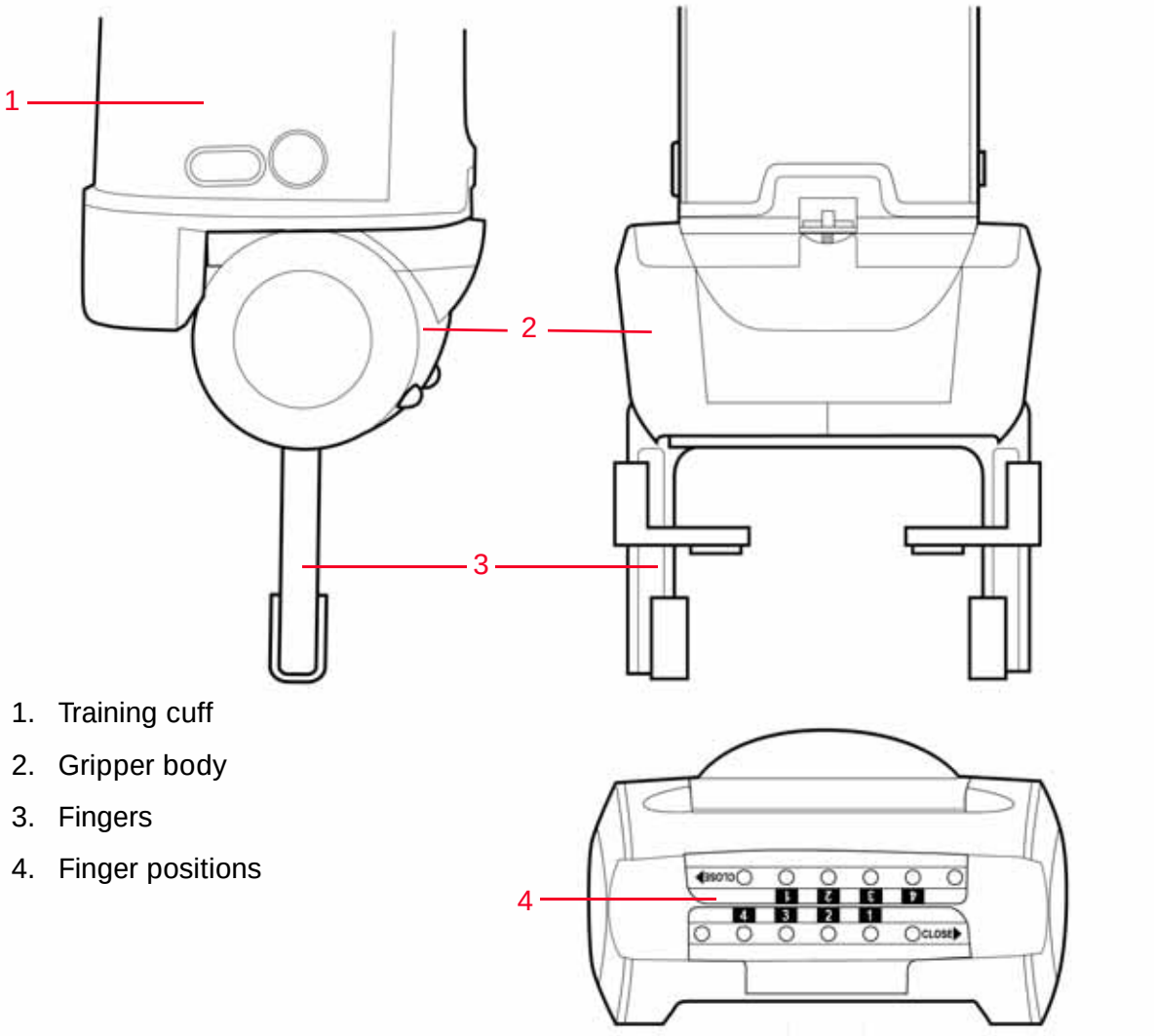
Grippers

Grippers are the robot's hands—they enable Baxter to grasp and release objects. The grippers attach to the *wrist plate* at the base of the robot's training cuff. Baxter supports two standard Rethink Robotics grippers: electric parallel and vacuum cup, and can support some custom grippers. Please contact Rethink Support with questions about other types of grippers.

After installing or altering a gripper, see "Appendix A: Configuring Grippers" on page 143 to configure it. (Note that installation and alteration instructions ship with the gripper kit.)

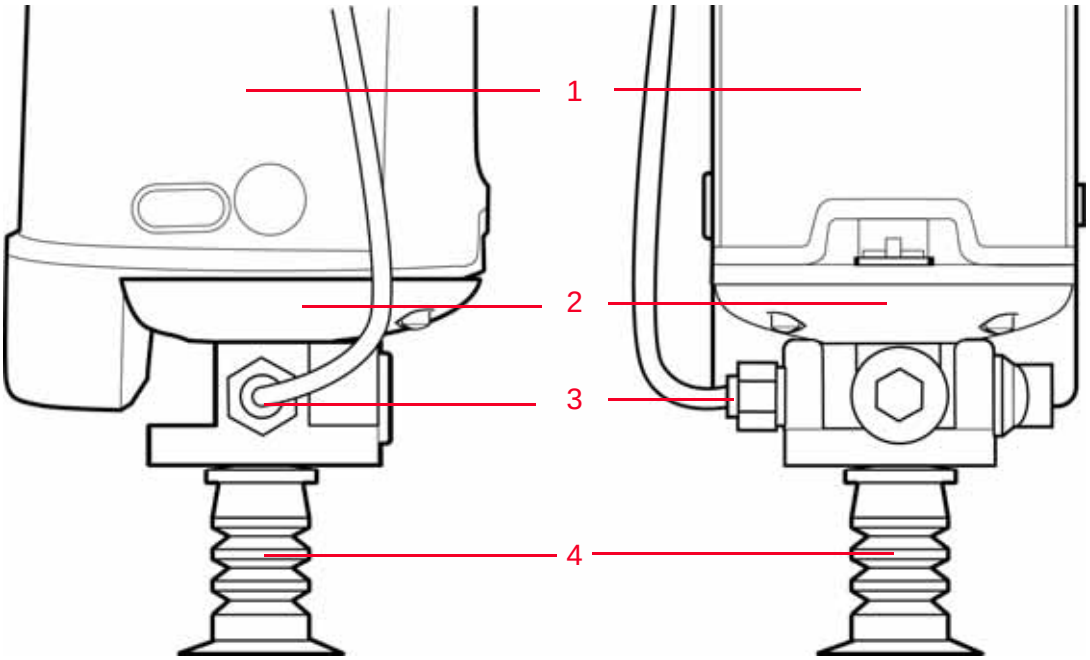
> ***Note:*** Custom finger lengths are supported and can be entered into the software, but custom widths are not currently supported by the software.

ELECTRIC PARALLEL GRIPPER



1. Training cuff
2. Gripper body
3. Fingers
4. Finger positions

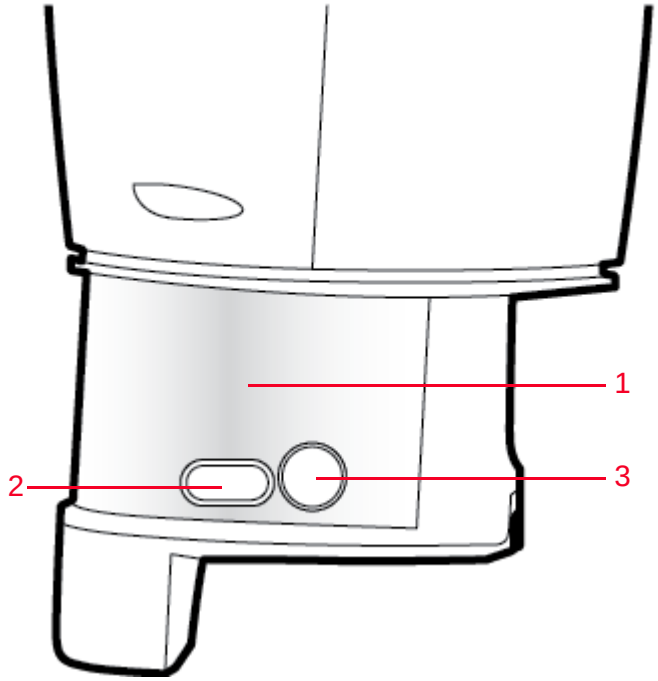
VACUUM CUP GRIPPER



1. Training cuff
2. Gripper body
3. Pneumatic tube fitting
4. Vacuum cup

Using the Training Cuffs

Use the *training cuffs* to move the arms, to manipulate the state of the grippers, and secondarily, to select on-screen options.



1. Training cuff switch
2. Grasp button
3. Action button

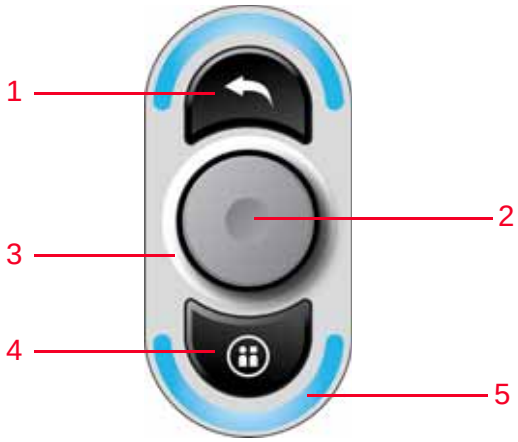
Training cuff switch: Squeeze this switch at the indentation in the cuff to move the robot's arm. When this switch is squeezed, the blue indicator on the arm's navigator button lights up.

Grasp button: Press to toggle a parallel gripper open or closed, or a vacuum gripper on or off.

Action button: Press to select items on the display screen. Create waypoints, Hold actions; select, copy, or move actions on the task map; create a new subtask; add/create landmarks; outline a visual search area.

Navigating the Screens

Use the *navigator* on either of the arms to scroll to and interact with options on the screen. When you press the OK button (2) (or the action button on the cuff), the white indicators on the navigator light up.



1. Back button
2. Knob (turn to scroll) and OK button (press)
3. OK indicator light
4. Rethink button
5. Training cuff indicator lights

Back button: Press to exit the current screen and return to the previous screen. Will also cancel the last action.

Knob: Scroll the knob to move between on-screen options. Press the knob (OK) to select an option.

OK indicator light: When the action button on the cuff or the OK button on the navigator is pressed, the white indicator around the knob lights up.

Rethink button: Press to display options for the current screen.

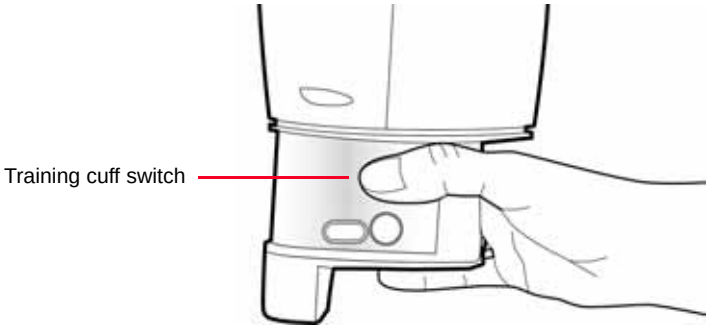
Training cuff indicator: When the switch on the cuff is squeezed, the blue indicators along the top and bottom edge of the navigator light up.

Moving the Arms

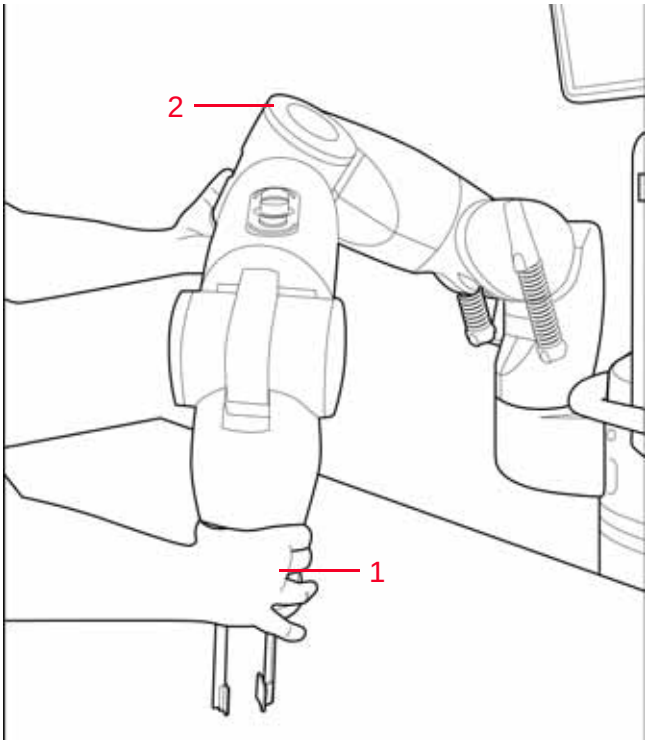
To move an arm, squeeze the cuff at the indentation just above the other buttons, and push or pull the arm to the location you want.

Squeezing the cuff releases the tension and resistance in the arm, making it easier to manipulate. With its seven degrees of freedom—an incredible amount of flexibility—Baxter enhances arm stability by attempting to fix its elbow in position whenever the lower arm is moved.

> ***Note:*** When the switch is pressed, the blue indicator lights illuminate on the corresponding navigators on the arm and torso.



When grasping the training cuff, you can move the arms by either repositioning the lower arm or changing the height of the elbow.



To move the lower arm: While squeezing the cuff (1), move the robot's arm to the desired location.

To move the elbow: By design, the elbow (2) will try to maintain its current height and will spring back if you do not actively reset it. While squeezing the cuff, move the elbow to the desired position. Continue to hold the elbow at the new location, and release the cuff. This will reset the elbow at the new position.

Grasping Objects

Training involves showing Baxter how to pick up and place objects.

To grasp an object: Position the gripper over the object, press **Grasp**.

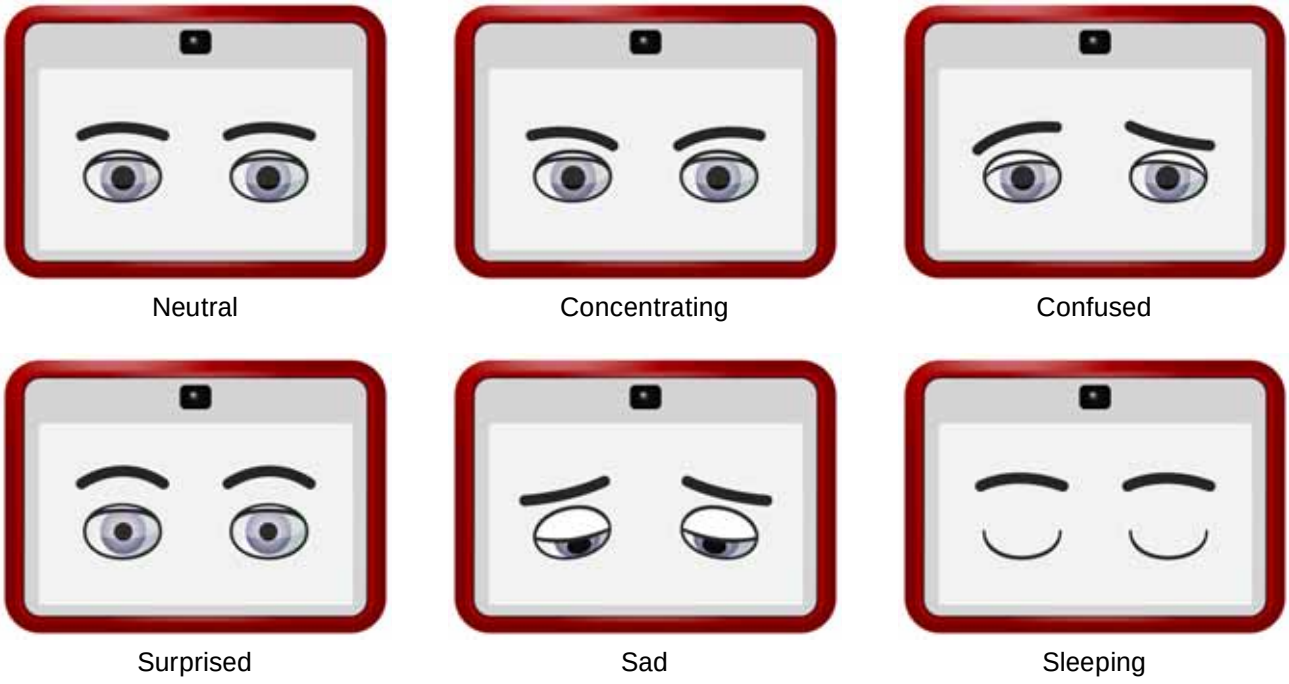
To release an object: With an object in the robot's hand, press **Grasp**.

To open or close the gripper without creating a pick or place: Without an object in hand, press **Grasp twice** quickly.

Baxter communicates through a combination of eye expressions, light rings, and thought bubbles. Baxter also responds to touch on a navigator or a training cuff—it stops moving and turns its head in the direction of contact on any of its primary touch points.

Eye Expressions

Baxter displays one of six eye expressions in response to what it is doing or what it senses happening in its environment.



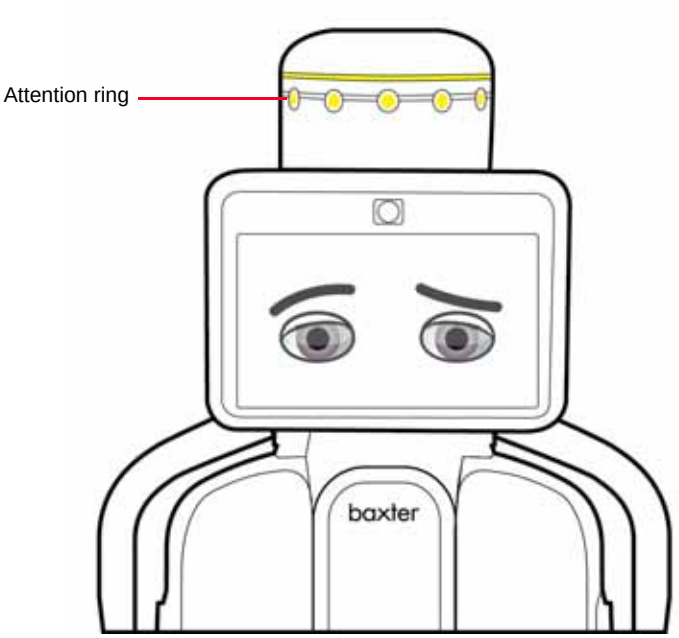
Neutral | Concentrating | Confused

Surprised | Sad | Sleeping

The surprised expression is emphasized with an orange background when Baxter is working and unexpectedly detects someone has entered its space (currently, this only happens when a safety mat is connected and stepped on); Baxter also automatically slows its movement.

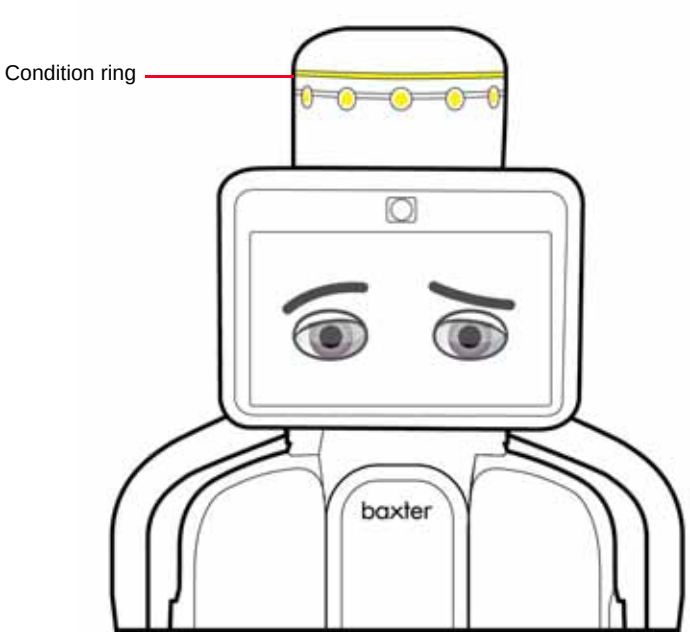
Attention Ring

The *attention ring* lights appear in clusters of two or three when Baxter detects movement.When Baxter is confused, the yellow lights in the ring appear and flash simultaneously.



Condition Ring

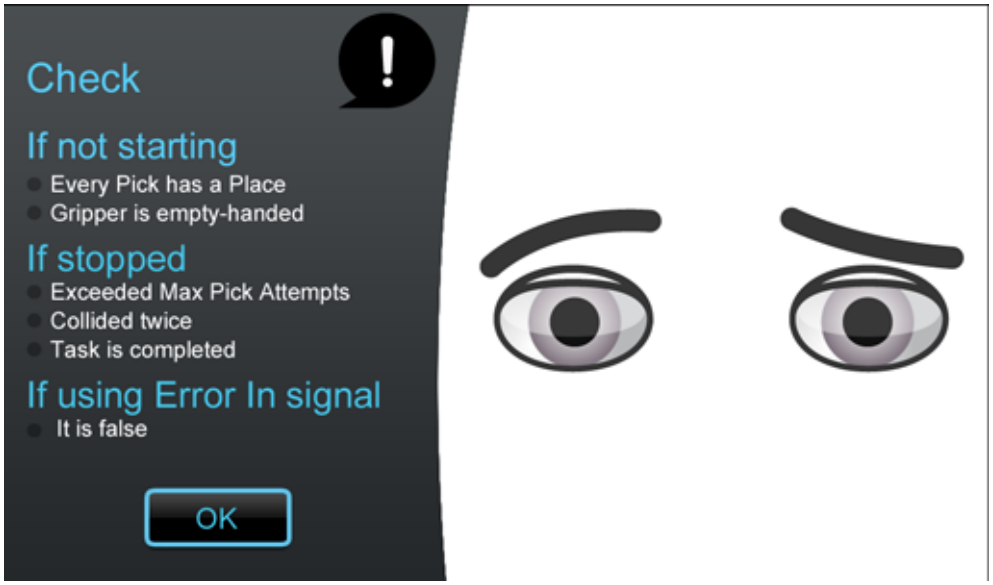
The *condition ring* communicates the condition of the robot.



Light Color and Pattern	What it Means
Solid green	Baxter is running a task
Slow pulsing green	Baxter is either idle or being trained by a user
Solid yellow	Baxter is confused and needs user assistance
Slow blinking yellow	Baxter is in sleep mode; its motors are disabled
Fast blinking red	Baxter reports an error

Confused Face Messages

When Baxter becomes confused, the display offers a list of possible explanations and solutions.



"Light Bulb" Tips

When you see a "light bulb" symbol  on a screen, that means there is a tip (or tips) on how to use that functionality. Select the light bulb to display the tip. (These tips are available on the Modify Waypoints Screen, the Advanced Screen, and the Action Practice screens.)

Main Screen

The main screen has two elements: the *button bar*, and *eye expressions*.

1. Current task name
2. Current task options
   - Run – run the task.
   - Reset – reset the count, and restart the task from the first action.
   - Modify – open the task map for the task.
3. Main options
   - New – create a task.
   - Tasks – opens the *task gallery*, a visual list of existing saved tasks. (See “Task Gallery” on page 33.)
   - Settings – open Baxter administration and advanced options.
   - Power – open Baxter power options: Sleep, Restart, Shutdown, Lock/Unlock.
4. Baxter eyes – Baxter uses eye expressions to communicate its current state.

To navigate a button bar: Rotate the knob to scroll (referred to as “scrolling”) through options. When the option is highlighted, press the knob (**OK**) to select it.

To exit a button bar option: Press **Back** .

Turning On Baxter

Press the white power button on the lower left back of the robot (see “Back View” on page 14 for the location). The lights on the head turn on, and the main screen appears on the Baxter display.

IMPORTANT: *Never hold the power button down* to shut down Baxter. Just press and release the power button.

Training and Managing Tasks

Getting to Know Intera

Intera is the name given to reflect our robot's interactive software platform. Intera provides an easy-to-use graphical user interface that staff can master quickly.

Here is a list of terms commonly found in this User Guide that will help you understand how to train tasks and put Baxter to work.

GLOSSARY

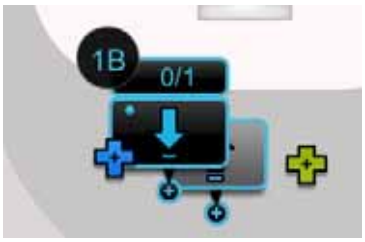
- Task - Made up of one or many Sub-tasks on one or both arms. A Task includes everything the robot is trained to perform.
- Sub-task - One or more actions that may be grouped together and performed in sequence.
- Actions - A Pick, a Place, or a Hold.
- Approach Point - The pose that immediately precedes an action.
- Retract Point - The pose that immediately follows an action.
- Task map - A top down view of the robot's workspace, often known as the "work envelope."
- Path - The arm movement between two actions.
- Waypoint - A location in space that the arm will move to along a path.
- Pose - A position and orientation of Baxter's arm at a location.
- Action Control - The parameter to tell the robot when the gripper should actuate.
- Motion Preset - The parameter that defines how precisely Baxter's arm follows a path's waypoints.

Tasks, Sub-tasks, and Actions

Generally, Baxter's tasks involve Pick actions and Place actions. Each Pick requires a subsequent Place. (However, this rule of thumb does not apply to a Hold action as a distinct subtask, explained in the chapter, "Hold" on page 93.)

To make it easier to distinguish one action from another, actions are labeled on the Task Map (see page 29) with the subtask number and appended with a letter. For example, if subtask 1 includes a Pick>Hold>Hold>Place, the actions on the Task Map will be labeled:

-- Pick 1A
-- Hold 1B
-- Hold 1C
-- Place 1D



Example of a subtask Place action with identifying labels

Each arm functions independently by default and is able to learn its own unique sub-tasks. You can also train Baxter to coordinate sub-tasks in the same location.

Each action has a location associated with it. You can customize actions by:

- Adding count – Baxter picks or places a fixed number of objects. (For Hold actions, you can change time instead of count.)
- Adding signals – Baxter sends or waits for a signal before or after performing the action.
- Changing paths - You can change the way Baxter's arm moves between two actions.
- Changing the approach and retract distance – Baxter begins and ends the actions from a specified distance.

- Changing the speed - As Baxter approaches or retracts from an action, you can specify when Baxter slows down.
- Changing the drop height – For vertical actions, Baxter drops the object into the Place location from a specified height.
- Add object weight – For Pick actions.
- Baxter can be instructed to Pick (or Place) an object when it arrives at a location, when it senses contact, or whichever comes first. (See “How to Make Detailed Modifications to an Action (Advanced Settings Screen)” on page 71.)

If you train multiple sub-tasks per arm, you can order them in the sequence you want Baxter to perform them.

The Difference Between Vertical and Non-vertical Tasks

The only difference between vertical and non-vertical tasks (as of Intera software 3) is that vision search is available only for vertical Picks. The camera does not operate for non-vertical tasks. There are no performance differences between the two types of tasks.

Non-vertical actions are identified by a "dot" symbol. These symbols show up on the Task Map when an action is highlighted or on the action's modify panel.

Examples of non-vertical (left) and vertical (right) place action icons

The Task Map

The *task map* is a graphical representation of the Baxter workspace. When you train Baxter to perform a task, the map displays icons that represent each of the actions included in the task. The icons are color-coded to match the arm on which the action was trained; blue (on the left of the screen) is the robot’s right arm, green (on the right of the screen) is the left.

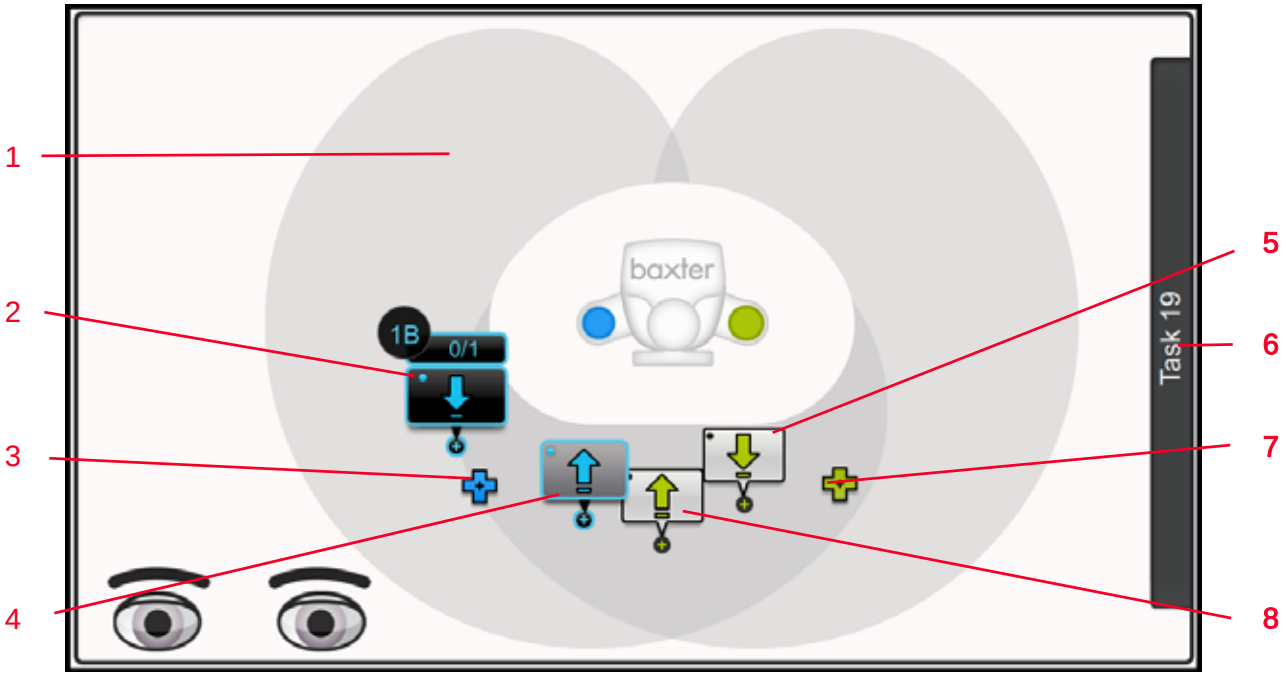
There are several ways to access the Task Map, including:

- Creating a new task
- Modifying an existing task
- Selecting a task from the Task Gallery

The gray, overlapping shapes—called the *workspace*—represent the maximum mechanical reach of each of the Baxter arms if the arms are fully extended and parallel to the shoulder joint. Baxter can execute actions within this area.

The overlapping darker area towards the center of the workspace indicates the area shared between both arms, enabling the arms to operate within the same workspace.

> ***Note:*** The robot's arms move within a sphere defined by the center point of the shoulder axis and the full reach of the arm. The actual reach of the arm at any given location is affected by the height of the robot's arm and angles of the joints. Actions are therefore limited at different heights and joint angles. The approach and retract distances for an Action may also limit where the Action can be performed.
>
> Tip: Baxter performs tasks more efficiently when the objects are located close to the center of the workspace.Tasks trained at the extremes of the workspace approach joint limits and are sometimes more difficult to execute consistently.



THE TASK MAP LABELS

1. Baxter workspace
2. Right arm Place action
3. Right hand location
4. Right arm Pick action
5. Left arm Place action
6. Task name
7. Left hand location
8. Left arm Pick action

From the Task Map, pressing the Rethink button opens the task map button bar.

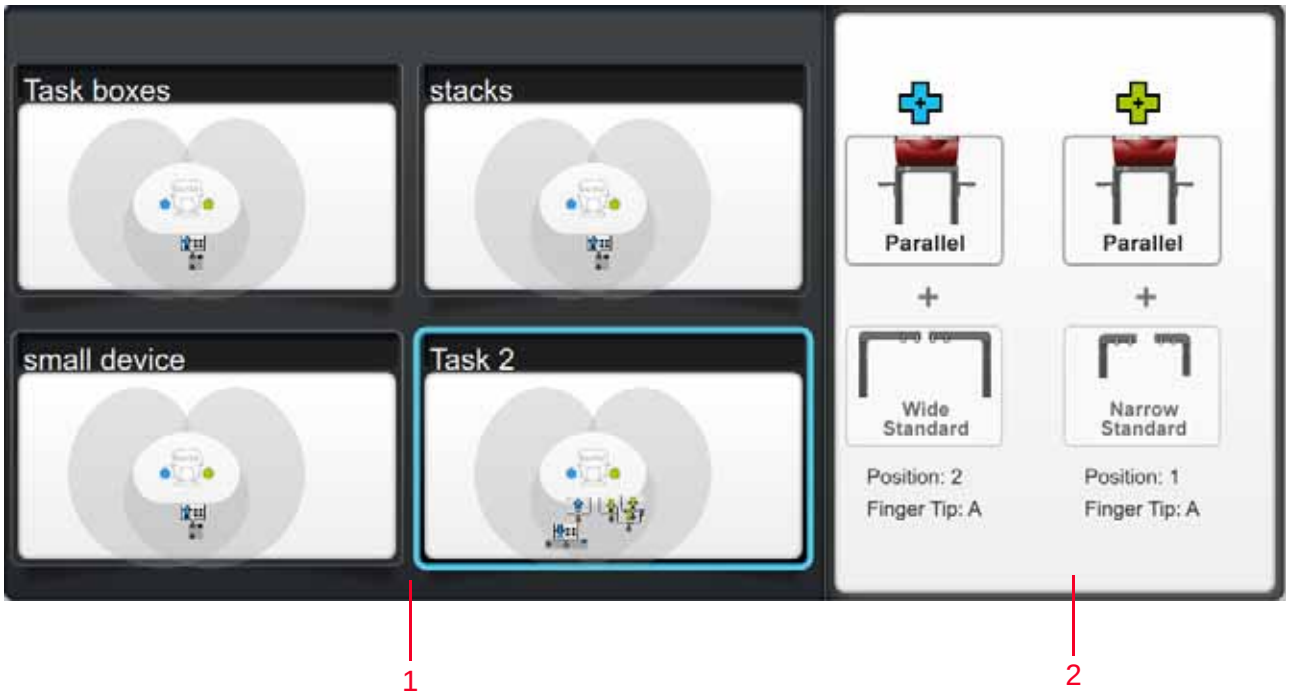
- Back – Close the button bar and return focus to the task map. This can also be done using the Back button on the navigator.
- Run – Begin or continue the current task.
- Order – Open the task order screen.
- Rename – Modify the name of the task. On **New**, Baxter gives tasks a default name with a numeric suffix.

  Tip: Entering a unique, descriptive name will help you to more easily identify the task in the task gallery.
- I/O – Open the signals gallery.
- Landmark – Open the landmark gallery. (See “Robot Positioning System” on page 109.)

  Note: Baxter automatically saves tasks as they are created or modified; you do not need to actively save while you train.

Task Gallery

The Task Gallery is accessible from the main screen, when you select the **Tasks** button from the button bar. Use the task gallery to view the details of and select, copy, delete a trained task. You can also delete all the tasks on the robot from here.



1. Displays a visual list of all saved tasks, each with the name of the task and a small preview image of the task map.

   Note: If a task name exceeds 21 characters, only the first thirteen and last thirteen characters of the name, separated by ellipses, will appear. On the Task Map, the task name will trail off on either side.

2. Displays details about the selected task.

   - Gripper specifics

     - This symbol indicates a mismatch between the installed gripper and the one used in the viewed task.

   Note: The task gallery cannot be empty. If you delete all tasks, an empty task is created automatically.

To navigate to a task: Rotate the **knob** to scroll through the tasks.

To select and open a task: Scroll to the task until it is highlighted, and press **OK**. A larger preview of the task map opens in the left panel, and the task gallery button bar opens at the bottom of the screen.

From the task gallery, press the **OK** button to open the task gallery button bar.

- Back – Close the button bar and return focus to the task gallery. This can also be done with the **Back** button on the navigator.
- Open – Open the task map for the highlighted task.
- Rename – Modify the name of the task. On **New**, Baxter gives tasks a default numeric name.

  Tip: Rename a task with a descriptive name when you first create it so that you can easily identify it later in the task gallery.
- Delete – Delete the task.

  Note: Baxter must always have at least one task stored. If only one task exists, and it is deleted, Baxter will create a new "empty" task.

  IMPORTANT Once the deletion is confirmed, the deleted task cannot be restored.
- Copy – Create a new task based on the current one.
- New – Create a new, empty task and open the task map.

To delete all the tasks on the robot, press the **Rethink** button from the task gallery. Baxter displays buttons that allow you to create a new task or delete all the tasks on the robot. You will be asked to confirm deleting all the tasks.

Training a Pick and Place

Baxter can pick up objects blind or by using its cameras.

- Blind – Baxter picks an object from a fixed location.
- Visual – Baxter learns the shape of an object, and uses vision to identify it and pick it up. Objects may or may not be in the same location. See “Training a Pick Using Vision” on page 36

  Note: Vision is only available for vertical Pick actions.

To train a basic Pick and Place task:

1. In the main button bar, click **New**.
2. Place the object you would like Baxter to grasp in the fixed location of the Pick.
3. Move the arm to the location, with the gripper’s fingers poised to grasp the object. (If using a vacuum gripper, place the suction cup on top of the object.)
4. Press the **Grasp** button on the training cuff. Baxter grasps the object.
5. Move the arm to the location where you want to place the object.
6. Press the **Grasp** button. Baxter releases the object.
7. Press **Back** to open the Main Button Bar, then select **Reset** or **Run** to perform the task.

   Tip: If Baxter’s wrist is not pointing straight down when performing an action, meaning the action is not vertical, a red circle is displayed next to the blue (for Baxter’s right arm) or green (for Baxter’s left arm) pointer. Non-vertical Picks cannot use vision. If the pointer is not blue or green but gray, Baxter cannot create an action in that location/pose.

You can change the number of times Baxter will attempt to Pick up an Object before stopping. For details, see “Change Number of Attempts to Pick an Object” on page 59.

Important Note:

Vision *only works for vertical Picks*. Picks are set to non-vertical by default, but you can take a Pick action that is already close to vertical and make it truly vertical using the Snap to Vertical check box:

1. Highlight the (nearly vertical) Pick on the Task Map and press **OK** on the Navigator.

Baxter displays the Pick's Modify panel.

2. Scroll to the icon  and press **OK**.
3. Select the Advanced Settings icon  on the Screen.

Baxter displays the Advanced Settings Screen.

4. Check the Snap to Vertical check box, the select **Done**.
5. Press the Back button on the Navigator to return to the Task Map and select the Pick.

It will now be a vertical Pick.

In some situations you will need Baxter to visually search for and recognize an object before picking it. Train a Pick using vision when:

- You want Baxter to locate an object that varies in location and/or orientation by more than 0.2 inches (0.5 cm) each time.
- You want Baxter to pick from a continuously moving conveyor. (Note: A conveyor that has been indexed would not require vision.)

- You want Baxter to automatically detect when materials are replenished. (You can also use signals for this purpose). If nothing changes in the search field, Baxter will eventually time out.
- Baxter needs to identify a particular object from other, different nearby objects.

Consider the following when training Baxter to look for an object:

- Baxter works best when its workspace is lit with bright, diffused lighting with minimal shadows.
- Shadows in the work area, including those created by the object, degrade Baxter's ability to see an object. So does glare, from the object or the work surface.
- In general, the higher the contrast between the object and the work surface, the better. Although when trying to see texture on a white or light-colored object, you may need to lower contrast/video gain.
- A clutter-free work surface works best.

To train a Pick using vision:

1. If there isn't already a Pick action, create one.
2. Highlight the Pick on the Task Map and press OK on the Navigator.

Baxter displays the Pick's modify panel.

3. Scroll to the Area Search icon 

and press OK.
4. Define a search area for the Pick. (For details on how to create a search area, see “Customizing the Size of a Visual Search Area” on page 64.)
5. Select the Train button on the object learning screen and press **OK**.

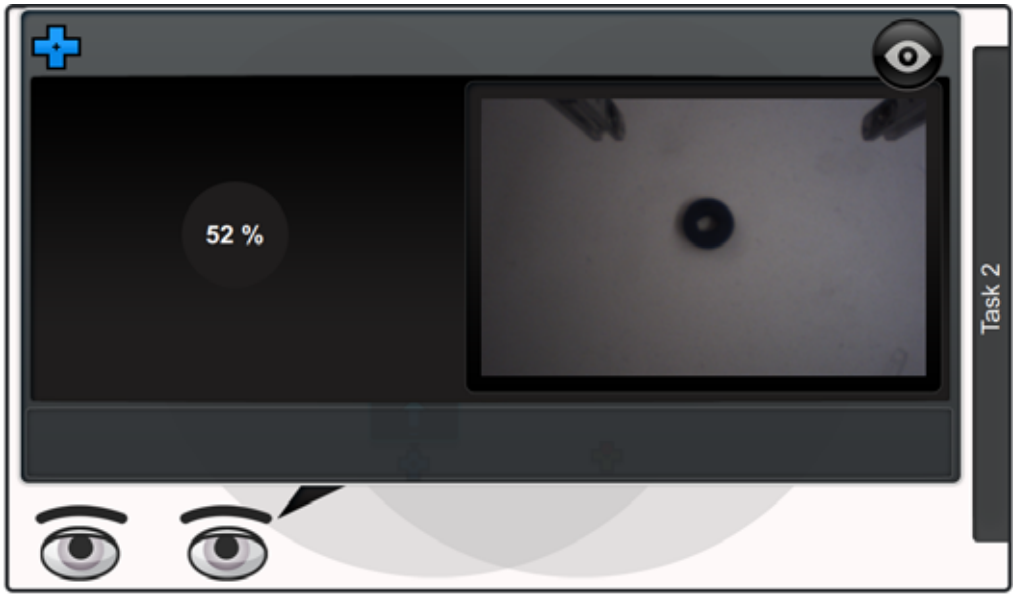
Baxter moves to the Pick location, briefly grabs the object to line it up with its camera, then takes a series of pictures of the object from several heights. A series of images of the object are displayed in order from closest to furthest view.

Generally, Baxter will be able to recognize the object if the yellow overlay completely outlines the object.

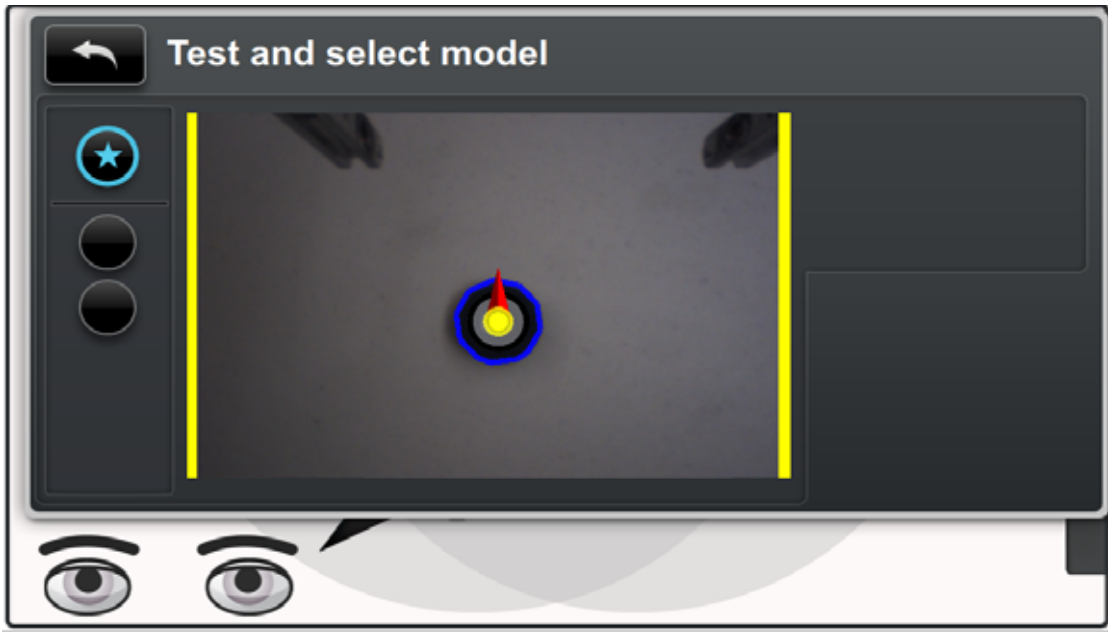
6. If Baxter cannot recognize the object, first try again, keeping in mind the troubleshooting tips (See “Troubleshooting tips:” on page 44) You can also adjust the camera settings (See “Camera Settings” on page 45.)
7. If that doesn’t work, retrain the grippers. (Go to **Settings -> Hardware --> Configure End Effectors** (image below). Retraining the grippers is a process in which Baxter learns what the grippers look like so they can be ignored while looking for objects. When retraining, ensure all blue or yellow pixels are removed from the screen except for the gripper fingers or vacuum cup.

8. From the vision screen, press **OK** to select the picture that best represents the shape of the object, then press the **Next** button.

Baxter takes more pictures of the object from various locations to gather more data and refine its perception of the object.

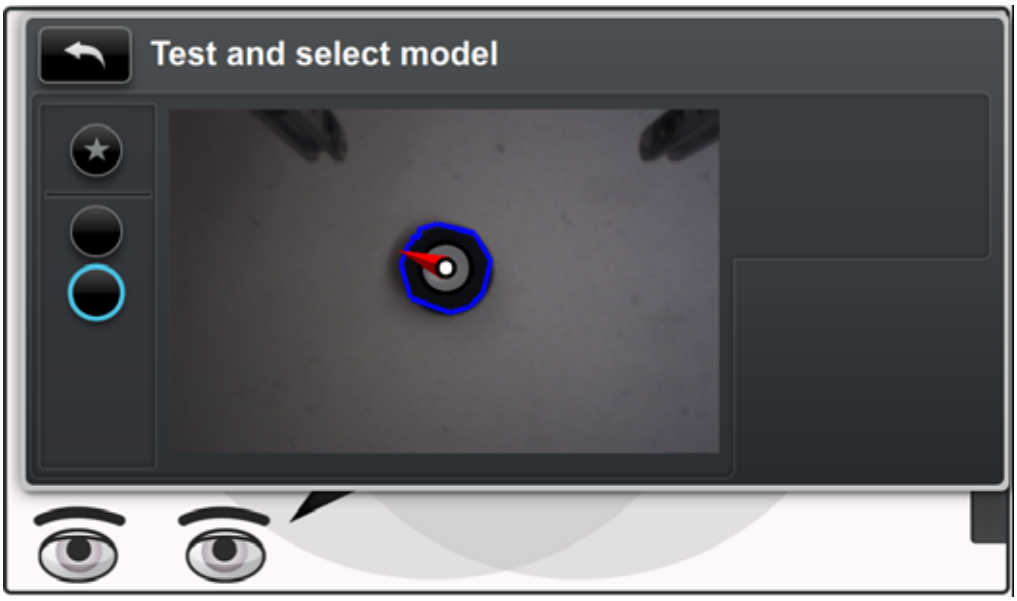


When done, Baxter displays a live view of the object on the Test and Select Model screen.



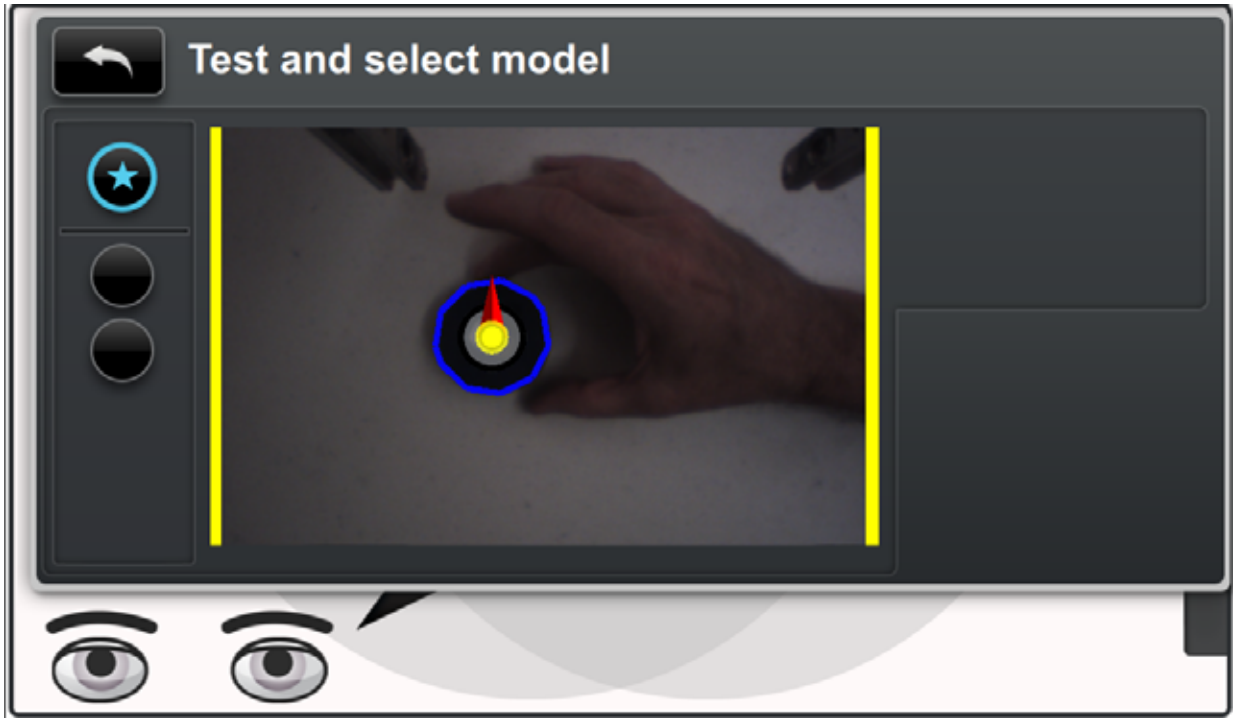
- The blue outline identifies Baxter's understanding of where the object is.
- The yellow circle represents Baxter's view of the center point of the axes of the object.
- The red arrow illustrates how Baxter perceives the orientation of the object for gripping.

When the arrow points straight up (in twelve o'clock position) and the circle is fully yellow as in the figure above, that is a valid alignment for gripping: Baxter can pick up the object.

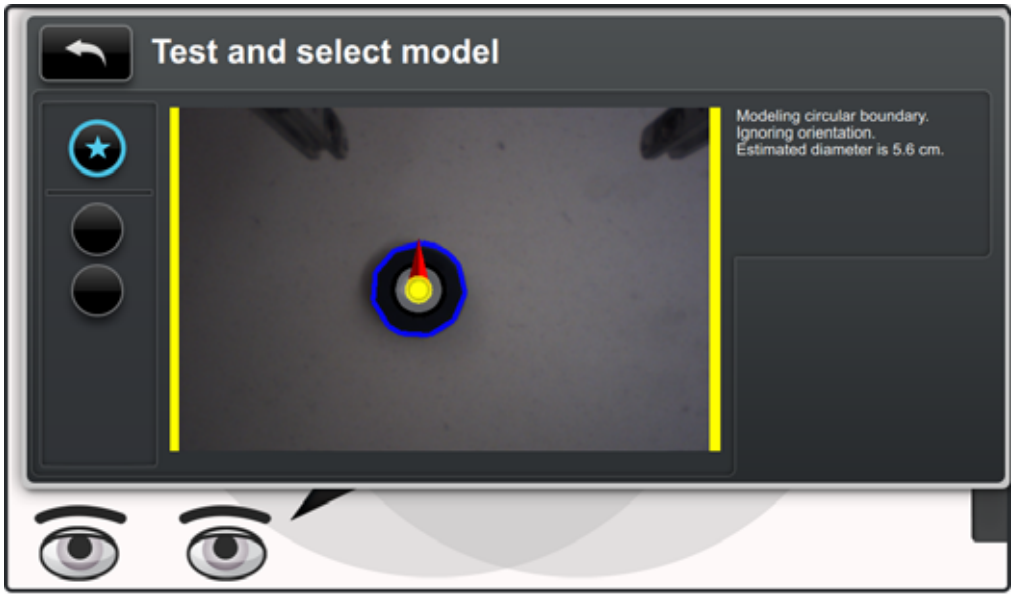


If the arrow is not straight up and/or the circle is not completely yellow, as in the above figure, Baxter may not be able to grip the object, or it will have to turn its wrist during the Pick in order to grip the object.

You may play with the placement and orientation of the object at this stage – in live view – to see how Baxter's ability to recognize the object is affected. A flickering outline and/or fading yellow circle and arrow indicate weaker detection. In that case, try another detector for improved reliability.



On the left side of the screen, Baxter flags the recommended model of the object with a star  symbol. Other possible models are also displayed. In general you will want to use Baxter's recommended model, but advanced users, or users looking for a particular type of model by which to recognize the object in question, may want to select from the list.



You can get further information about each of the models by pressing the Rethink button on the Navigator. That displays which “detector” Baxter used to identify the part along with other information, for example, the diameter of the part, what information (texture, contrast, background, boundary) it considered when building the model, etc.

9. Select the best model. The object is now trained.

TROUBLESHOOTING TIPS:

If Baxter did not locate the object, or if the object is not correctly covered by the overlay, try the following:

- Adjust the lighting in the work area to improve the contrast and remove shadows around the object.
- Change the contrast between the object and the work surface by placing the object on a piece of paper.
- Remove any clutter near the object.
- Change the camera settings. See “Camera Settings” on page 45.

Camera Settings

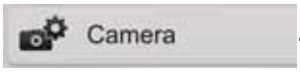
You can change the settings for Baxter's cameras to adjust for the amount and quality of light Baxter perceives in the work area. (Technical note: the adjustments apply primarily to the lighting variables of gain, white balance, and exposure.) You can make adjustments using a simple slider or you can let Baxter adjust its own camera lighting settings automatically by selecting the Auto checkbox. This capability is available per task, per arm.

Note: When you create a new task, the current camera settings are inherited based on the previous open task.

How to Change the Lighting Settings for Baxter's Cameras

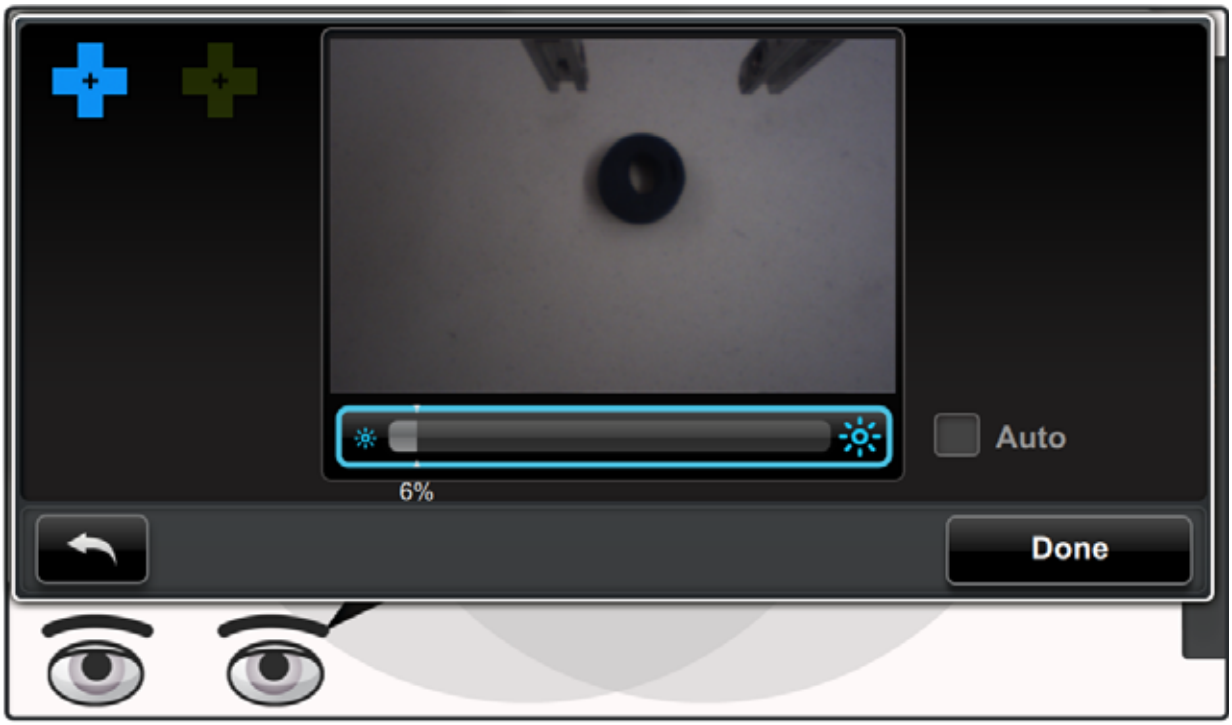
1. With a vertical pick highlighted on the Task Map, press the Rethink button on the Navigator, then select the Order button on the Task Map button bar.

2. On the Task Order screen, highlight a task bar for either arm and press OK to display the task bar buttons.

1. Select the More Options icon  .
2. Select the camera settings button 

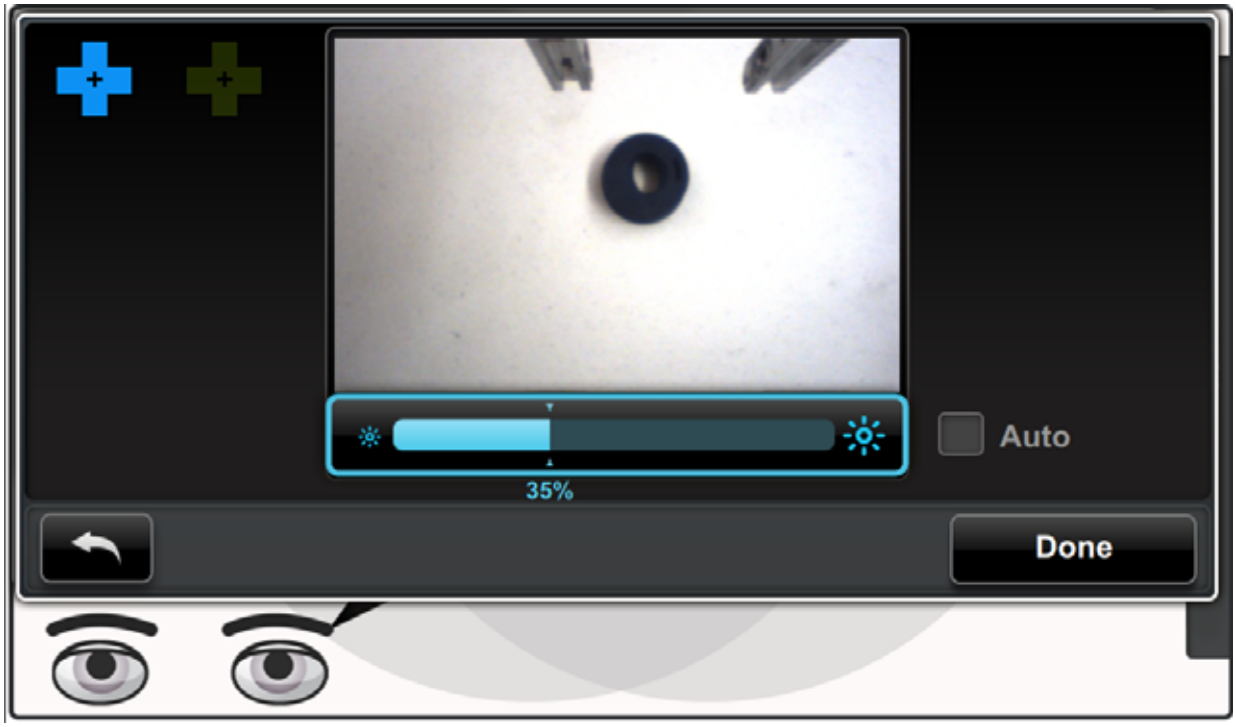
.

Baxter displays a live camera view.



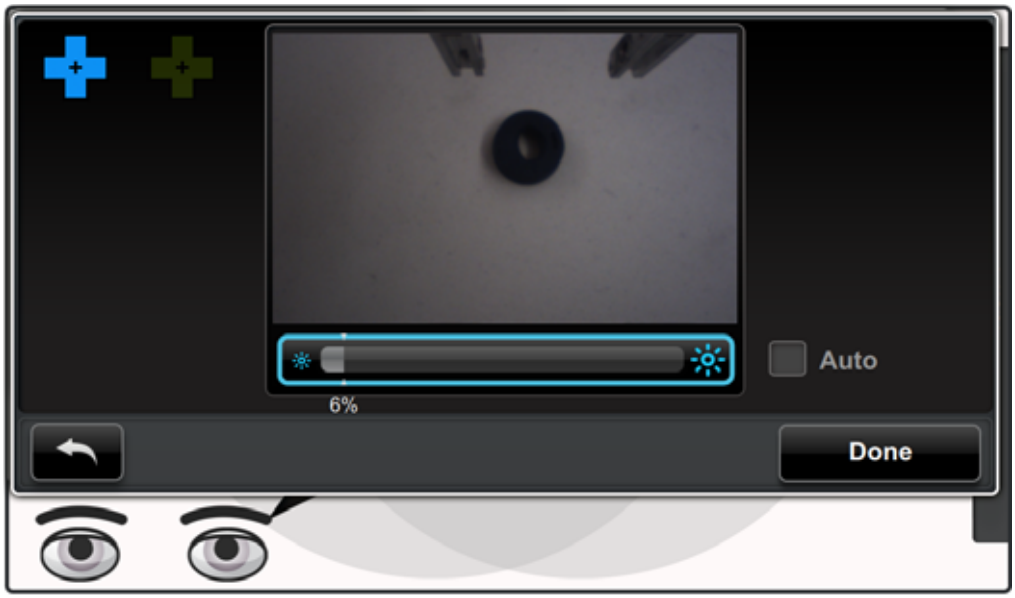
There is a slider underneath a live camera image of the active camera's arm. You can scroll among the slider, the "Auto" option, the Back button, and the Done button. (If "Auto" is active, the slider is not needed, therefore it's not highlighted.)

1. Press OK to activate the slider.
2. Scroll to move the slider left or right.



Scrolling left reduces the amount of light the camera allows in. Scrolling to the right lets in more light. (This is also known as decreasing or increasing the gain, respectively.)

If you have trained an object using vision, you can see in real time the effect your lighting adjustments have on the object and on Baxter's detector (the blue outline/yellow circle/red arrow indicators).



3. When you're satisfied with the appearance of the live image, press Done.

Note: You can also change the camera settings from the Object Training screen.

Training a Group of Pick or Place Actions

When you need Baxter to pick a group of objects from a number of individual locations, or place them in a number of individual locations (e.g., when moving items from or into a segregated box or tray), create an *action group*. Note that just as Baxter remembers the order of individual actions that you train it to perform, it will also remember the order of actions within an action group. Also, when you make changes to an action group, it affects all actions within the group.

To create an action group:

1. Highlight the action you want to use to start a group. Press **OK.**
2. Scroll to and click **Add** on the Modify window.
3. On the Task Map, you'll see an icon labeled "Add." Move the robot's hand to the second desired location, and press the action button. (You can also press **OK**, but the action button is usually more convenient.) The added action is placed in the location.
4. Repeat as many times as needed.
5. When finished, press the **Back** button. (Don't press OK to finish. That will continue to add locations to the action group.)

NOTE: If, when training Baxter, you need to put an object in the gripper and you don't want to copy or add a new action, *double-click* the grasp button.

Managing Tasks and Sub-tasks

Use the Task Order Screen to display and change the order of actions that make up a task. You can also use this screen to manage task settings and add counts or signals to a whole task or part of a task known as a *sub-task*.

Use the Task Order screen to view the current sub-task order, rearrange and combine sub-tasks, coordinate sub-tasks across arms, and merge orphan Pick and Place actions into sub-tasks. To open the Task Order screen, in the task map, press the Rethink button, and click **Order**.

1. Displays a visual list of all sub-tasks per arm (numbered in order of execution), and the corresponding Pick and Place actions (including action groups) within each sub-task.
2. Displays the task map for the selected task, and below it, any signals that correspond to the entire task or sub-task. (In this example, you can see a ready signal.)

To make changes to the task for that arm, select the corresponding bar, at the top. To make changes to any sub-task, select the task and press **OK**. The button bar for the task or sub-task appears.

Task Button Bar

- Back – Close the button bar and return focus to the task order screen.
- Count – Change count to a task for one or both arms.
- Signals – Add a signal to a sub-task, or remove one. (See “Signals” on page 127.)
- Motion Presets - Define how Baxter's arm follows a path's waypoints. These presets will help Baxter complete a wider variety of tasks. (See “Motion Presets” on page 89.)
- Clear Actions – Delete all the subtasks on one arm. This helps you quickly retrain a task by allowing you to reset the subtasks on one arm while not affecting any signals, task settings, etc. you have already set up. While actions are cleared, the following are retained: signals and landmarks set up for the task; task settings (e.g., end effector settings, camera settings, arm reset behavior, drops/ missed picks count); motion presets, task-level counts and signals.
- More Options – Access end effector settings (see “Changing Gripper Parameters” on page 56); camera settings (see “Camera Settings” on page 45); and adjust the number of times Baxter will attempt Picks (see “Change Number of Attempts to Pick an Object” on page 59).

Sub-task Button Bar

Top row, left to right:

- Back – Close the button bar and return focus to the task order screen.
- Count – Add count to a sub-task.
- Copy – Copy a sub-task and all its details to the same location on the Task Map. The copied sub-task will appear on the Task Map just below the original.
- Signals – Add a signal to a sub-task, or remove one. (See “Signals” on page 89.)

Second row, left to right:

- Rename - Create or change the name of the selected sub-task.
- Reorder – Reorder sub-tasks for the selected arm. You can also merge incomplete sub-tasks.
- Coordinate Order (Across Arms) – Shift when a sub-task begins on one arm in relation to a sub-task on the other arm. If the sub-task is already coordinated, this button becomes “uncoordinate.”
- Combine – Combine two sub-tasks on one arm into one sub-task. The highlighted sub-task moves into the sub-task below it.
- Delete – Delete the current sub-task on an arm.

To reorder or merge sub-tasks:

1. In the sub-task order button bar, click the reorder icon.
2. Scroll up or down. A yellow line appears to indicate the new location.
3. Press **OK** to move or merge the sub-task.

To name a sub-task:

1. From the Order screen, highlight the sub-task you want to name and press OK.
2. Select “Rename” from the Sub-task menu.
3. Use the text wheel to create a name for the selected sub-task.
4. Select **OK**.

You can also modify or delete sub-task names.

Coordinating Sub-tasks Across Arms

Coordinating arms allows Baxter to conduct a sub-task on one arm before conducting a sub-task on the other arm.

1. Pick the sub-task you want to move relative to the other arm. Press **OK**.
2. Click the coordinate icon in the sub-task order button bar. A yellow line appears in the list of sub-tasks on the other arm (In this example, the user wants to move the second sub-task on the left [green] arm.).

3. Scroll to the right or left to move the yellow line until it appears after the sub-task that the selected sub-task should follow.

4. Press **OK**.

   After the sub-tasks are coordinated, a gray line appears between them to indicate the order.

To uncoordinate sub-tasks across arms, highlight the sub-task used to coordinate arms and scroll to the coordinate option. It will now read "uncoordinate". Select it and that coordination will be removed.

Combining Sub-tasks

Combining sub-tasks within an arm lets the robot decide when to complete part of a task. For example, if three parts need to go onto a tray, but the order does not matter, you can combine each sub-task into one large sub-task, and Baxter will determine in which order to complete the sub-tasks. Baxter will combine two sub-tasks next to each other on the same arm.

1. Select the first sub-task of the two.
2. In the sub-task order button bar, click the combine icon. The selected sub-task merges with the one below it.

   Note: It is not possible to split combined sub-tasks.

Changing Gripper Parameters

Apply custom gripper settings to optimize Baxter gripper performance with a wide variety of objects.

Note: These settings apply to both Rethink Robotics grippers and custom grippers, and are applied for all actions on an arm for that task.

To change a setting:

1. Create a task.
2. Go to the Task Order screen.

3. Select the task bar at the top of the screen, and press **OK**.

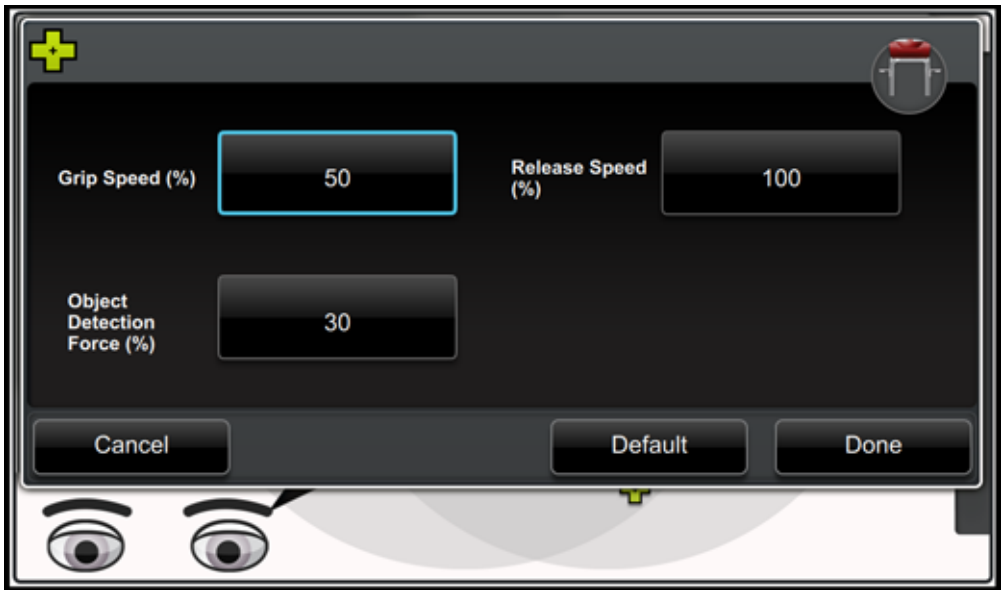
4. Click the **More Options**  icon.
5. Click the **End Effector Settings** icon.

6. Change the setting.

ELECTRIC PARALLEL GRIPPER SETTINGS:

- Grip Speed (%): Gripper closing speed as a percentage of maximum.
- Release Speed (%): Gripper opening speed as a percentage of maximum.
- Object Detection Force (%): Threshold for object detection—the amount of force required to detect when an object is grasped before the robot moves to the next action.

  Note: If the force is set too high, a soft object in the gripper may not be detected. Set high initially, and back it off if the gripper is crushing things.



VACUUM CUP GRIPPER SETTINGS:

- Blow off time (sec): Amount of time the vacuum gripper will blow air when releasing an object. (Note that this feature requires additional "plumbing.")
- Grip Detection Threshold (%): Threshold in which the vacuum sensor detects a successful pick. This setting is intended for custom vacuum cup grippers and/or 3rd party vacuum cups, and is dependent on the mechanical properties of the vacuum cup mechanism.

  Examples:

  - For a single piece of paper, which is likely porous, set a lower threshold. That tells Baxter the material is porous and the gripper sensor will trigger at a lower threshold.

- For a rigid non-porous object, less of a vacuum is required, so set a higher threshold. Setting a higher threshold ensures the object in the gripper does not trigger prematurely.
- When using a custom vacuum gripper, it is a best practice to start with a higher percentage, and reduce the value as needed.

- Grip Attempt Timeout (sec): Duration in which a vacuum end effector attempts to grip an object before stopping the attempt.

Change Number of Attempts to Pick an Object

Baxter attempts to pick up a specific object by default twice. (If it misses the first time, it will try again, and if misses a second time, Baxter will stop.) You can change this setting to be any number between 1 and 99.

This setting also applies to parts being knocked out of Baxter's hand, for example.

This setting is changed at the task level, not the action level.

To change this setting:

1. With the task highlighted on the Task Order screen, select the advanced settings icon.

2. Scroll to **Attempts** on the resulting menu and select it.

The default is 2 attempts.

3. Highlight the spin box.
4. Change the number of attempts to your preferred number. (A check box also gives you the option of stopping Baxter immediately if the object is dropped.)
5. Press the **Return** button on the Navigator to make the change for that task.

> ***Note:*** Although you can change this setting on either arm, the setting applies to both arms. You cannot assign different settings to each arm. Further, the setting applies to both drops and misses. They are counted separately, but the number to apply is specified once.

Modifying a Pick Action

You will want to modify a Pick action if:

- The surface (such as a conveyor belt) is moving.
- The location will vary more than 0.2 in (0.5 cm).
- The robot needs to identify a specific object.
- You want the task to include a count.
- You need to adjust the entry/exit height
- You want that part of the task to start based on a signal or send out a signal when finished.

Note: You can only modify a Pick with the arm on which it was originally trained.

1. Back – Close the modify screen and return to the task map.
2. Arm and action – Indicates the arm being modified (blue for right, green for left) and the action, in this example, a Pick.

3. Copy – Copy the current action (and all its modified details). Creates an action group.
4. Add - Similar to Copy, but this icon enables you to add additional locations to the original, making an action group. (See “Training a Group of Pick or Place Actions” on page 49.) To add to an existing action group, choose any single action in the group, then select Add.
5. Move – Move the location where the action takes place. (Note that this will delete the path to the Action, so you may want to use and Modify to preserve the path.)
6. Paths - Select from the Task Map a path you want to modify.
7. Delete – Delete the action. You’ll be prompted to confirm the deletion:

Note: Once deleted, an action cannot be restored.

8. Visual pick training – Preview only. If a Pick on the arm includes a trained object, a small preview image of the object is displayed. Teach Baxter to recognize an object (see “Training a Pick Using Vision” on page 36).
9. Add Features – Adjust more details:
    - Add Count – Specify the number of times an action should be completed.
    - Add Signal – Specify which defined signal(s) you want to attach.
    - Add Weight - Specify a weight for the object Baxter will hold for a task.
    - Add Landmark - Create a landmark used by the Robot Positioning System. (See “Robot Positioning System” on page 109.)
10. Area Search - Define the area to search for the Pick.
11. Work surface type (vision only) – Toggle between a moving surface (conveyor) and a static one (table).
12. – Practice or modify the approach, retract, or action poses. You can also change the distance Baxter’s arm travels as it approaches or retracts, and determine how

slowly the arm should move when approaching or retracting. See “How to Modify/Practice an Action” on page 68.

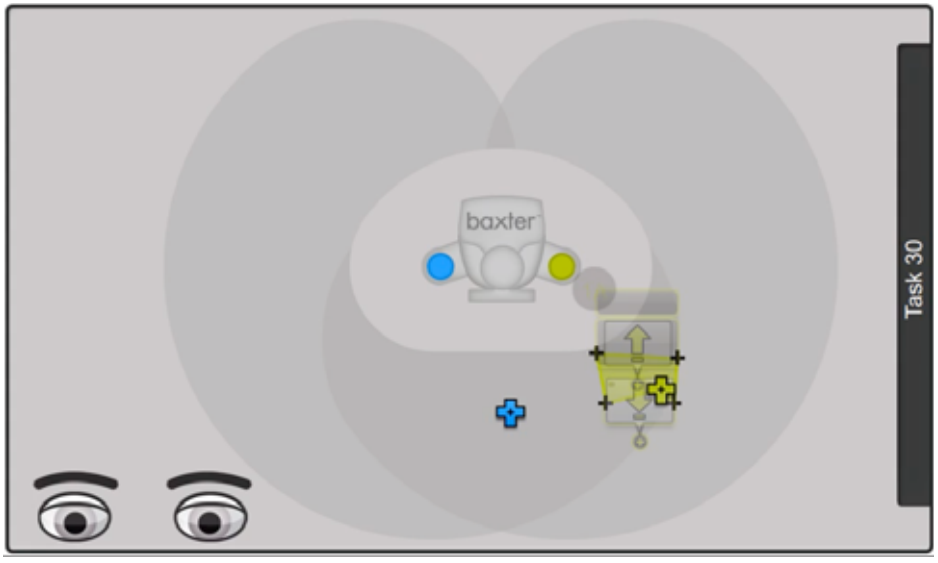
Customizing the Size of a Visual Search Area

By default, when vision is turned on, Baxter looks for objects within a small, limited area. To resize the area (such as to expand it to the width of a conveyor or to the size of a box), you can train a visual search area.

1. With the Pick action already created, go to the task map.
2. Highlight the Pick and press OK.
3. From the Modify panel for the Pick, Choose Area Search, and press **OK**.
4. Place the arm at one of the "corners" of the search area and press the Action Button on the cuff. The first point of the search area appears.
5. Trace the outline of the search area by moving the arm, pressing the Action Button at each corner of the search area. Add as many points as necessary to complete the desired search area.

   Note: A visual search area must be defined by placing a minimum of three points. Also, make sure that the search area surrounds/circumscribes the Pick keypoint.

   Note: If you draw around more than one pick for that arm (e.g., an action group), Baxter will create a new search area with just one keypoint, removing all existing pick actions.



6. To complete your definition of the search area, return to the *first point you taught* and double-click the action button. The revised search area is now attached to the Pick.

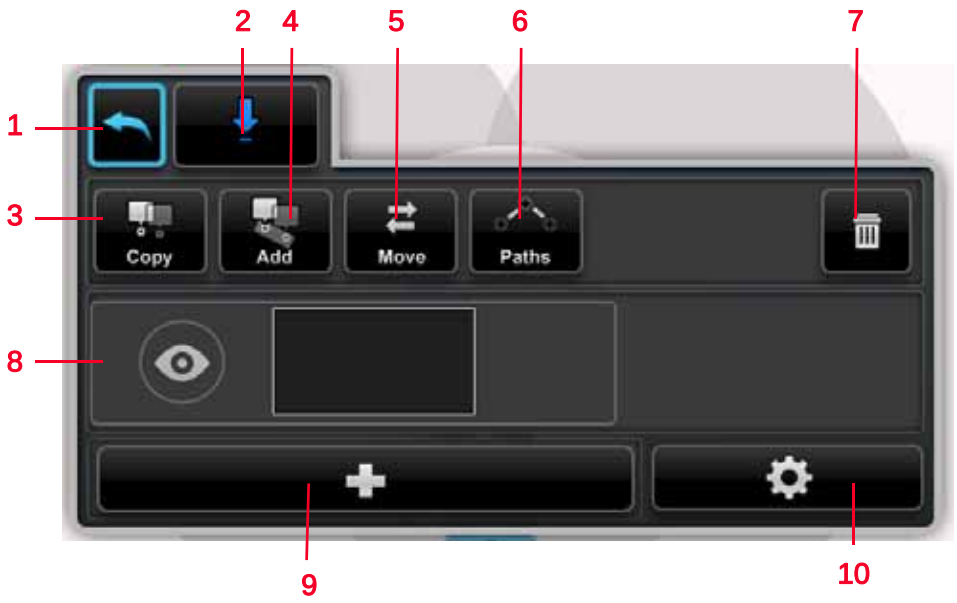
   Note: If you fail to return to the original point you taught, the area will be drawn as a triangle, which is probably not what you want.

The smaller the search area you define, the faster Baxter is likely to perform the task.

Modifying a Place Action

You will want to modify a Place:

- To change a Place location.
- To place a specific number of objects (count).
- To adjust the drop height.
- To switch from a drop to a place, or to change the drop height.



1. Back – Close the modify screen and return to the task map.
2. Arm and action – Indicates the arm being modified (color-coded blue or green) and the action. In this example, it's a place being performed by the right arm.
3. Copy – Copy the current action (and all its modified details).

4. Add - Similar to Copy, but this icon enables you to add additional locations to the original, making an action group. To add to an existing action group, choose any single action in the group, then select Add.
5. Move – Move the current action to another location. (Note that this will delete the path to the Action, so you may want to use and Modify to preserve the path.)
6. Paths - Select a path from the Task Map to modify.
7. Delete – Delete the action, and remove it from the task map. You'll be prompted to confirm the deletion:

Note: Once deleted, an action cannot be restored.

8. Visual pick training – Not applicable for a Place action, hence grayed out.
9. Add Features – Display a sub-menu where details of the Place can be adjusted, specifically:
    - Add Count – Specify the number of times an action should be completed.
    - Add Signal – Specify which defined signal(s) you want to attach.
    - Add Landmark - Create a landmark used by the Robot Positioning System. (See "Robot Positioning System" on page 109.)
10. – Practice or modify the approach, retract, or action poses. You can also change the distance Baxter's arm travels as it approaches or retracts, and determine how slowly the arm should move when approaching or retracting. See "How to Modify/Practice an Action" on page 68.

To move a Place location:

1. On the modify screen, click **Move**. The task map opens with a temporary “ghost” copy of the location displayed with the move icon over it.
2. Move the arm to drag the ghost to the desired new location.

   Tip: Remember to maintain arm pose alignment.
3. Press the action button or **OK** on the Navigator.

To copy a Place location:

1. On the Modify screen, click **Copy.** The task map opens with a “temporary ghost” copy of the location displayed with the copy icon over it.
2. Reposition the arm to drag the copy to the desired location.

   Tip: Remember to maintain correct arm pose alignment.
3. Press **OK** on the cuff to make the copy.
4. Repeat Steps 3 and 4 as many times as needed.
5. When you reach the final Place location, press **OK** twice. (Alternatively, press **Back** .)

Modifying Count

Actions/action groups and tasks have the following counts by default:

- Pick action – unlimited count
- Place action – count of 1
- Action group (for both Pick and Place) – count of 1 for each location within the group.
- Task – unlimited count (it resets automatically)
- Sub-task – no count (acts like 1)

You can modify any of these counts, as well as add count to a sub-task.

To modify count to an action:

1. In the Modify screen, click the Add Features icon.
2. Click **123**.
3. Select the highlighted box, **Max Count**.
    - If the count is currently unlimited, click the box to un-check it.
    - To make the current count unlimited, click the box.
4. On the count wheel, scroll to the first number, and press **OK.** Repeat for each number, up to a maximum of 9999.
5. When all numbers are entered, on the screen, press **OK**.
6. Click **Done** in the count screen. The new count shows up in the Modify window next to the Add Features button, as well as for the action on the task map.

How to Modify/Practice an Action

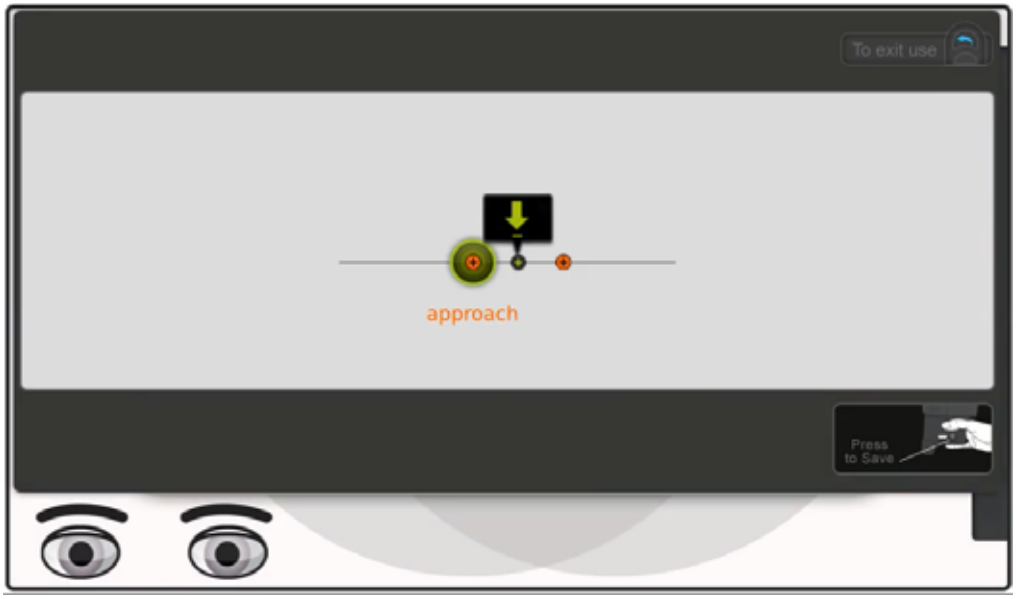
After you have trained an action, you can modify its settings in the Panel.

1. Select the action on the Task Map.

2. Scroll to the icon  and press **OK**.

Baxter displays the modify screen.

3. Scroll to the Modify button and press it. Baxter displays the modify action screen.



4. Scroll to the approach, action (in this example it's a Place), or retract point. Baxter's arm and hand move to the point as you scroll to it.
5. Grab Baxter's cuff, adjust the pose and/or location, and press the action button on the cuff. A check mark is briefly displayed on the screen to register the new pose/location.

   Note: Instead of manually adjusting the pose, you can also choose to more precisely nudge the pose after selecting the approach, action, or retract point. See "Nudge" on page 99 for details.
6. Press the back button when done.

You can have Baxter practice the new action by pressing the Practice button.

How to Make Detailed Modifications to an Action (Advanced Settings Screen)

1. From the modify screen (such as in the figure above), press the Advanced button  .

Baxter displays the Advanced Settings Screen.

2. Make the desired adjustments to the action, described below, and press **Done** when complete.

Approach Distance – The distance Baxter's arm will travel when it approaches its action, for example, a Pick. (More technically, this is the point along a vector perpendicular to the position on the cuff joint from the action's location that will move into position before moving along the vector to the action.)

Retract Distance – The distance Baxter's arm will travel when it retracts from an action, for example, a Place. (More technically, this is the point along a vector perpendicular to the position on the cuff joint from the action's location that will move into position before moving along the vector to the action.)

> **Tip:** To align an Approach, Action and Retract, change the Approach and Retract values to 0 and click Done. This aligns the three poses. Now go back to the Advanced Settings and adjust your Approach and Retract to your desired values.
>
> There may be times when you want the Approach and Retract to move in different directions. For example, when picking up an object horizontally from a shelf, the Approach might be parallel to the table while the Retract is perpendicular to the table. In cases such as this, use modify to adjust the magnitude and direction of Approach and Retract after setting them to 0.

Go Slow Approach – You can define here a point between the Approach pose and the Action pose where the arm slows down so the Action will be more precise. This is also the point at which the end effector lines up with the Action. Therefore if "Go Slow" is turned on for the whole Approach, the orientation of the end effector doesn't matter; it aligns with the Action at the very beginning of the Approach (or with the Retract, in the case of "Go Slow Retract.") On the other hand, if "Go Slow" is turned off for the whole Approach, the end effector will gradually change its orientation until it gets to the Action.

For contact actions (described below), if Baxter feels contact, the arm will attempt the action. in the direction of travel.

Go Slow Retract – You can define here a point between the Action pose and Retract pose where the arm finishes going slow because it is safely away from performing the Action. This is also the point at which the end effector lines up with the Action. Therefore if "Go Slow" is turned on for the whole Retract, the orientation of the end effector doesn't matter; it aligns with the Action at the very beginning of the Retract. On the other hand, if "Go Slow" is turned off for the whole Retract, the end effector will gradually change its orientation as it retracts.

Snap to Vertical – Check this box if you want Actions, Approaches, and Retracts that are performed within 5 degrees of vertical to become truly vertical. (Note that the robot's Approach, Action, and Retract poses must be aligned and within 5 degrees of vertical for this function to be enabled.) If you want to preserve a slightly off-vertical action, make sure this box is unchecked. You can toggle the checkbox, as long as your pose (Action, Approach or Retract) is within 10 degrees of vertical.

> ***Note:*** If you're training a vision-guided Pick, Snap to Vertical must be enabled before you use the vision system.
>
> ***Note:*** See the tip above, under Retract Distance, to learn how to use the Advanced Settings Screen to align the Approach, Action and Retract poses.

Action Control Settings – Select here to control when Baxter will perform an action. The options are:

- At Location – The robot will grip or release a part when it arrives at the trained position -- not when it feels force from an object or achieves a vacuum seal.
- First – The robot will grip or release a part when it either feels contact (if it's using an Electric Parallel Gripper), when it senses a vacuum seal has been achieved (Vacuum Cup Gripper), or when it arrives at the trained position, whichever happens first.
  - The robot will only travel 2cm beyond the end point if it doesn't sense contact or reach the trained position. This is intentional and is meant to ensure the robot doesn't inadvertently collide with other parts of the workspace.
- Contact (Electric Parallel Gripper only) – The robot will grip or release the part when it feels force from the part or work surface.
  - The robot will continue on its approach vector until it comes in contact with a part and then grasp. This setting is helpful when creating stacks.
- Sensed (Vacuum Gripper, Pick Action only) – The robot will grip the part when it senses a vacuum seal.
  - The robot will continue on its approach vector until it senses a vacuum seal on the part, and then grasp. This setting is helpful when creating stacks.
- Mixed – When modifying an Action Group, if the Action Group's individual locations have a mix of other settings -- for example the first place is Contact and the second place is At Location -- you will see Mixed as the setting.

  Note: You can change Mixed to another setting, but you cannot change another setting to Mixed. In other words, if you change Mixed to another setting, for example At Location, all of the actions in that group will Pick At Location, but you cannot change from another setting to Mixed since you cannot specify which settings will be assigned to which actions in the group.

Default Action Control Settings - Pick:

- Electric Parallel Gripper - At Location
- Vacuum Gripper - First

Default Action Control Settings - Place:

- Electric Parallel Gripper - At Location
- Vacuum Gripper - At Location

Drop Height – Define here the height above zero at which Baxter will perform a Place. For vertical Place actions only. (The zero point on Baxter is where the gray lower front panel meets the black metal that connects to Baxter's pedestal.)

Motion Presets - Motion presets define how Baxter's arm follows a path's waypoints. "Inherited" means the preset is inherited from the task level. See "Motion Presets" on page 89.

Note: When you see a "light bulb" symbol  on the Advanced screen, that means there is a tip (or tips) on how to use that functionality. Select the light bulb to display the tip.

Running Tasks

To run a task:

- Click **Run** in the main button bar.
- Press the Rethink button on the navigator. Click **Run**.
- Press the **Reset** button in the main button bar. Reset will reset all counts everywhere.

Note: If the robot has an object in hand, it will first look to place that object.

Note: When setting a signal, always reset the task before running it.

To stop a task: Touch any navigator or training cuff.

Create a Path for Baxter

Paths, Waypoints, Poses

There are times when you may want to define the path Baxter's arm takes when it moves from one action to another. This is useful for basic machine tending, for example, or to ensure the arm avoids hitting items in the immediate work area. To accomplish this, you create a path for Baxter. A *path* is a series of *waypoints* or *poses* of Baxter's arm.

This illustration shows waypoints along a defined path. In the middle a transit waypoint is highlighted.

Waypoints are poses you create along the arm's path where Baxter's arm changes in some way from its previous or next location. Changes in position and/or orientation of the arm are opportunities to create waypoints.

A **pose** is a position and orientation of Baxter's arm (shoulder, elbow, hand, wrist, etc.) at a waypoint.

There are also two kinds of paths: *default* and *custom*.

A **default** path is one in which you allow Baxter to create waypoints along the path automatically. You move the arm from one action to another and Baxter records the waypoints and poses. This is also called a system-generated path.

You create a **custom** path when you define the specific waypoints and associated poses along Baxter's path.

To reduce clutter, only custom paths are displayed on the Task Map, unless you are in Path Mode (accessed when you select the Paths button on an action's modify panel).

How to Create a Custom Path for Baxter

To illustrate this feature, we will create a Pick and a Place with a user-defined, or *custom* path.

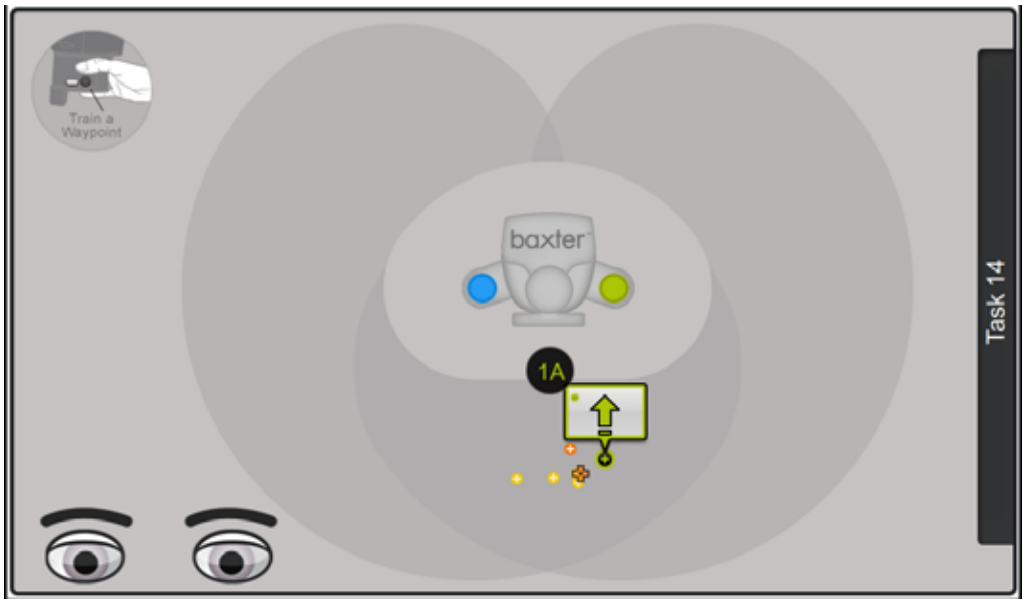
1. Create a Pick for an object.
2. With the object in hand, press the Action Button (the round button on the cuff).

Baxter displays the action bar.

3. Scroll to the Path icon to highlight it, then press **OK** on the Navigator.
4. Elevate the arm above the location of the Pick, pose the arm and hand as desired, and press the Action Button to train the first waypoint/retract point. Because you're creating a custom path, this first waypoint will become the Pick's *Retract point*. A Retract point is the location and pose to which Baxter will return after an Action. (This is also the location where the "Go Slow" command ends and normal speed resumes. See "How to Make Detailed Modifications to an Action (Advanced)" on page 60.)

A “path mode” crosshair indicates on the Task Map the location of the Retract point.

5. Move Baxter’s arm to the next waypoint, keeping in mind the position of the arm and hand as you move it along the path. Press the action button to establish another waypoint.
6. Continue creating the desired path by moving Baxter’s arm and hand and pressing the action button on the cuff to create a series of waypoints.



The last waypoint you create before the Place action (in this example) will be automatically set as the Approach point. The Approach point is the location and pose of the hand in anticipation of an action--in this example, the point at which Baxter’s arm will begin moving toward the Place location.

On the Task Map, Approach and Retract points are orange.

Transit points are points along the path not associated with an action. They are locations that guide Baxter’s arm along a path. Transit points on the Task Map are displayed in yellow.

The waypoint closest to the Pick or Place automatically becomes the Approach or Retract point. Keep in mind that Baxter moves in curved Joint Coordinates along transit waypoints, but in straight Cartesian Coordinates between the Pick or Place and the Approach and Retract points. This is important when Baxter needs to move along a straight line in the direction of the gripper, such as when placing an object into a box or assembling two components. However, while the transit way-

point poses are approximated as Baxter moves along the path, Pick, Place, and Hold poses are precise.

7. Create the Place by pressing the Grasp button.
8. You can now select Run from the Task Map button bar to run the Pick and Place task.

USAGE NOTES FOR CREATING A PATH:

- When you create a path, Baxter remembers the orientation and angle of each joint in its arm and the coordinates of its wrist for all the waypoints except for the Approach and Retract points.
- If, when training Baxter, you need to put an object in the gripper and you don't want to create a new action, *double-click* the grasp button. Baxter will grab the object without creating a new action.
- If you press the Back button while creating a path, all waypoints in that path are deleted.
- When you run a task, notice that the arm rewinds along the path you created when it returns to the Pick location.
- You can add a custom (user-defined) path between poses by modifying and retraining a path. That path will show up on the Task Map. To do this, modify a pose, select the Paths icon in the Modify Path panel, then select the action where the path leads.

Best Practices: Creating Waypoints

- It is not necessary -- or even desirable -- to define a large number of waypoints when training a path. The more transit points you add, the longer the path and therefore, the more time the task will take to run.
- If you train a number of waypoints relatively close together along a path, Baxter's arm movement will become jerky.
- Train just those points needed to avoid obstacles that may be in Baxter's path.

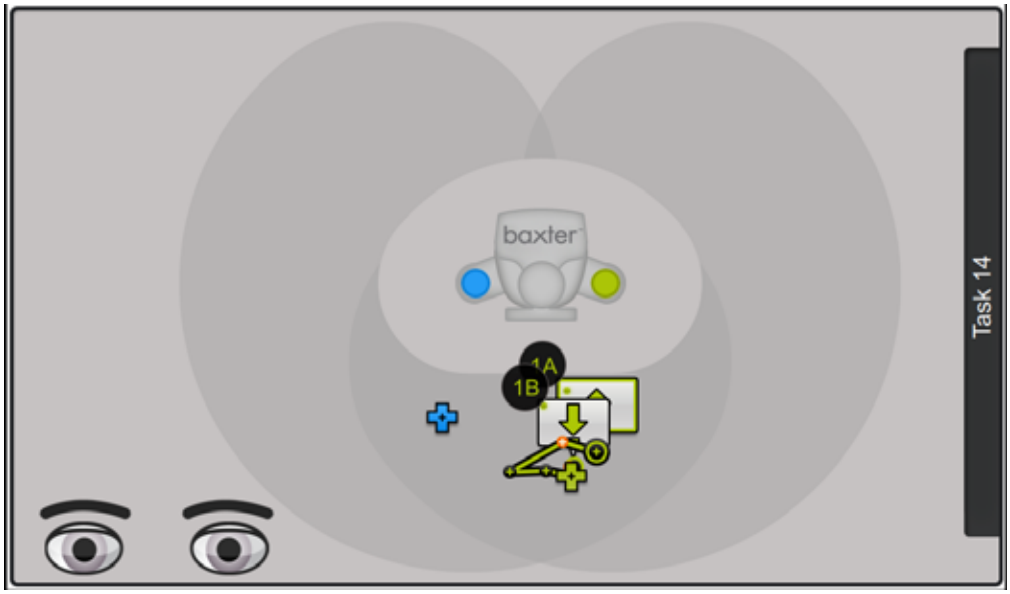
How to Practice a Path

1. Select an action on the Task Map and press OK on the Navigator.

Baxter displays the Modify Panel for the action.

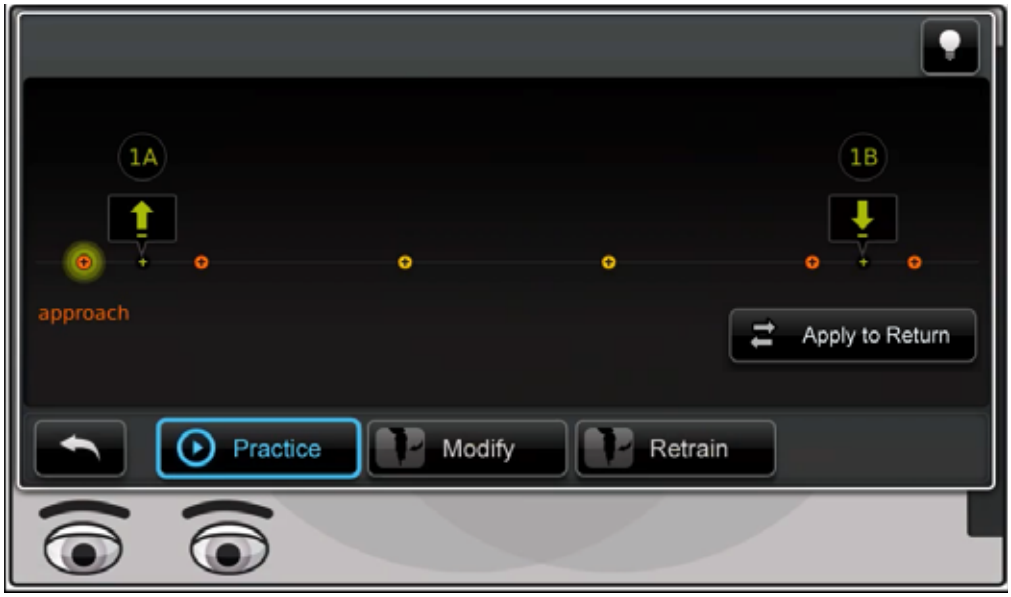
2. Select the Path icon in the Modify widow and press OK on the Navigator.

Baxter displays the Task Map with the action and its path.



3. On the task map, select the path your want to practice.

Baxter displays the Panel for the selected path.



In the illustration, the orange waypoints represent retract and approach points. Yellow points are transit points, the points between the Pick and the Place. The approach pose for the Pick is high-lighted.

4. Press the Practice button.
5. Select to practice the path at either slow or full speed. (Slow speed is equal to approximately one-half full speed.)

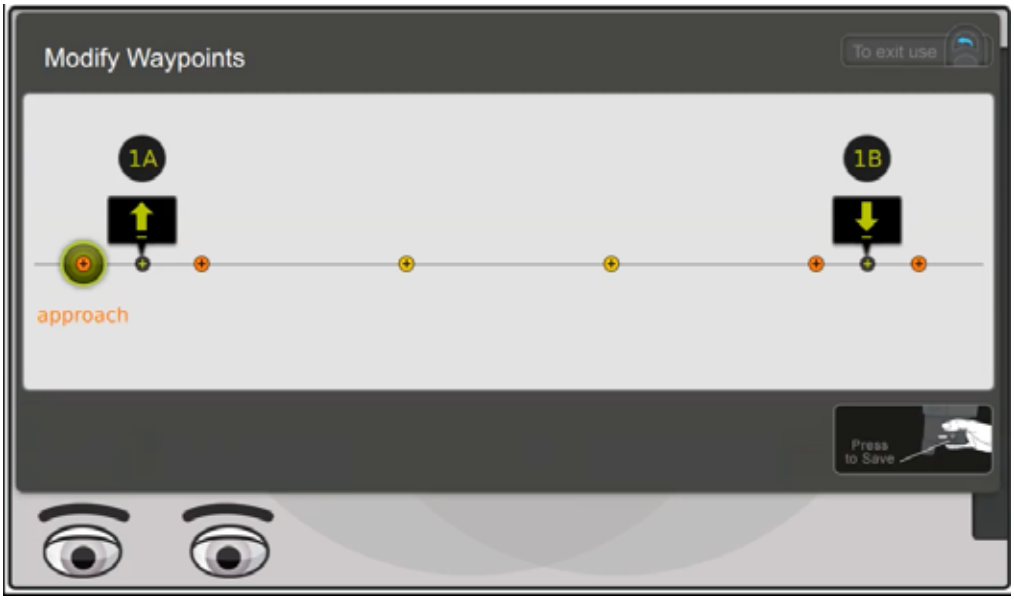
Baxter practices the path.

Note: You can grab the cuff while Baxter is in practice mode to stop the arm from moving. That does not alter the waypoints in the path or any of the poses associated with the path.

How to Modify a Waypoint

> ***Note:*** See “Nudge” on page 99 for details on making precise changes to Baxter’s arm and gripper location and orientation.

1. Select the path you want to modify on the Task Map and press OK on the Navigator.
2. Baxter displays the Modify Transit Panel for that path.
3. Press the Modify button.
4. Scroll the Navigator knob to the waypoint you want to modify. Each waypoint is highlighted with a halo as you scroll to it. Baxter's arm will move through each waypoint until it reaches the selected waypoint.



5. Grab Baxter's cuff, change its arm location and/or pose and press the action button. A check mark is briefly displayed and the pose for that waypoint is updated.

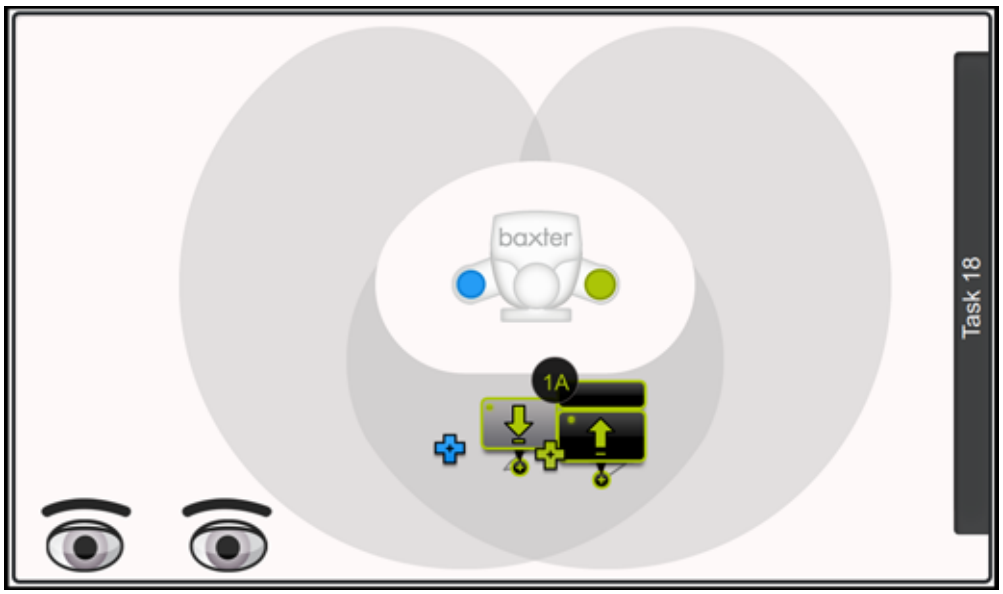
WAYPOINT/PATH NOTES:

- You can scroll through to any waypoint on the path. For example, you can scroll through the path one waypoint at a time—Baxter's arm will move to each point in turn—or you can scroll directly to the waypoint you want to modify and Baxter's arm will skip directly to that point. Be careful when skipping waypoints using the Modify Transit Panel, though, because it causes Baxter's arm to deviate from the path: the arm moves directly between points and it may bump into a fixture or obstacle.

- You cannot nudge (See “Nudge” on page 99) a transit waypoint.
- When you see a "light bulb" symbol on a Modify Waypoint screen, that means there is a tip (or tips) on how to use that functionality. Select the light bulb to display the tip.

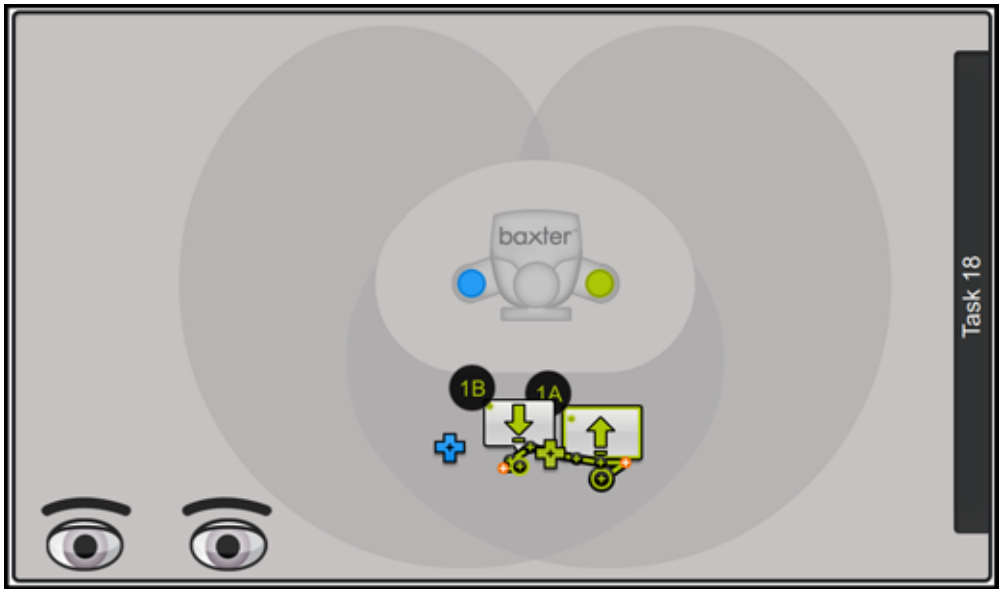
How to Modify a Path (includes Practice and Retrain)

1. With a task already created, select the action where the path originates. For example, if the path is from a Pick to a Place, scroll to the Pick.



2. Press OK and select the Paths icon from the Modify screen.

Baxter displays the Task Map.



3. From the Task Map, scroll through the possible paths, and press OK on the one you want to change.

Baxter displays this screen. From here you can choose to practice, modify, or retrain the path.

After making changes to a custom path you can quickly apply those changes to its return path by clicking the **Apply to Return** button. This button is always available when returning to view a path.

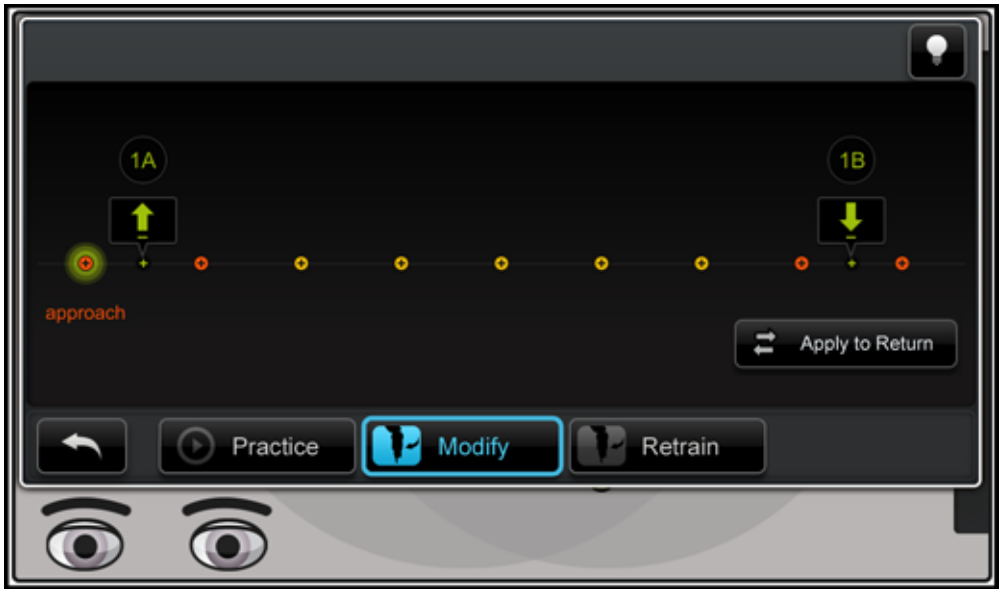
PRACTICE

Practice gives you a run-through of the path as it exists now. You can practice at two different speeds: slow and full.

RETRAIN

Retrain enables you to quickly modify an existing path. Pressing Retrain deletes the transit way-points on the current path, while keeping the pick and place actions and their associated approach and retract points. (You can then add new waypoints to the path.) Retrain is also an option in the Modify Panel submenu for selected waypoints.

MODIFY



Modify enables you to change one point at a time, whether it's an action, a transit point, an approach or retract.

1. Select Modify.

Baxter displays the Modify Waypoints panel.

2. Select a waypoint by scrolling to it and pressing **OK** on the Navigator.

The submenu changes depending on the kind of waypoint selected and the kind of action upon which the path is based.

MODIFY PANEL SUBMENU OPTIONS

Back - Returns to the previous screen.

Remove - Delete the selected waypoint.

Nudge - Allows for precise movement of the location and orientation of end effectors. See “Nudge” on page 99.

Retrain - Enables you to quickly modify an existing path. Pressing Retrain deletes the transit waypoints on the current path, while keeping the pick and place actions and their associated approach and retract points.

Add - Adds waypoints to the path.

To add a waypoint:

1. Select a path from the Task Map.
2. On the screen, select Modify.

Baxter displays the Move Pose Mode screen.

3. Scroll to the waypoint on the path before which you want to insert the new pose/point.

4. Press OK to display the submenu for that waypoint.

5. Select Add.

Baxter displays the screen in Add Waypoints Mode.

6. Manually position Baxter's arm and end effectors in the pose you want to add.
7. Press the round action button on the training cuff to set the new pose.
8. Repeat for each new waypoint. Changes are saved automatically.
9. When done, press the Back button.

Suggestion: Use Practice to run through the path to check the new pose.

NOTE: You may find that some locations or poses will be invalid. That means the location or pose cannot be performed by Baxter because it's near a joint limit. On the Task Map this would show up as a grayed out icon. On the screen, Baxter displays the message, "Add pose failed."

Motion Presets

Motion presets define how Baxter's arm follows a path's waypoints. These presets will help Baxter complete a wider variety of tasks.

There are three types of presets:

- **Balanced** ("best of both worlds") - The default preset. This is the way Baxter has followed waypoints along its path in the past. (If you upgrade a task from a previous version of the software, this is the preset that will be selected.)
- **Explicit** ("more precise but slower") - Baxter will follow the waypoints closely, and in a controlled manner (that is, more closely and controlled than either the Balanced or Express presets.) This preset would be a good choice for machine tending tasks.
- **Express** ("faster but less precise") - Baxter will use the path's waypoints more as a guide to follow rather than as a specific target to hit. With this preset, Baxter is optimized to complete its actions faster than the other presets. Use this preset when cycle time is paramount and repeatability or precision is not critical.

You set presets at the task level, as you do for signals, counts, and advanced settings, but you also have the option of overriding the preset at the action level (i.e., pick, place, or hold).

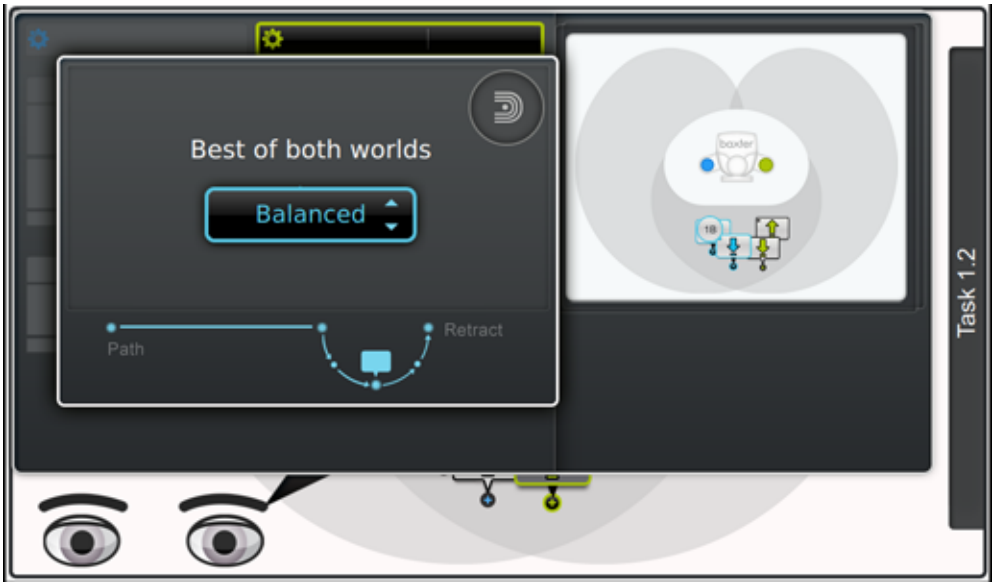
How to Change Motion Presets at the Task/Arm Level

1. From the Task Order screen, highlight the training icon  for either arm.

2. Press **OK** to display the menu button bar.

3. Select the Motion presets icon.

The current or default motion preset is displayed.



4. Scroll through the motion presets options and select a preset.
5. Press OK.

How to Change the Motion Preset at the Action Level

1. Highlight the pick, place, or hold action on the Task Map and press **OK**.
2. On the modify action screen, select the  icon.
3. Select the Advanced icon  on the modify screen to display the advanced action modification screen.

The default setting for the action is "Inherited." That means the setting is the same as, or inherited, from the task level.

4. Change the motion preset for the individual action by selecting the Motion Presets icon.
5. Scroll through the options.
6. Press **OK** to select one of the presets, then press **Done** to save it.

IMPORTANT NOTE ABOUT MOTION PRESETS

The destination action -- the action to which the arm is moving along the path -- is where you apply the motion preset. For example, if you need Baxter's arm to move in a controlled, deliberate fashion from a Hold to a Pick, you would open the advanced screen for the Pick and choose Explicit.

Hold

Baxter can hold an arm in position for a defined period of time or an unlimited period of time until a signal is triggered. This feature is useful for such jobs as holding an object in a pose (or a series of poses) for inspection, scanning, labeling, painting, etc. It can be used when you want to move an arm to a neutral location to wait for machine cycling, or for a process to be finished.

You can create a Hold as a distinct subtask. Baxter will move to that location, hold for as long as you define and then move on to its next pose.

Hold works with or without a part being grasped, and in any pose or orientation.

> ***Note:*** Hold is not a waypoint and Baxter does not treat it as such. Rather, Hold is an action that takes place in a specific location.

How to Train Baxter to Perform a Hold

To illustrate this feature, we'll create a new task in which Baxter will hold up a part to be scanned.

1. Create a new task.
2. Create a Pick by grasping an object.

3. Position Baxter's arm and hand in the location and orientation you want it to hold, e.g., in front of a scanner.
4. Press the action button (the round button on the training cuff) to display the action bar.

5. Select Hold and press OK.

Baxter creates a Hold action and displays a Hold icon on the Task Map. (As with other actions, Holds display their numbers, which are based on the subtask.)

Note that the Hold icon has a time feature indicator associated with it. The default Hold time is zero seconds.

How to Modify a Hold

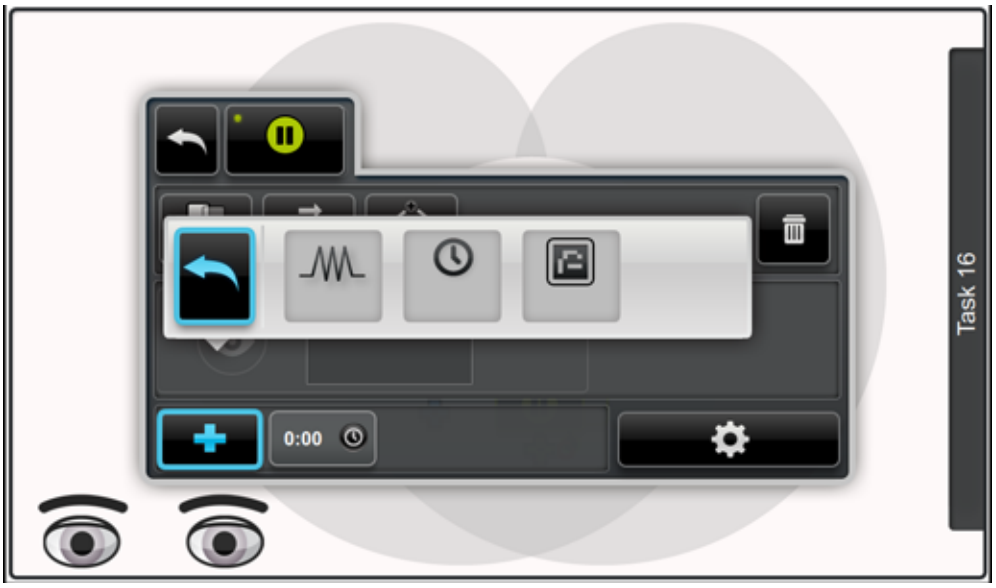
You can modify the characteristics of a Hold action the same way you do a Pick or Place: from the modify panel or the task order screen.

To change the duration of a Hold:

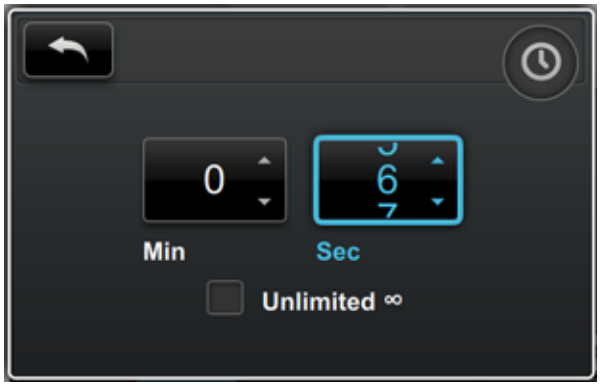
1. Select the Hold icon on the Task Map and press OK on the Navigator to display the Modify screen for the Hold action.

2. Select the Add Features button  to display the Add Features submenu.

This submenu allows you to add a signal to a Hold or modify the duration of a Hold.



3. Select the Time icon  to display the Time panel.
4. Select the spin box then scroll through to change time for the Hold or check the Unlimited checkbox for a hold of unlimited duration, for example, if you want Baxter to hold its pose until it receives a signal.



5. Press the **Back** button to complete.

The Unlimited Hold capability gives you greater flexibility when working with tasks that require signals to move on from a Hold.

> ***Note:*** As of Intera 3.2, Baxter no longer displays a confused look if a ready signal is assigned to a Hold.

How to Create a Series of Hold Subtasks

1. Create a new task.
2. Pose the arm in the location where you wish to pose the Hold.
3. Click the action button.

4. Select **Hold** from the submenu.
5. Create a series of Holds along a path you define using the action button and selecting Hold from the submenu for each pose.
6. Create durations for the holds as needed.
7. To easily define the end of a subtask and create a new subtask, select **+Subtask** on the action bar.

Baxter displays a checkmark at the top left of the Task Map to confirm.

8. Press the **Back** button to complete.

The Task Order screen with a series of holds might look like this:

Note: You can re-order a hold into a new subtask.

Baxter treats hold-only tasks as if there is no object in hand, so you cannot specify a weight for a part. If Baxter's arm is holding a part that has some weight to it, the movement and performance of the arm can be unsteady.

NOTE: The **+Subtask** feature is not just for Hold subtasks. You can use it any time you want to start a new subtask.

Nudge

The Nudge feature enables you to finely tune the location and orientation of the tip of the end effectors. The benefit: you can define precisely the position, orientation, and angle where a pick, place or hold action takes place.

You can also use this feature to nudge an action's retract and approach points if the action is non-vertical. (You cannot nudge a vertical action's approach and retract points.)

How to Nudge a Pose

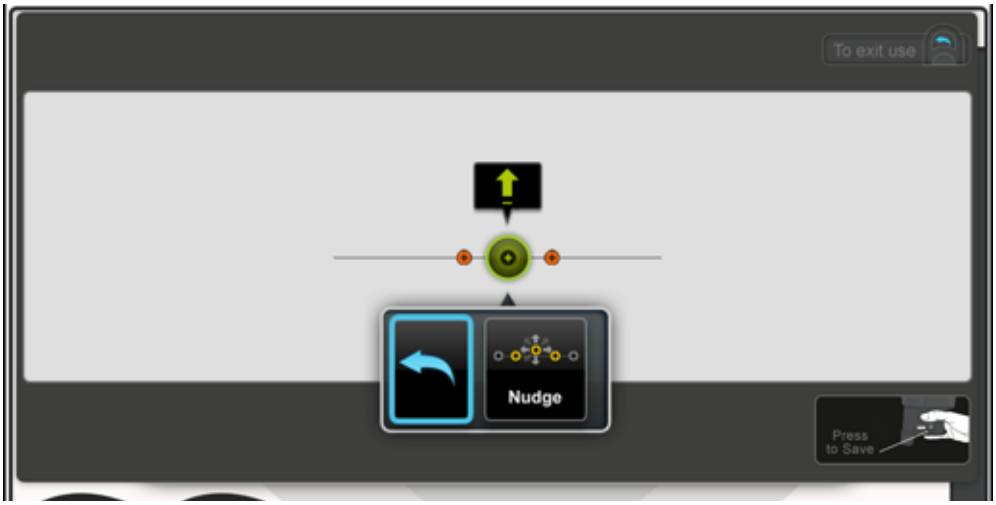
1. Select a pick, place, or hold action on the Task Map.

Baxter displays the action's Modify panel.

2. Select the icon.

The panel is displayed.

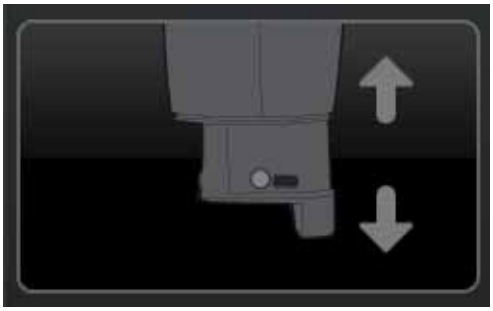
3. Click on the **Modify** button.
4. Select the specific action whose location you want to change. This can be the action itself, or its attract or retract point if the action is non-vertical. The Back and Nudge buttons are displayed.



5. Select **Nudge**.

Baxter moves its arm to the currently defined pose and displays the options for how the pose can be nudged.

NOTE: Pay close attention to the icons on the Nudge screen, specifically the cuff's profile in the display images compared to that of the cuff on your robot. Use the location and orientation of the cuff's camera as a reference point.



Training cuff profile: camera on right

Training cuff profile: camera in back

In short, when you nudge Baxter's cuff, make sure the profile of the robot matches the image shown in the display.

YAW, PITCH, AND ROLL

Yaw, pitch, and roll are terms used to describe the way in which an airplane moves about its three axes.

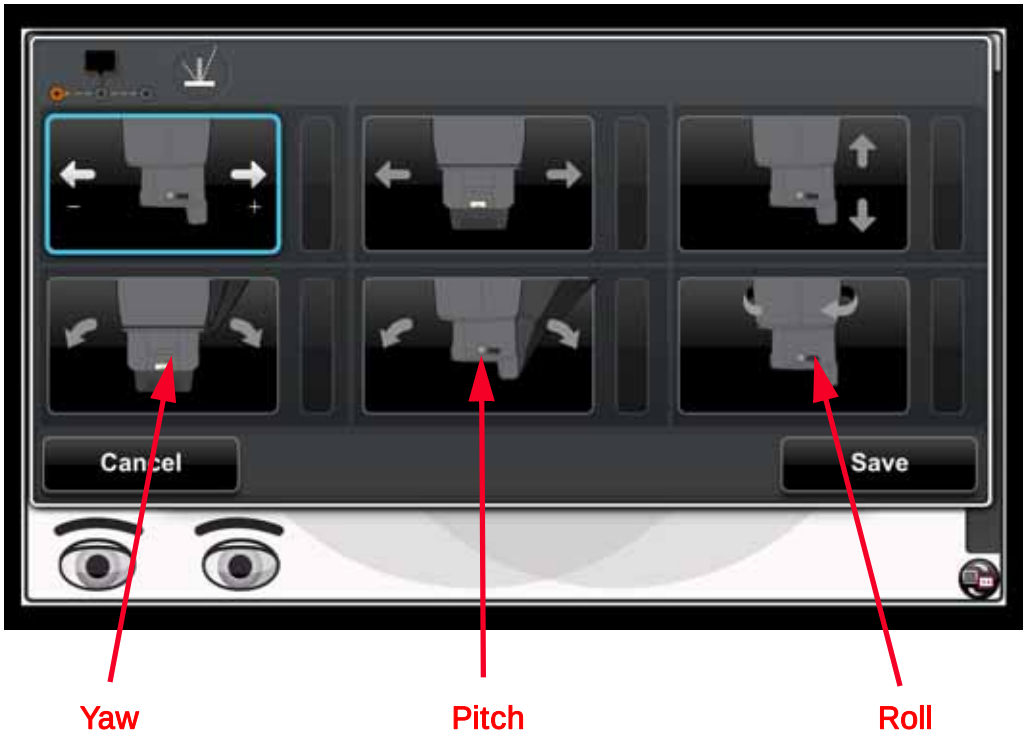
- Yaw - twist or oscillate (nose left or right) about the vertical axis running up and down the plane.
- Pitch - move nose up or down about the axis running from wing to wing.

- Roll - rotate about the axis running from nose to tail.

It is helpful to keep these terms in mind when using the bottom row options (on the next page) in Nudge. Just picture the orientation of Baxter's wrist as below and equate this orientation with the nose of an airplane. In other words, picture the front view of wrist, with the gripper fingers pointed at you *and the camera on the bottom*, as being the nose of the airplane. Then yaw, pitch or roll accordingly.

Side view

Front view



(Top row) You can nudge the arm in millimeter increments along the X, Y, Z axes of the cuff (called a translation change) specifically:

- along the x axis: in a line from the gripper connector to cuff camera
- along the y axis: left and right, perpendicular to the cuff camera
- along the z axis: up and down

(Bottom row) You can nudge the angle of the wrist around the X, Y, and Z axes in fractions of degrees (0.25), specifically:

- yaw the wrist
- pitch the wrist
- roll (rotate) the training cuff

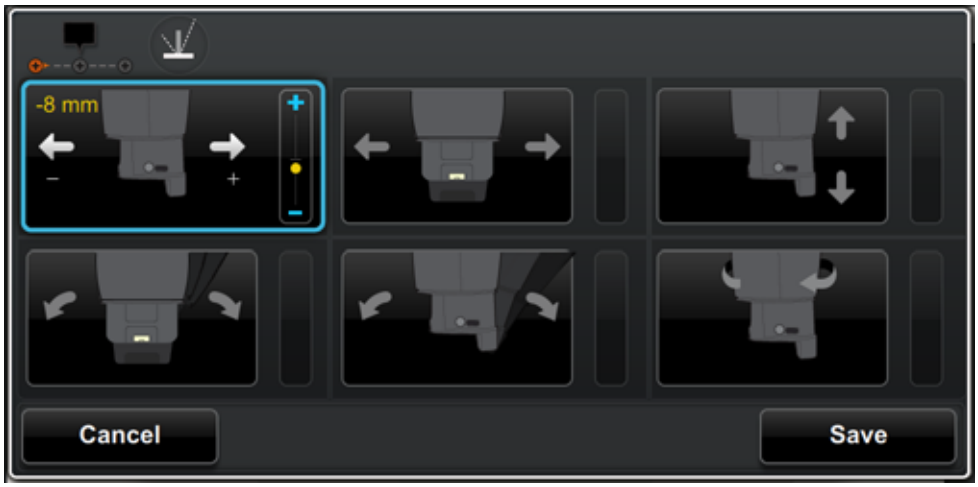
Approach-action-retract and non-vertical indicators; vertical action indicator

The icons in the upper left of the Nudge panel remind you whether you are nudging (from left to right) the approach pose, the action itself, or the retract pose, and whether the action is vertical or non-vertical. In the first example, the approach pose for a non-vertical action is highlighted.

If the pose is non-vertical, you can nudge in six degrees of freedom. If vertical (snap to vertical is checked), there are four degrees of freedom available for nudging.

6. Select from among the options, then dial a distance or degree using the Navigator scroll knob. You can nudge at intervals of 1 mm for translation and .25 degrees for orientation.

Baxter's arm moves to the new location or angle.



This option will nudge the arm -8mm along the x axis from its present pose. Note the profile of the training cuff.

This option will nudge the lower portion of the arm 3.75 degrees away (along the z axis) from Baxter.

7. To save the new pose, press **OK.**

Note: You can make multiple nudges to Baxter's arm, both along and around the XYZ axes, by pressing **OK** after each Nudge.

8. When done, press the **Save** button.

NOTES ON NUDGE

- If you are nudging a vertical pose, you cannot nudge the angle of the training cuff. The first two options in the bottom row are grayed out. This helps ensure the vertical pose does not change to a non-vertical pose.
- You should move the arm *before* you enter Nudge mode. While in Nudge mode, you can move the arm by squeezing the training cuff and moving the arm as you normally would in zero gravity. If you press the Save button after moving the arm, this becomes the updated pose from which nudges are made.
- Keep in mind that, if you nudge an Action, its Retract and Approach are *not* nudged proportionally. This is true for any Nudge, including Holds with a zero Approach/Retract distance. So, in the case of the Hold, if you nudge, make sure you go to the advanced menu and make the Approaches/Retracts zero distance.
- Pressing the Action button after manually moving the arm to a new pose does NOT save the pose.

- You cannot nudge transit waypoints.

You can use the Navigator on either arm when in Nudge mode.

Lock/Unlock

You can lock and unlock Baxter using a password stored on a USB stick.

This feature helps prevent unauthorized personnel from tampering with the tasks stored on the robot. If the robot is locked, users can only run, reset, clear errors/confusion, or power cycle (activate/deactivate Sleep) on the robot. When Baxter is locked, tasks cannot be created, modified or changed.

If the robot is unlocked, users have access to all of the robot's features, tasks, etc.

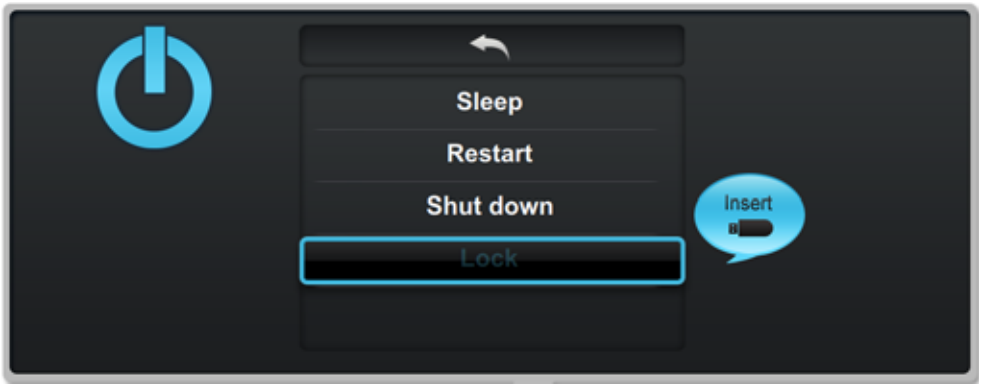
This feature requires a USB device, formatted FAT32, with a text file with the name, RethinkPassword.txt. Baxter will recognize this .txt file only if it resides on the USB device's root directory.

You can create your own text file with this character string or download it directly from the Rethink Robotics FTP site.

Note: The password file will then be provided by the Rethink Robotics Support team via Rethink's FTP site.

How to Lock or Unlock Baxter

1. Insert the USB device containing the RethinkPassword.txt into the USB port on the back of Baxter. If not inserted, the lock/unlock option will look like this:



2. Once the stick is inserted, from Baxter's button bar, select **Sleep**.
3. Select **Lock** or **Unlock**, depending on what state you want Baxter to be in.

Robot Positioning System

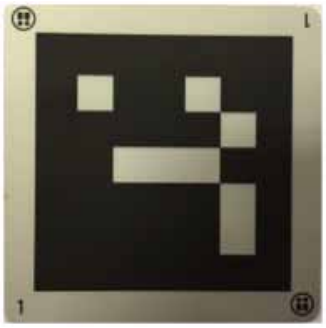
Introduction

Collaborative robots are designed to work next to humans and to be deployed quickly from one task or work cell to another. This design is a beneficial one but it also introduces a whole new set of challenges for robotics. For example, moving robots from one work cell to another means the locations of Pick, Place, and Hold actions for a task must be adjusted in the new work area.

And when human operators accidentally bump into tables, conveyors, or the robot itself, the locations where the robot expected to perform those actions get moved. That would make the robot fail to perform the tasks.

For these reasons we have designed the Robot Positioning System feature. In a new workflow using this feature, an operator can quickly reregister the robot to the workspace and continue working without having to retrain a task or spend time trying to fine-tune a previously trained task.

Please keep in mind that at present the Robot Positioning System only works while setting up the task; it does not dynamically adjust as the robot performs the task. Also, the Robot Positioning System is not used to load tasks or make decisions on what action to perform.



Sample landmark

A landmark is a design or mark placed in the field of view of an imaging system to be used as a point of reference. It's similar in some ways to a registration mark used in printing to keep the different images aligned.

Rethink Robotics currently supplies landmarks on anodized aluminum with an adhesive backing. These landmarks are placed on the surface of modules in the work area.

If Baxter -- or the surface containing the landmark on which an action takes place -- moves, either accidentally or not, you can use the Robot Positioning System feature to re-register the action in relation to the original location and quickly reorient Baxter in relation to the task.

Please note this feature is designed for relatively small changes in location. The movement between the original location and the re-registered one should not be more than a distance +/- 50mm and/or a rotation of 10 degrees.

IMPORTANT:

- When re-registering to a previously associated landmark, it's very important that you do not move the arm from the original location. Doing this will introduce error into the associated actions. Therefore, we recommend pressing the OK button on the other arm or Baxter's torso.
- For certain tasks you may need to mechanically fix Landmarks to the workspace. For example: tasks where the surface is particularly hot, which would affect the adhesive on the landmark, allowing it to drift.

When to Use the Robot Positioning System

This feature is useful whenever you anticipate that the location of an action (usually a Pick or Place) may change and you want to quickly reregister Baxter to the new location.

The change in location could be caused by:

- rolling Baxter away for routine calibration and then moving the robot back into the same work cell.
- operator error, for example, accidentally bumping a table.
- planned moves of the robot and setup, for example, when moving an entire work cell to a new location on the factory floor.

IMPORTANT:

- Assign every action in a task to a landmark.
- Use unique Landmark numbers for each module and for each arm.
- Do not reuse Landmark numbers in the same task.

Tip: When precision is required, move the landmark as close as possible to the location where the action takes place.

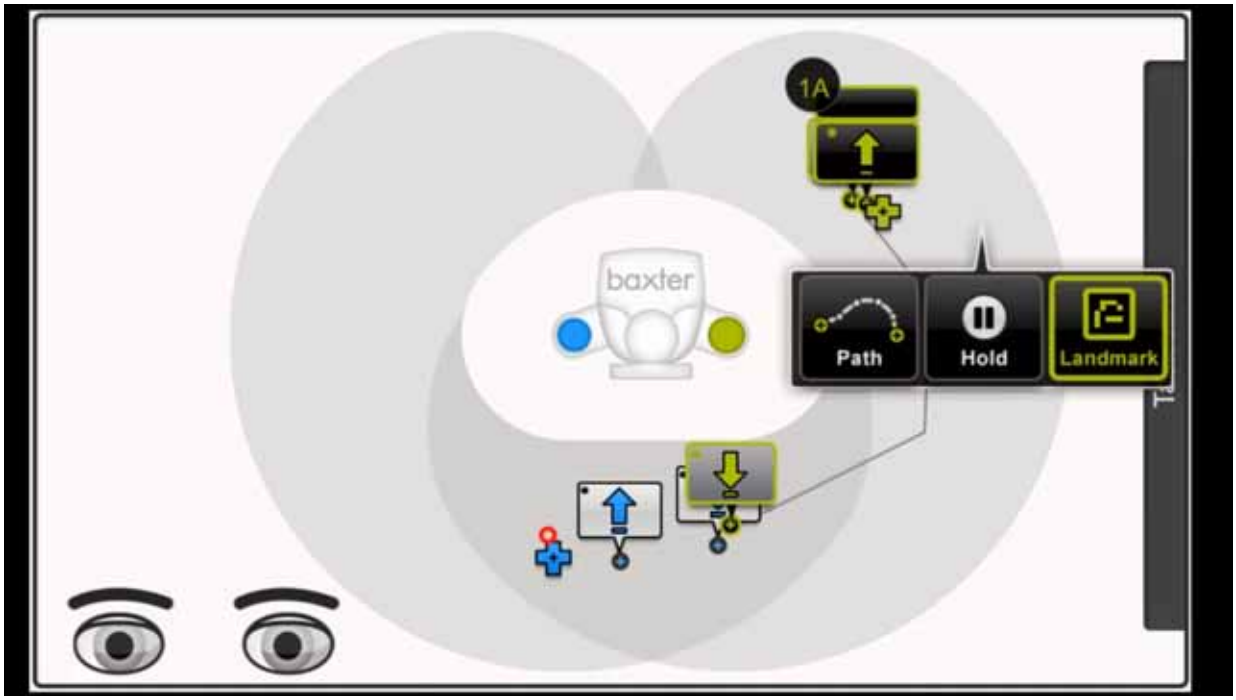
How to Create a Landmark

IMPORTANT:

- Make sure there are no obstructions between the end effector and the landmark.
- Make sure Landmarks are placed on a flat, horizontal, leveled surface and that the surface is properly cleaned before placing the landmark.
- The further away a landmark is from the actions, the less precise it might be when reregistering the robot. We recommend landmarks be no further than 50 cm away from the actions associated with them.
- To allow Baxter's imaging system to see the landmark, position the end effector camera approximately 20cm above the landmark, with the landmark in the center of the field of vision. You may also need to ensure there is sufficient light by adjusting the gain.

To create a Landmark with the Action Button:

1. In the Task Map, press the action button on the training cuff and select **Landmark** from the submenu.



2. Position Baxter's arm approximately 20cm above the landmark, with the landmark centered in the camera's display.

Baxter should recognize the landmark and highlight it with a green outline.

If Baxter cannot locate the landmark, as in the example below, do one of the following:

- make sure the camera is 20cm above the landmark.
- adjust the gain to make the image brighter or darker.
- move the landmark module so that it's closer to the center of the camera's point of view.
- remove the end effector.

The strength of the recognition is displayed by the height and brightness of the vertical green bar in the middle of the screen: taller and brighter = stronger recognition. The landmark is recognized when it is outlined in green and a message displays with the landmark's number, as in the example below.

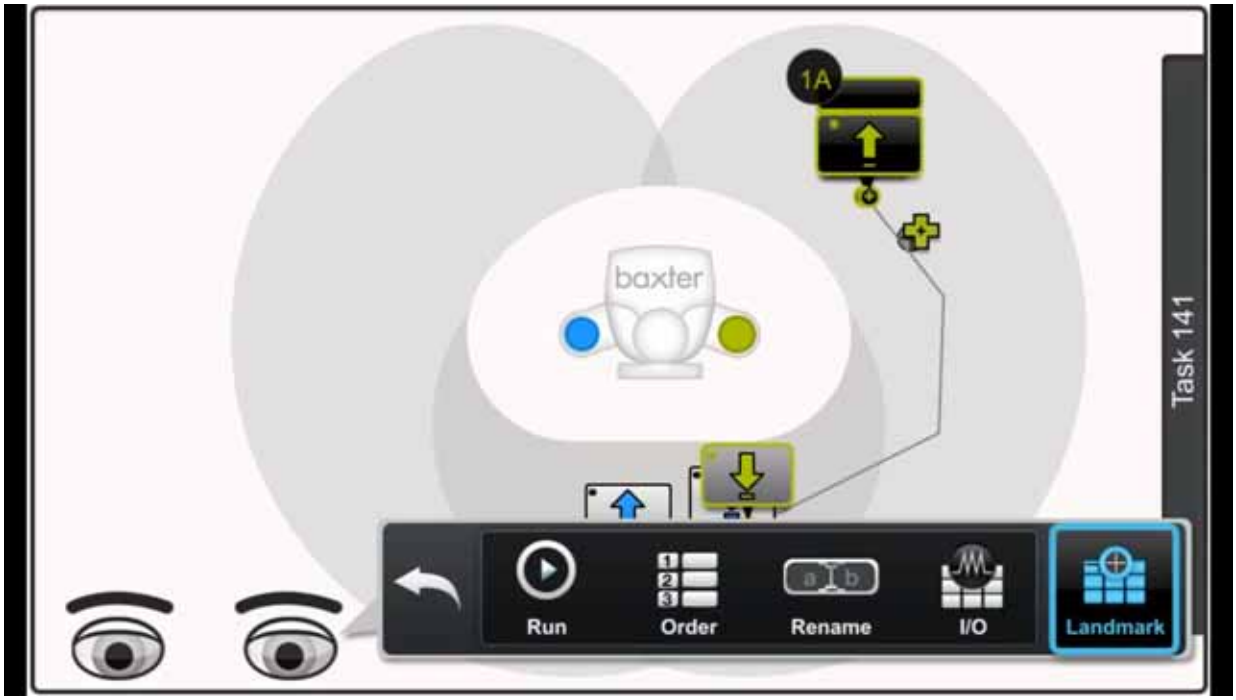
3. Save the landmark by selecting **Save**, but, to avoid moving the camera, press the **OK** button on the torso or the other arm.

When the landmark is saved, the screen displays a checkmark and the number of the landmark, as in the example below.

Alternate Way to Create a Landmark

You can also create a landmark this way:

1. Press the **Rethink** button.
2. Select the landmark gallery icon.

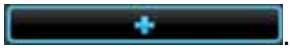


3. Select **Create New**.

That displays the Create a Landmark screen, as seen previously.

4. Save the landmark as before, using the navigator button on the torso or other arm.

How to Associate a Landmark to an Action

1. Select the action on the Task Map.
2. Select  .
3. Select 

.

The Associate Action to Landmark screen displays.

4. Select the landmark for the action.

In this example, landmark 7 is associated with Pick 1B.

5. Press **OK**.

NOTE: You can also press the Rethink button and the landmark icon to display the landmark gallery, where you can associate multiple actions to a single Landmark. This is a more efficient approach when there are multiple actions that need to be associated to Landmarks.

How to Reregister a Landmark

After one or more of the action locations has been moved -- whether because the robot has been moved, a fixture has been inadvertently bumped, Baxter has been inadvertently bumped, etc. -- it's easy to reregister the actions using the Robot Positioning System rather than retrain them.

Note: When re-registering to a previously associated landmark, it's very important that you do not move the arm from the original location. Doing this will introduce error into the associated actions.

To reregister a landmark:

1. Press the Rethink button.
2. Select the landmark gallery.

3. Select the landmark to be reregistered. In this case, it's landmark 8.
4. Select **Reregister**.
5. Press **Start**.

The arm moves to its original location.

A gray outline indicates the location where the landmark was originally saved.

If the new location of the landmark is no more than 50mm and/or 10 degrees rotation from the original landmark location, Baxter will recognize the new location.

If the new location is too far off, just move Baxter or the module until the green outline is displayed.

6. Press **Reregister**.

The landmark is reregistered (note the checkmark) and the location is realigned with the original task location.

- To make it easier to move Baxter back into its approximate, original position, especially if it's common to move the robot periodically, many customers find it useful to mark Baxter's work location on the floor.
- When registering a landmark, give the arm a moment to settle (a good rule of thumb is 5 seconds) before registering. The same applies when reregistering.
- When registering the robot to a landmark, avoid pressing the OK button on the arm being registered; this makes the arm shake and may register the robot incorrectly. You can use the OK button on the other arm, or on either side of the torso.
- Custom paths are not redefined when you reregister using Robot Positioning System, so you may want to keep your waypoints limited in number and relatively far apart from the Approach and Retract points in order to give more flexibility to the robot.
- If you do need to avoid an obstacle, use a series of Holds and associate those to a landmark instead of using paths to avoid the obstacle.
- Keep the surface containing the landmark(s) level.
- Pay attention to the height of the robot when reregistering. The height should be the same when reregistering as it was when originally registered. So, for example, if you unlock the casters on the pedestal and raise the robot to roll it out of its work location temporarily, remember to return the robot to its original height when you roll it back.
- The weight of the grippers can affect the accuracy of Baxter's arm movements. If you register landmarks for a task with the grippers attached, make sure the grippers are also attached when you reregister. Conversely, if the grippers were off when registering, they should be off when reregistering.
- If you have registered landmarks for both arms, reregister first one arm, then the other. It may take several reregistrations to complete the process. That is, you may need to go back additional times to reregister one arm after you have reregistered (and/or adjusted) the other.

Q: I tried registering a landmark, but I get a message that says "Multiple landmarks are visible." What should I do?

A: The robot is seeing more than one landmark. Cover one of the landmarks with your hand until just one is recognized. Then, press Save and keep your hand covering the other landmark until the desired landmark is saved.

Q: I registered a landmark but now I would like to remove it. What do I do?

A: Select the action whose landmark you'd like to remove and go into the landmark gallery panel as described above. Once in this gallery, select  and the landmark will be de-associated from that particular action.

Q: When I relocate the robot, will my custom paths be erased?

A: No. The path will remain the same but the end points (i.e. Approach/Retract) will move to the new locations.

Q: When I have Action Groups, do I need to associate each action to a landmark or may I just associate the whole Action group to the landmark?

A: If you have an Action Group and would like to associate all actions to a landmark, you can just associate the whole Action Group in one step.

Q: Are there any special lighting requirements for using landmarks?

A: Recognition of landmarks works best with soft, diffused lighting that does not produce hard shadows.

Q: Does the landmark need to be trained at the same orientation as the pick or place action?

A: No. You could have your landmark mounted horizontally to the frame of the conveyor even though Baxter will pick in an off-vertical orientation on the conveyor.

Q: Can a landmark be associated with a Hold?

A: Yes.

Q: What do I do when a landmark is damaged?

A: Replace it with a new landmark and use the Overwrite feature in the landmarks gallery. Remember to overwrite the Landmark before removing it from the workspace.

Q: What do I do when I need to associate waypoints in a path to a Landmark?

A: It's not currently possible to associate paths to a Landmark. Therefore, if you absolutely need to make sure waypoints are associated to a Landmark, please turn these waypoints into Holds and associate those to a Landmark.

Application Examples

Unloading Parts from a Rotary Table and Onto Conveyors

TASK DESCRIPTION

Baxter is working on a rotary table offloading parts from the table and placing them on conveyors to either side of the robot using both arms. The rotary table has more than one nest where it will pick parts from. The table and conveyor are on wheels and this line is constantly being moved. The engineer doesn't like to have to train the task every single time they have to move the line somewhere else.

SOLUTION

Even though there is more than one nest on the rotary table, the pick location is the same for all of them. Therefore landmarks only need to be applied on one of the nests and the conveyor belts.

1. Train PICK and PLACE for RIGHT arm.
2. Train PICK and PLACE for LEFT arm.
3. Position one landmark on each of the conveyors so that Baxter can clearly reach and see them.
4. Position one landmark on each of the sides of one nest so that each of the arms can reach and see its respective landmarks.

5. Create and associate each action to its relevant landmark.

Done.

Transferring Parts from One Conveyor to Another

TASK DESCRIPTION

Baxter is working at the end of a line transferring parts from one conveyor to another and is using both arms. Operators work near the conveyors and often bump into these, moving them out of place and Baxter has problems picking or placing. The engineer would like to be able to re-register the robot without having to retrain the task or even retrain specific actions.

SOLUTION

Even though there are only two modules, four landmarks will need to be placed because each arm is independent of the other.

1. Train PICK and PLACE for RIGHT arm.
2. Train PICK and PLACE for LEFT arm.
3. Position one landmark on each of the conveyors for each of the arms so that both arms can reach and see its respective landmarks.
4. Train each ACTION to its relevant landmark.

Done.

Putting parts into fixtures that require precision

TASK DESCRIPTION

Baxter is working near a bench with a fixture that is often being moved depending on what task is being run that day. The fixture requires a lot of precision during the placement and the engineer would like to be able to replace the fixture and not have to retrain the task every time.

SOLUTION

In order to increase precision, place the landmark as close to the action as possible.

1. Train PICK and PLACE.
2. Position one landmark on the fixture close to the actions.
3. Train each ACTION to its relevant landmark.

Done.

Signals

Working with Signals

Baxter can send (out) or receive (in) digital (on/off, true/false, yes/no) signals from other machines. It has two built-in signal ports on its DB15 connector, one In and one Out. You can attach and configure additional devices via the robot's Ethernet port.

Baxter sends and recognizes the following signals:

Note: Unless otherwise noted, level signals are active when true; edge signals look for false-to-true transitions.

You'll notice that Baxter displays in-context descriptions of each of the signals in its signal library, so if you're unsure which signal you want to use in your current situation, these descriptions will help.

- In Ready (level and edge) – Signals to Baxter that the external world is ready for it to perform an action. In some cases, the In Ready signal also tells Baxter to reset counts. You can configure a ready signal as Gate or Enable. See "Ready Signal: Configure as Gate or Enable" on page 134.

- In Error (level) – Signals to Baxter that an external machine or device has an error. Baxter stops and waits until In Error becomes false before resuming where it left off.
- In Pause - Freezes Baxter when true. (Pause can sometimes be more convenient than an Error In signal, which causes Baxter to display a confused face and requires someone to interact with Baxter to "fix" whatever caused the error in signal.)
- In Skip (level) - For sub-tasks, signals that the task should skip to the next sub-task. This signal is only considered when a sub-task is between action sequences. For Hold actions, causes the hold action to terminate immediately instead of waiting until the time interval has elapsed.
- In Do Subtask - Allows you to more easily tell Baxter what to do and when to do it. If a task has all its subtasks with the Do Subtask signal assigned, each subtask is, in effect, in "listening" mode. You can send a Do Subtask signal at any point to instruct Baxter to perform a specific subtask and then wait there until the next signal tells Baxter where to go and what to do. This provides greater flexibility when working with a ready signal and reduces ladder logic in a PLC. If all subtasks do not have the “Do Subtask” signal associated with them, Baxter will perform its task typically, skipping those subtasks that have "Do Subtask" associated but not asserted.
- Reset In - Baxter can receive a Reset In Signal if a PLC triggers Baxter to reset its task to start at the first action. This is essentially the same as stopping Baxter and pressing the reset button. Returns all counts to 0.
- Reset Count - Resets count when true.
- Out Done (level) - This signals that Baxter is done with an action, sub-task or task, i.e., that the count is complete. This signal may stay true for an arbitrary length of time, but never less than 0.5 seconds.
- Out Count (edge) - Signals that Baxter has executed an action that has changed a count.
- Out Error (level) - Signals that Baxter has a problem and has stopped executing the task.
- Out Confusion (level) - Signals that Baxter may need materials or help. User intervention is likely required.
- Out Action Started (edge) - Signals that Baxter is starting on an action or subtask, i.e., that the arm has reached the action's approach point. In other words, start pulses at the approach pose of the first action of the subtask. You can define the duration of a pulse for as much as 5 seconds or as little as .5 seconds. The default is 1 second.
- Out Action Ended (edge) - Signals that Baxter has finished an action or subtask, i.e., pulses at the retract pose of the last action in the subtask. You can define the

duration of a pulse for as much as 5 seconds or as little as .5 seconds. The default is 1 second.

- Reset Out - Baxter can send a Reset Out Signal to reset a PLC when the user presses “Reset” in Baxter’s UI. Returns all counts to 0.
- Hold Active - Sent when Baxter’s arm arrives at a Hold location. When Baxter's arm settles in the hold pose, the Active signal is sent out and will remain true for the duration you have defined, whether 5 seconds, 30 minutes or unlimited. When that time is up, Baxter will move on to its next location and wait for the next signal.

> ***Note:*** The duration of the Active signal is equal to whichever is longer: the configured hold time or the pulse duration.

Internal Signals

Internal signals do not involve communications between Baxter and outside devices. Rather, they use the existing signaling system for communication within the robot itself.

Internal signals enable more granular control over arm coordination with less reliance on a PLC. Whereas in previous versions you could coordinate across arms at a subtask level, as of 3.2 you can coordinate anywhere you can add a signal, say at the start of an action, during the action, or the end of an action.

As one example, with internal signals, Baxter can perform a pick on one arm, then signal the other arm with a Done signal. That triggers the Ready signal of the other arm, which then performs its task.

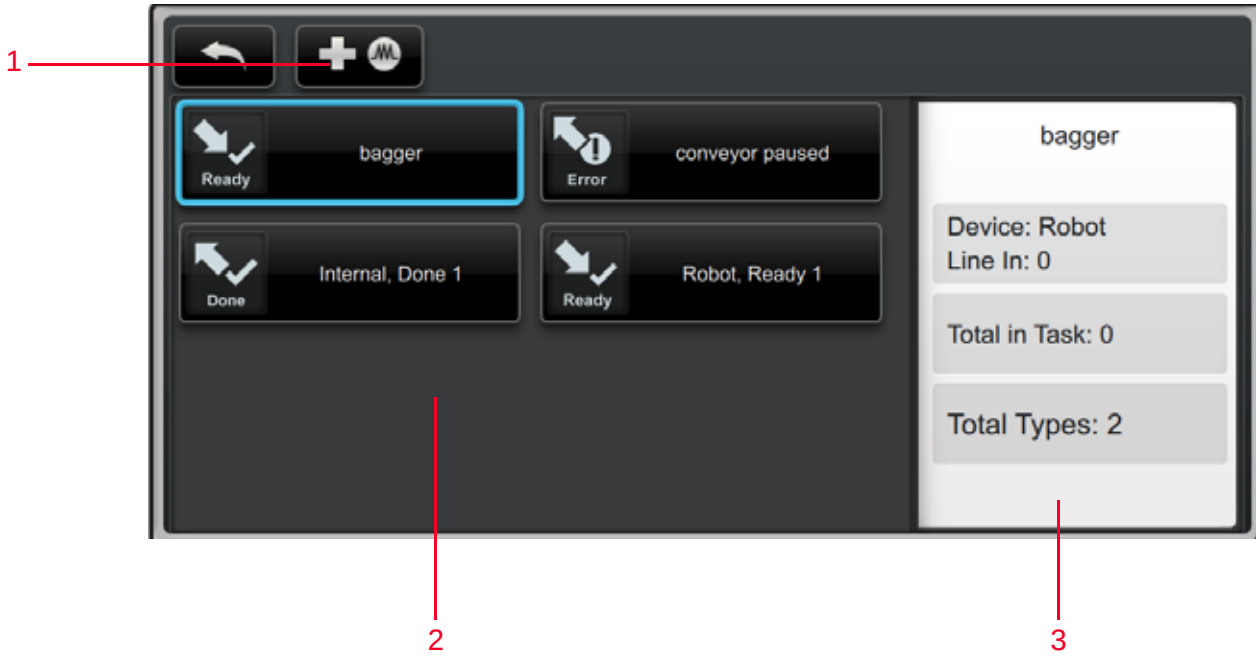
To set up, internal signals need to have an input and output on the same line, and the trigger logic of the input (Gate/Enable) needs to work with the duration of the output, i.e., Gate will work with a duration of 0.5 seconds, but Enable will likely need a longer duration.

> ***Note:*** Baxter will show confusion when an internal input signal does not have a corresponding output signal on the same line.

THE SIGNALS GALLERY

From the Task Map, press the Rethink button, and click **I/O** to access the *signals gallery*. Use this screen to view available signals, or add new ones.

When you first access the signals gallery, it will be blank, as in the illustration above, if no signals have been created yet. If signals do exist in the gallery, the display will be similar to the one below.



1. Create signal – Add a signal to the gallery.
2. Displays a list of all signals defined for the current task.
3. Displays the details of the selected signal.
    - Name of the signal
    - Device name and line number
    - Number of places the signal is added to the task
    - Number of the type (e.g., In Ready) of signals created

Creating Signals

To set up signals, first attach and configure the device (see “Appendix C: Configuring External Devices” on page 151), then, create a signal and store it in the signal gallery:

1. In the task gallery, click the create signal icon.
2. In the add signal screen click the type of signal. “In” signal icons feature a right-and-down pointing arrow (first and second rows, below); “out” signals all have a left-and-up pointing arrow (third and fourth rows).

In the configure signal screen, change the name if it is not clear to your team; then reference the correct device, and the line number.

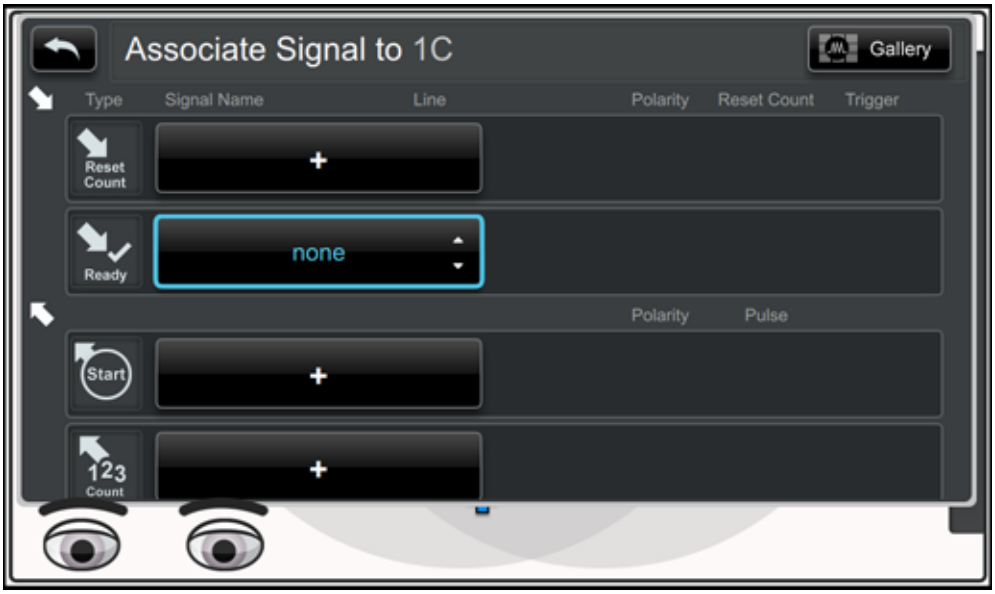
3. When complete, click **Done**. You can later return to modify any of these details.

Assigning Signals

To assign a signal:

1. Select an action, task, or subtask.
2. From its modify screen, select the **+** button.
3. Select **Signal** from the submenu.

Baxter displays the Associate Signal screen, where you can both define and assign a signal:



4. Select the plus (+) button to define a signal and its attributes.
5. When finished, click the **Back** icon on the screen.

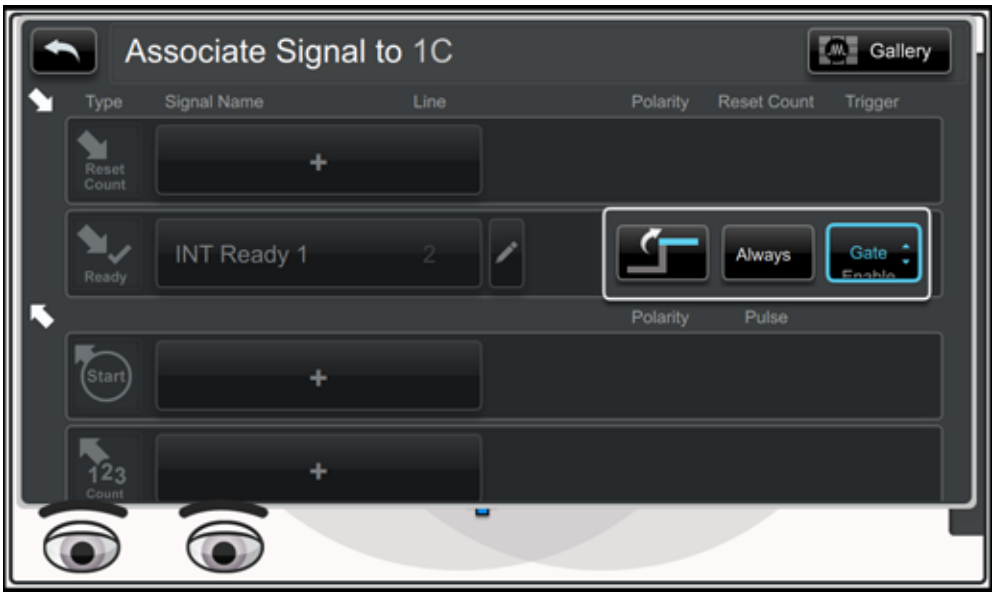
SIGNALS NOTES

- You can easily invert the signals Baxter sends or receives by clicking on the invert signal icon  in the Polarity column.
- Pulse - For more flexibility when integrating with external devices, you can define the duration of a pulse for an Out signal. You can set it to as much as 5 seconds or as little as .5 seconds. The default is 1 second.

- To disable an existing signal, select none in the spin box next to the signal, then return with the **Back** button. This removes the association of the signal from the current action, subtask, or at the task level, but the signal itself remains available, so it can be associated to other actions, subtasks, or at the task level.
- Internal signals default names all begin with INT. (e.g. INT Ready 1)
- As of Intera 3.2, the designation Torso is now Robot, and default names all begin with Robot. (e.g. Robot, Ready). As a reminder, Baxter has a single input and a single output accessible through the robot's Db15 port.
- The "Reset Count" policy for a Ready signal can be set to **never**, and you can separately assign a Reset Count signal, if needed.

READY SIGNAL: CONFIGURE AS GATE OR ENABLE

For pick and place actions with a Ready signal, you have the option of instructing Baxter what to do if a signal that was true when Baxter started the action becomes false. For example, in the case of using a part present signal, if the part disappears (and the signal is false), you can choose whether you want Baxter to continue moving or to stop.



- If **Enable** is chosen for the signal, and the part present signal disappears (turns false), Baxter will stop, go back to its approach, and wait for the signal to be true before trying again.

- If **Gate** is chosen for the signal, (the gate being defined as the action's approach), once past the gate, even if the part present signal disappears, the arm will continue.

Maintaining and Supporting Baxter

Powering Down Baxter

1. Clear the area around the robot.
2. If performing maintenance, grab the training cuff or turn the knob to cause the head to move to the side. (Pressing the Navigator button may run or reset a task, so it's safer and simpler to grab the cuff or turn the knob.) Moving the head to the side makes it easier to remove the front cover. If the robot does not have power, carefully move the head manually.
3. Press the white power button on the robot pedestal.

   The shutdown process is complete when the green and yellow lights around the head shut off.

Unplug the power cord from the wall outlet/power source.

Maintaining Baxter

Cleaning Baxter

To clean Baxter, periodically wipe it down with a clean, damp cloth.

Replacing the Air Filters

Check the Baxter air filters at least every six months, and replace them as necessary. Baxter has two air filters, one on each side of the torso.

- To remove a filter, use a 2 mm hex key to remove the two screws from the air filter; remove the filter.
- To install a filter, use a 2 mm hex key to install the two screws and attach the filter to the side of the torso.

Upgrading Software

IMPORTANT

- Please refer to the Read Me First guide posted on the FTP site for best practices when upgrading.
- You must be running Intera 3.1 or 3.1.1 to upgrade to Intera 3.2. If you have an older version of the software, you must upgrade to Intera 3.1 or 3.1.1 before Baxter can be upgraded to 3.2.
- Please export all your tasks prior to upgrading to Intera 3.2.
- Should you need to downgrade from the Intera 3.2 beta to 3.1.1, please contact support.
- We recommend using a USB stick with at least 4GB of storage.

TO UPGRADE:

1. On Baxter, go to **Main Screen > Settings > Advanced > Update Software**.
2. Insert the USB device that includes the software upgrade, and wait for Baxter to recognize the device.
3. Select the version of software you want to install.
4. Select **Yes Continue** in the confirmation dialog.

   A status screen appears as the software loads.
5. When the software finishes installing, restart Baxter.

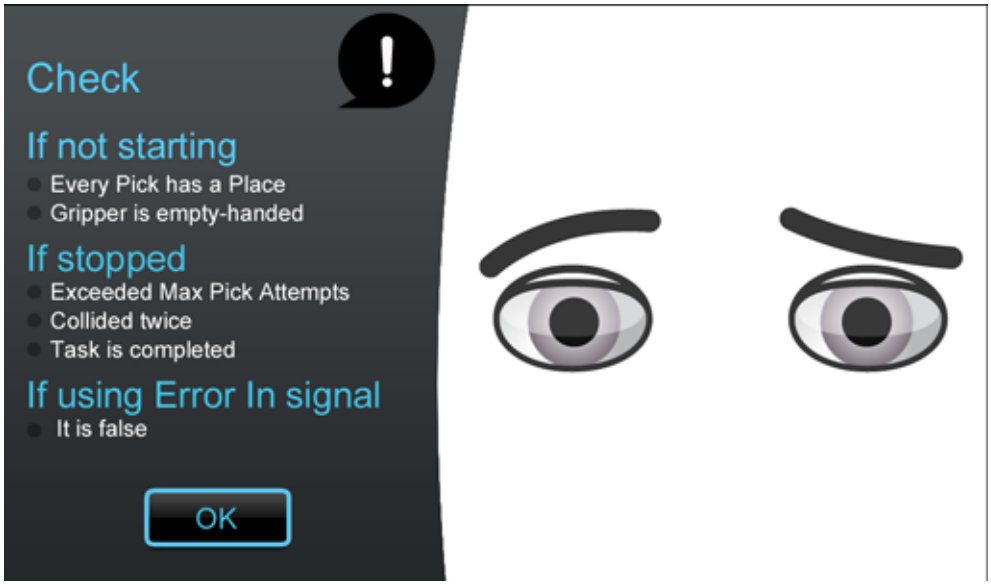
Supporting Baxter

Occasionally, Baxter encounters problems that can inhibit its ability to perform tasks. This section describes the types of problems that may occur, and the actions you can take to resolve them.

Typically you will be able to solve the problem yourself. In some cases, however, you may need to contact your technical support representative for assistance.

Helping Baxter When It Is Confused

When Baxter encounters a problem, it typically will stop and display a message on the screen.



When you see this type of message, follow instructions on the screen to resolve the issue.

Other types of “confused” screens concern external devices not being connected, internal signals not being fully defined, and end effectors that are not configured.

If the issue is not solved even after shutting down and restarting Baxter, contact your technical support representative for assistance.

Calibrating the Arms

Calibrate the arms to troubleshoot common error messages, and to help Baxter maintain its peak performance. It is also recommended that calibration is performed according to the following schedule:

- Weekly – perform a Basic calibration on both arms.
- Monthly and whenever the robot is shipped – perform a Factory and Spring calibration on both arms.

IMPORTANT During calibration, Baxter’s arms must be able to move freely in all directions, starting from the base of the robot on up.

IMPORTANT During calibration, Baxter's force sensing is turned off. Before calibrating the arms, remove the grippers, and make sure the workspace is clear above the base of the robot. (Baxter's arms calibrate above the work surface.) If it is not possible to clear the workspace, move Baxter away from the workspace, and clear a 5-foot radius around the robot. While calibration is active, it is important to maintain a distance outside of this 5-foot radius.

If one (or both) of the Baxter arms begins to lose pick and place accuracy while performing trained tasks, try calibrating the arm(s) to fix the problem. Baxter offers three types of arm calibration:

- Basic – performs a basic calibration on the arm or arms selected; use as a first step in fixing the problem. The process takes approximately 15 seconds per arm.
- Factory – performs a thorough calibration of all joints on the arm or arms selected; use if spring calibration does not fix the problem. This process takes approximately 7 minutes 20 seconds per arm.

  Note: Always follow up a Factory calibration with a Spring calibration.

- Spring – performs a shoulder calibration on the arm or arms selected; use if basic calibration does not correct the problem. The process takes approximately 3 minutes 20 seconds per arm.

To calibrate an arm:

1. Make sure there is a clear, 5-foot radius around and above the base of the robot.

   If Baxter is attached to a pedestal, and it is not possible to clear the workspace around the robot:

   - Mark the current location of Baxter by drawing on or affixing tape to the floor near the edges or corners of the pedestal. (This action will help to re-position Baxter after moving it for calibration.)
   - Roll Baxter on its pedestal, away from the workspace and into an area large enough for the arms to move freely.

2. Make sure Baxter is level.
3. Scroll to **Main Screen > Settings > Advanced > Calibrate Arms**; then select a form of calibration (**Basic**, **Factory**, or **Spring**).

4. Select one or both arms; then press **OK** to begin the calibration.
5. Move away from the robot, and make sure all persons are clear of Baxter.

   The selected arm moves as follows for each type of calibration:

   - Basic – the arm drops to the side of the robot, then rises up and extends outward.
   - Factory – the arm moves to the side of the robot, then rises up and extends outward in a few different directions.
   - Spring – the arm moves to the side of the robot with the elbow at the lowest point, then rises up and extends outward.

6. When the robot finishes calibrating, if a Factory calibration was performed:
   a. Reboot the robot.
   b. Scroll to **Main Screen > Settings > Advanced > Calibrate Arms**, and select **Spring Calibration**.

   Wait for the robot to complete the Spring calibration.
7. Return Baxter to its workspace (if moved).
8. If the grippers were removed, reinstall them.
9. Restart the robot.
10. If the grippers were removed and reinstalled, configure and train each gripper.

If after calibration, Baxter still does not function correctly, try retraining and running the task. If the problem is not solved, contact your technical support representative.

Troubleshooting Baxter

To troubleshoot Baxter:

- If Baxter isn't behaving as expected, restart the robot, then try running the task again.
- If Baxter is having trouble accurately picking and placing objects, try calibrating the arms (see "Calibrating the Arms" on page 138 for instructions).

If this does not solve the problem, please consult the knowledge base in the Rethink Robotics customer support portal. If the problem persists, contact your authorized Rethink Robotics service provider for technical support.

Exporting Log Files

Baxter logs its daily activity and saves it into files. When an unidentified problem occurs with the robot, your technical support representative may ask you to export log files to a FAT 32 USB device, download them to a PC, and upload the files to Rethink Robotics support. The files may help them to troubleshoot and fix the problem.

To export a log file:

1. Touch one of the four navigator buttons on the robot to open the button bar.
2. Select **Setting** > **Advanced > Diagnostics**.
3. Insert a formatted FAT 32 USB device into Baxter. Make sure there is at least 2 GB of available space on the device.
4. Select **Export Logs to USB > Export**.

   The log files copy to the USB device.

To retrieve the files from the USB device and email them to Rethink Robotics, insert the USB device into a PC, copy the files from the device to the PC, then attach the files to an email message, and send the message to the requester.

Enjoy!

This concludes the core content of the *Baxter User Guide*. Please refer regularly to our wiki, located here:

mfg.rethinkrobotics.com

On behalf of the entire team at Rethink Robotics, we wish you great success with your Baxter robot, and hope you find it to be a valuable solution for your business.

Several appendices follow, with more detailed examples of information contained in this document.

Appendix A: Configuring Grippers

When you attach a Rethink gripper, Baxter automatically detects the gripper type, and prompts you to configure it. Configuration teaches Baxter:

- Finger type and open/closed finger position of a parallel gripper
- Vacuum cup size of a vacuum gripper

You can also attach custom or third party grippers the same as Rethink grippers, essentially by entering the gripper's length and weight and then training Baxter.

See "Configuring a Non-Actuating Custom Gripper" on page 147.

If you change any component of a gripper (such as adding extensions to a vacuum cup) without detaching it, go to **Settings > Hardware Settings > Configure End Effectors** to reconfigure it. If you do not do this, Baxter may have trouble picking up or holding on to objects.

Configuring a Vacuum Cup Gripper

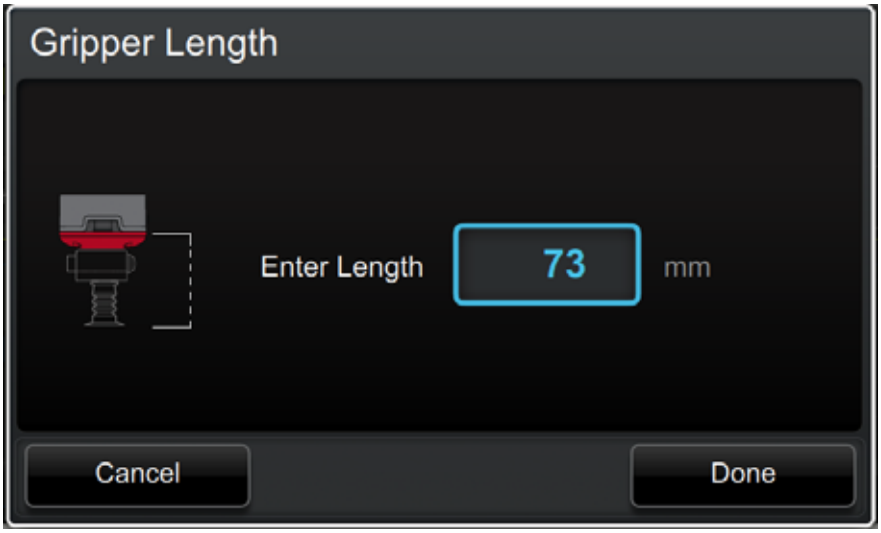
Using the navigator on the arm with the gripper you want to configure:

1. If the gripper is holding an object, release the object.
2. If not already open, scroll to **Main Screen > Settings > Hardware Settings > Configure End Effectors**.

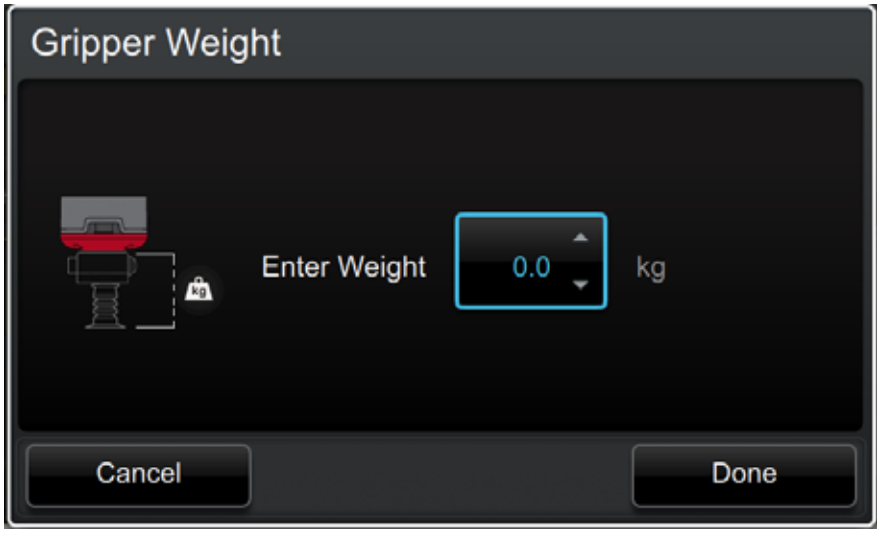
3. If you need to install or adjust the gripper, depending on where you are standing, click **Behind** or **Front**. Baxter automatically presents its hand to you, either in front, or off to the side in back.

   Note: You can also manually reposition the arm to access the gripper.

4. Select **Length**, then enter the length of the gripper based on the graphic, which illustrates where to measure.



5. Click **Done**, then select the vacuum cup's **Weight** icon.



6. Enter the weight of the gripper and click **Done**.
7. Click **Train**. The gripper rotates as Baxter learns it.

Configuring an Electric Parallel Gripper

You configure electric parallel grippers the same as you do vacuum grippers. Just enter the gripper's length and weight. This also applies to custom, third-party grippers.

Using the navigator on the arm with the gripper you want to configure:

1. If not already open, scroll to **Main Screen > Settings > Hardware Settings > Configure End Effectors.**
2. If you need to install or adjust the gripper, depending on where you are standing, click **Behind** or **Front**. Baxter automatically presents its hand to you, either in front, or off to the side in back.

   Note: You can also manually move the arm to access the gripper.

Here are the weights and lengths for each component in the Baxter gripper kits:

Component	Weight (Kilograms)	Length (Millimeters)
Electric Parallel Gripper without fingers	0.3 Kg	43 mm
Wide Short Finger	0.02 Kg	73 mm
Narrow Short Finger	0.01 Kg	73 mm
Wide Long Finger	0.02 Kg	112 mm
Narrow Long Finger	0.02 Kg	112 mm

3. Select **Length**, then enter the length of the gripper based on the graphic, which illustrates where to measure.
4. Click **Done**, then select the gripper's **Weight** icon.
5. Enter the weight of the gripper and click **Done**.
6. Optionally, click **Calibrate** before final training. Baxter automatically opens/closes the gripper to test its grasp dimension.
7. Click **Train**. The gripper rotates as Baxter learns it.

Configuring a Non-Actuating Custom Gripper

You can also attach a non-actuating custom gripper to Baxter for use with hold subtasks, for example, for tasks using a vision system. The camera is attached to the end of Baxter's arm but not plugged in to the robot's wrist. You must still configure and train a gripper even if you are not using a gripper or a non-actuating gripper in your hold subtask.

Note: Hold subtasks do not consider object weight, so if you're using a non-actuating gripper, make sure you adjust the weight and length appropriately in order to improve usability and performance.

Restore Gripper Configuration

If you remove a Rethink gripper and then reattach it, you do not have to go through the process of reconfiguring it, if you have previously configured a gripper of the same type you are reattaching (vacuum or electric). After calibration, for example, this new feature allows you to reattach the gripper and get back to work quickly. When you reattach the gripper, Baxter will display the information for the last gripper of that type, and ask you to confirm.

The Restore Gripper Configuration feature does not work for non-Rethink, non-actuating grippers.

If you choose the Configure button to make a change, Baxter will display question marks for length and weight. If you click on one, Baxter will display the previously calibrated numbers. This is meant to save you time if you only want to change one of the two settings.

Appendix B: Specify Object and Custom Gripper Weights

To achieve optimized arm performance, you can specify the weight of the object Baxter will handle as well as the weight of custom grippers you may use. This feature makes Baxter capable of recognizing weight – and adjusting to it – so arm movements will be smoother and more efficient. For instance, if you input a payload of three pounds (1.4 kg) for the gripper weight, Baxter will recognize that weight, so when you squeeze the training cuff to move Baxter's arm, it will feel essentially weightless and performance may also improve. (Note, however, that if you adjust the weight of a custom gripper and do not specify that change, Baxter's arm performance will likely suffer.)

Baxter can support up to five pounds (2.2 kg) on each of its end arms. An end effector is made up of the plate and its attachments (electronic gripper or vacuum, fingers).

NOTE: The five-pound limit includes both the weight of the objects Baxter will be handling and the weight of the end effector itself, so keep that in mind when specifying total gripper weight.

How to Specify Object Weight

1. Select a Pick action or Pick action group on the Task Map and press **OK** on the Navigator to display the Modify Task Window.

2. Scroll to the Add Features button and press OK to display the task button bar.

3. Highlight the Weight icon and press OK to display the weight entry screen.

4. Select the spin box, enter the desired weight and press OK.
5. Press Done to confirm the weight.
6. Press the Back button on the Navigator once to return to the Task Modify screen.

The weight appears in the Modify window with its own Added Features button.

7. Press the Back button again to return to the Task Map.

Appendix C: Configuring External Devices

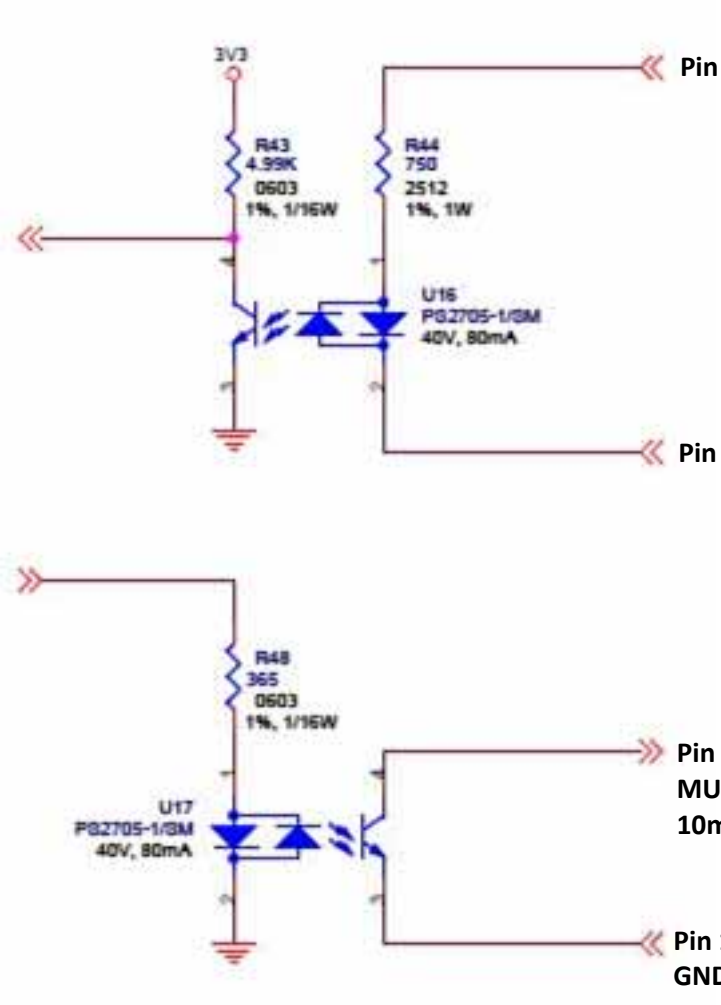
Note: For the latest information, please refer to our wiki at: mfg.rethinkrobotics.com

Baxter communicates to external machines via its open logic ports in one integrated DB15 connector or by adding an external Ethernet-connected Modbus Remote Terminal Unit (RTU).

Attach a terminal block to the DB15 connector to accommodate two signal lines—one in and one out—and provide lines for the e-stop and a safety mat.

TABLE 1. DB15 Pinouts

DB15 Pin			
1		E-Stop	E Stop Switch
	9	E-Stop	E Stop Switch
2		Safety Mat	To +5 (6) via safety mat cable
	10	Safety Mat	To GND (8) for safety mat
3		Safety Mat	To +5 (5) for safety mat
	11	Safety Mat	To GND (13) via safety mat cable
4		**Torso 0 In**	**Torso 0 In (Ready In)**
	12	**Torso 0 In Return**	**Torso 0 In Return (Ready In Return)**
5		1K to +5	To (3) for safety mat
	13	GND	To (11) via safety mat cable
6		1K to +5	To (2) via safety mat cable
	14	GND	
7		**Torso 0 Out**	**Torso 0 Out (Done Out), +5v - +24v, MUST BE LIMITED TO 10ma MAX**
	15	**Torso 0 Out Return**	**Torso 0 Out Return (Done Out Return), GND**
8		GND	To (10) for safety mat



Pin 4: Torso 0 In (Ready In), 5v – 24v

Pin 12: Torso 0 In Return (Ready In Return)

Pin 7: Torso 0 Out (Done Out), +5v – +24v MUST BE EXTERNALLY CURRENT LIMITED, 10ma MAX

Pin 15: Torso 0 Out Return (Done Out Return), GND

Note:

- Torso 0 In is FALSE when current is flowing, and TRUE otherwise. A disconnected input will appear as TRUE.
- Torso 0 Out is open when FALSE, and closed (current flowing) when TRUE.

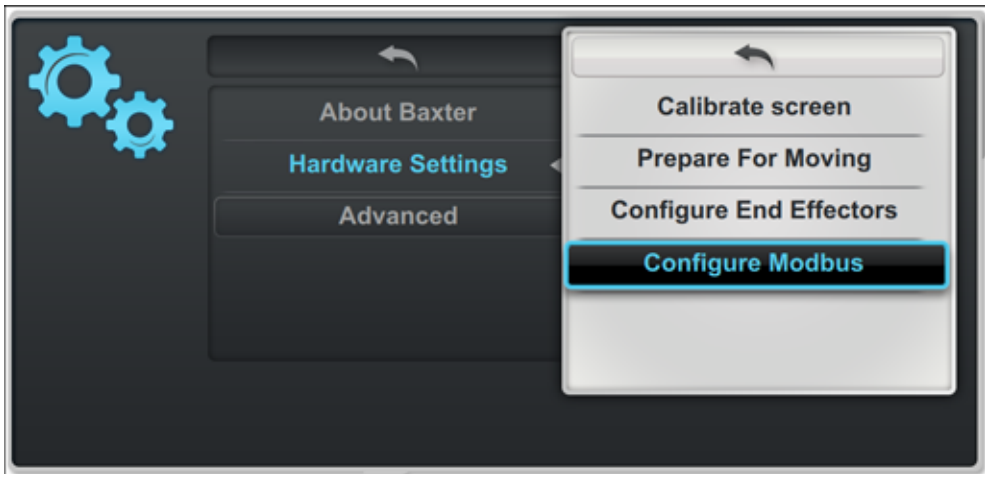
1. Set the IP address of the Modbus device to:

   `169.254.#.#`

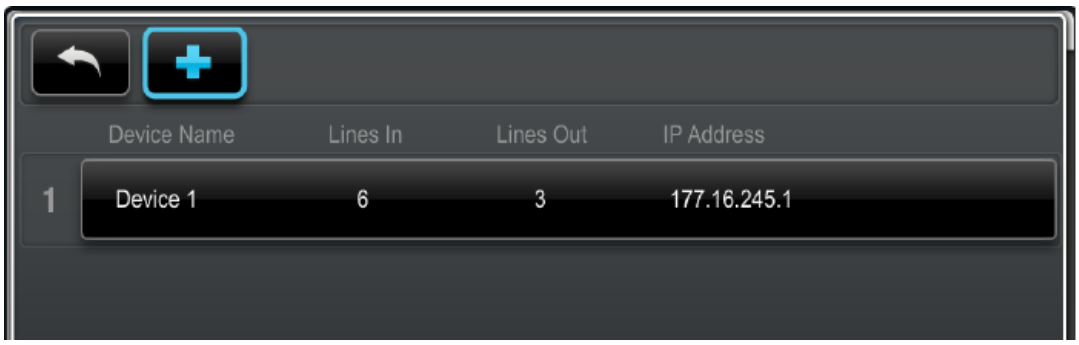
   where # is any number between and including 1 to 254, and the subnet mask is `255.255.0.0`. (Please refer to the RTU manufacturer's instructions for assigning the IP address.)

   Note: With Baxter 1.1 software, Rethink Robotics qualified the Moxa ioLogik E1212 Remote Terminal Unit.

2. With Baxter shut down and powered off, attach the device to the Ethernet port.
3. Turn on the device.
4. Power Baxter on.
5. Go to **Settings > Hardware Settings > Configure Modbus**.



6. In the device list screen, select the + icon to add a device.



7. In the configure new device screen, enter the following:

   - Device Name – Keep the default, or enter a descriptive name for the device (maximum 16 characters).

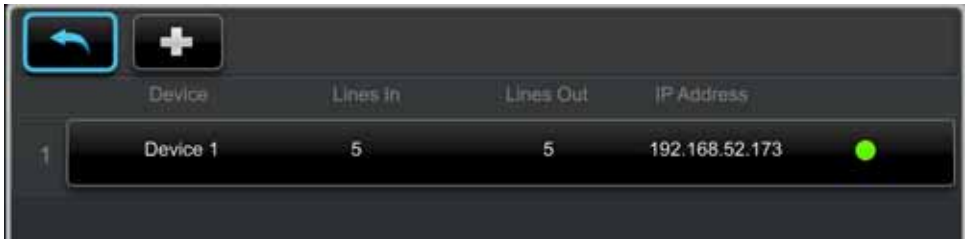
   Tip: Create an easily recognizable name. This makes it easier to identify when creating and adding signals to a task.

   - Number of Lines In and Lines Out
   - IP Address

   To change the default Input and Output Base of 0, and parameters, select the Advanced icon.

8. Click **Done** to save the new device.

When you have a successful connection to a Modbus device, the UI displays a green indicator:



Additional Information About the Modbus RTU

Please note the following when setting up signals:

- For ModBus digital (binary) signals, Baxter uses function code 2 (Read Discrete Inputs) for reads and function code 5 (Write Single Coil) for writes.
- The ModBus device must be configured in SLAVE mode. When using settings other than the default, you must set the input and output base addresses in the Baxter configuration panel if other than 0/0, and the inputs and outputs must be digital (discrete coils, not registers) and contiguous.

Appendix D: Signals and their Definitions

This appendix discusses available signals and their exact definitions.

Terminology

Signal: a signal transmits a piece of information. Signals are binary, meaning they are only on or off. A signal can be an input signal received by Intera from an external source or an output signal sent by Intera to an external source.

Polarity: a binary signal is either true or false. By default, when Intera reads an input signal, it interprets a zero as false and a one as true. Conversely, when it sends an output signal, it sends a zero for false and a one for true. How zero and one relate to the real world depends upon how the external devices are wired and configured.

Invert: Intera has the option to invert an input or output signal. An inverted signal is simply interpreted as opposite to the default. Namely, a zero is considered true and a one is considered false.

Signal classes: Intera uses two main types of signals:

Level: the information is contained solely in the current value of the signal. This represents the state of something, e.g., whether a part is present or whether an operation is done. Input level signals are used in one of two ways:

- **Gate (input)**: Intera waits at specific points in a task for a gate signal to be true. Once true, the value of the gate is ignored until that point in the task is reached again. To be reliably recognized, a gate input should have a minimum duration of 0.5 seconds.

- **Enable (input)**: Intera will wait for an enable signal to be true before executing particular actions, then requires that the enable signal remain true or it will abort the action as soon as possible.

Pulse (output), edge (input): the information is contained in the change of the signal from false to true (the rising edge of the signal.) How long the signal remains true doesn't matter. This represents the occurrence of an event. For example, when an action is started, a pulse is sent.

- An edge input should remain true for a minimum of 0.5 seconds to ensure it is reliably recognized.
- Pulse outputs are true for at least 0.5 seconds.
- Other notes

In advanced applications, there are some cases where it makes sense to connect a pulse output to a level input, or a level output to an edge input. For a contrived example, a user could connect a Done (output level) signal to a Task Reset (input edge) and the task would reset when the Done signal became true.

Task element: a task element is a piece of a task to which signals can be assigned. Elements include: the overall task itself, a subtask, an action group, an individual action. Action Sequences are also task elements, though signals cannot be attached directly to them.

Signal types: Intera has a predefined set of signal types. In order to define a signal, a type must be selected, it must be named, and it must be associated with a particular input or output. Once defined, a signal can only be connected to an input or output of a task element of the same type.

Signal Types

Intera has a predefined set of signal types. While a type implies a certain high-level meaning, the details of how any signal operates are dependent upon the element to which the signal is attached. The main types are described below.

INPUTS

Ready (edge and level): when true, indicates that the task element is okay to run. In many cases the edge of the Ready signal is also used to reset the count or error state of the connected element.

Skip (level): when true, causes Intera to move on from the current element.

Task Reset In (edge and level): pauses (level) and resets (edge) the task.

Error In (level): stops the task.

Pause (level, enable): pauses the task when asserted

Do Subtask (level): when true, signal the subject is allowed to run.

Reset Count (edge): reset count for the associated task element.

OUTPUTS

Done (level): the count for the particular task element has been reached. Stays true until the count is reset.

Note: while Done is a level, due to the automatic resetting of counts it will often stay on for only a short period of time, but always at least 0.5 seconds.

Increment Count (pulse): the count for a particular task element has just changed. This only happens if the element is successful.

Start (pulse): a task element is starting.

End (pulse): a task element is finishing.

Task Reset Out (pulse): the Task has been reset.

Error Out (level): the Task has an internal error.

Confusion (level): the Task is in a confused state.

Active (pulse): the associated hold is currently executing.

INTERACTION OF READY AND CONFUSION

In most cases, connecting the Ready signal to a task element will suppress that element from causing confusion (and, therefore, setting the Confusion signal true). Specifically, if a task is not currently running any actions, Intera makes an effort to determine whether a Ready signal becoming true

would allow the task to proceed or whether the rising edge of Ready will reset a count or error state. If so, Intera suppresses the confusion signal.

Task Element Details

ACTION

An action is a Pick, Place or Hold that is performed at a particular pose in the workspace. Signals can be attached to a single Action that is not part of an Action Group.

ACTION GROUP

An Action Group is a Pick or Place that is applied, usually with common parameters, to a group of poses in the workspace. Signals can only be applied to an Action Group as a whole, not to individual Actions within the group. For input signals, it is as if the signal was attached to each Action individually. For output signals, Intera generates the logical OR or logical AND of the outputs from each of the Actions, depending upon what makes sense for the particular signal type. For example, the Done signal is true if and only if all of the Actions are done (logical AND), whereas any of the pulses (e.g., Start) occur when any one of the Actions generate them (logical OR).

ACTION SEQUENCE

An Action Sequence (“AS”) consists of five lists of Actions executed in a defined order each time the AS is started. The lists are:

1. Zero or more Holds, executed sequentially
2. One or more Picks, from which one is chosen
3. Zero or more Holds, executed sequentially
4. One or more Places, from which one is chosen
5. Zero or more Holds, executed sequentially

In a Subtask with a single AS, the AS will start if a Pick is available to run. In a Subtask with multiple AS’s, an AS will start if both a Pick and a Place are available to run. Normally, an Action Sequence will run to completion once it starts. However, if the start condition becomes false before a Pick has been completed, the AS will abort. If an AS has picked a part but there is no available Place to run, the AS will continue to run and wait until the Place becomes available.

SUBTASK

A Subtask comprises one or more Action Sequences.

Subtasks are defined to end when no Action Sequence is running and either:

a. all of the Place counts for all Actions in all Action Sequences in the Subtask are full or,

b. the Skip signal is true.

Errors (e.g., pick or place failures) will not cause a Subtask to end and will not cause the count to be incremented. Therefore, if errors prevent Actions from running and Place counts can't be satisfied, the Subtask may never end.

Signals

In Intera, there are a number of task elements to which signals can be attached. These include the overall task, subtasks, action groups, as well as individual actions. The meaning of a signal is dependent both upon its type and the place to which the signal is connected. Discussed below are each of the places that support signals and each of the signals they support.

TASK

These signals are accessed in the Task Order screen. For non-coordinated tasks, these signals can be attached separately to the task for each arm, except where noted. For coordinated tasks, these signals are attached to the overall task.

INPUTS

- **Ready (level (gate))**: checked before starting the first subtask of a task. When true, allows the task to start.
- **Task Reset In (edge, level)**: as an edge, resets the task. The reset happens immediately, all counts are reset and, if running, the task is started over from the beginning. As a level, the task will remain paused while true.
    - Acts like pressing Reset from the menu, but will not start the task if it's not already running.
    - If either arm is gripping an object at the time of reset the task will not run and Intera will show confusion.

- **Error In (level):** when true, the robot is stopped. The user will need to press the run or reset button. The Error In signal can be asserted at any point in task execution, or even during training.
    - The Error In signal can be assigned to the task for each arm, but asserting the signal on either task will stop both arms.
- **Pause (level):** At any point during task execution, if the pause signal is asserted, task execution will be paused until the pause signal is cleared.
- **Reset Count (edge):** When the Reset Count pulse is detected, the task count will be reset.

OUTPUTS

- **Done (level)**: true when the task is done, i.e., it has completed the number of cycles specified by the count.
    - Goes to false immediately when the task is reset.
    - A task is only considered Done when it has completed the specified count of cycles. If error conditions prevent the task from finishing then its count will not increment and it will not be Done.
- **Increment Count (pulse)**: sent when the task has completed its last subtask and the task count has been incremented.
    - If a subtask is unable to complete because of errors, then the task won't complete and this signal will not be sent.
    - If all subtasks are complete either because their count is done and has not been reset or Skip is asserted, the task count will increment rapidly until a subtask starts to run. In this case, the Task Increment Count signal won't be particularly useful.
- **Error Out (level)**: true when there is an error that prevents the task from running.
    - Error Out is asserted when there are alert stop messages from the UI including EStop.
    - In a non-coordinated task, though the task for each arm has a separate Error Out signal, they are usually both the same. (If Task Editor is used to set the FailureStrategy to Stop, then an Action failure on one arm can assert Error Out on that arm without asserting it on the other.)
    - If the Error Out signal is due to task-related causes such as failure to pick or place, it will be reset when the task is reset. If the signal is due to hardware or external errors, it will remain asserted through a reset until the error condition itself is cleared.
    - For non-error conditions see Confusion below.
- **Confusion (level)**: true when the robot is showing confusion.

- In a non-coordinated task, it is possible for one arm's task to be paused due to confusion while the other arm's task continues to run.

- **Reset (pulse)**: signals pulses true when the task is reset by any means.

SUBTASK

INPUTS

- **Ready (edge, gate)**: when true, allows the subtask to start. When a task reaches a subtask with a false Ready signal, the task will pause until the signal becomes true. The rising edge of Ready immediately resets the subtask count.
- **Skip (gate)**: when true, causes the subtask to finish as soon as it can and the task to continue to the next subtask.
  - A Skip signal is only examined between Action Sequences. A subtask will never end while in the middle of an Action Sequence.
  - If Skip is true when a subtask with count of one is about to start, the subtask will be skipped.
  - A skipped subtask will increment its count and send an Increment Count signal.
- **Do Subtask (level):** When associated, signal must be asserted for subtask execution to occur.
- **Reset Count (edge):** When the Reset Count pulse is detected, the subtask count will be reset.

OUTPUTS

- **Done (level)**: true when the subtask is done, i.e., it has completed the number of cycles specified by its count.
- **Increment Count (pulse)**: sent when the subtask has completed a cycle and the subtask count has been incremented.
- **Start (pulse):** signal pulses true when subtask execution starts
- **End (pulse):** signal pulses true when subtask execution ends

GRIPPING ACTIONS: PICK, PLACE

INPUTS

- **Ready (enable, edge):** when false, prevents the action from running. When true, allows the action to run if all other conditions are met (e.g., count.) In addition, the rising of edge of Ready immediately resets the count the on the action depending upon the reset always/full setting.

- If Ready goes false while an action is running and the action has not yet taken place (i.e., the part has not yet been picked or placed), then the action is aborted immediately. If the action has been performed then it completes normally regardless of the state of Ready.

- **Reset Count (edge):** When the Reset Count pulse is detected, the action's count will be reset.

OUTPUTS

- **Done (level)**: true when the Action's count has been reached.
  - Due to the automatic reset of counts, if a Ready signal isn't connected Done may be on for only a short time, but in no case less than 0.5 seconds.
  - Internally, Intera counts the number of parts available for a Pick or Place. Therefore, Picks count down and assert Done when the number of available parts reaches 0. If a Pick fails a certain number of times in a row, normally 2, one of two actions will be taken:

    1. The Pick goes into an error state which leaves the count alone, so Done will not be asserted. This is the default.
    2. If the SoftFailureLimitAction attribute is set to EMPTY, the count will be set to zero (a sensed empty condition) and as a result Done will be asserted.

- **Increment Count (pulse)**: sent when the Action has succeeded and the count has changed.
  - The pulse is sent when the Action successfully picks or places a part and the count has changed. This is typically after the retract motion has completed, but may be earlier if the Action is aborted during the retract phase, e.g., if the user grabs the cuff.
  - The internal count is not changed when an error occurs, therefore the increment count signal will not be pulsed.

- **Start (pulse)**: sent when the action is starting its approach.
  - One pulse will be sent for each retry of the Action.

- **End (pulse)**: sent when the action has finished its retract.
  - The pulse is sent when the Action has completed, whether successful or not, typically after the retract motion.
  - One pulse will be sent for each retry of the Action.

OTHER ACTIONS: HOLD

INPUTS

- **Ready (level (enable))**: when false, prevents the action from running. When true, allows the action to run if all other conditions are met (e.g., count.)
    - If Ready goes false before the hold time is up, then the Hold is aborted immediately and the Action Sequence will wait until Ready becomes true before restarting the Hold.
    - Since Holds in an Action Sequence are executed sequentially, the task will be paused when it encounters a Hold with a false Ready signal.
- **Skip (level (gate))**: if true any time during the hold period, the Hold acts as if the wait time has completed.
    - The Hold will always execute the approach and retract regardless of the Skip signal. However, the Skip signal can reduce the hold time to effectively zero.

OUTPUTS

- **Done (level)**: not applicable.
- **Increment Count (pulse)**: not applicable.
- **Start (pulse)**: sent when the Hold is starting its approach.
- **End (pulse)**: sent when the Hold has finished its retract.
- **Active (pulse):** When the hold is active / currently holding at the hold pose, the active signal will be pulsed true.

ACTION GROUPS

When actions are in a group, signals can only be attached to the action group and not to individual actions within the group. When an input signal is attached to an action group, it acts as if it was attached to each action within the group individually. When an output signal is attached to an action group, it is true if the output of any of the individual actions is true, and false otherwise (i.e., the outputs of the individual actions are OR'ed together.)

FAQs - Signals and Their Definitions

Q: How long will a Done signal stay true after completing a Task, Subtask, Action?

A: In general, the Done signal remains true until the count on the element is reset. When using automatic reset, i.e., the Ready signal isn't being used, Action counts are reset when their containing

Subtask ends, whereas Subtask counts are reset when the Task completes. Due to the automatic resetting (e.g., in a Subtask with only one Place Action, the Subtask will end when the count is satisfied and then immediately reset the count). Done signals may only stay true for a short period of time, but in any case no less than 0.5 seconds.

Q: Why doesn't my Action run the second time through even though the Ready signal has always been true?

A: Check the count, which is only reset on the rising edge of Ready. Therefore, if you have a count of 1 and you leave Ready true, the Action will only happen once and the count will never be reset. If you're using Ready to control a Pick, set the count to infinity. If you're using Ready to control a Place and are using multiple subtasks, you can either set the count to infinity and use the Skip signal to move on to the next subtask or make sure that you cycle Ready false to true to reset the count.

Q: How do I use signaling and an external PLC to run Action Sequences out of order?

A: There are two main approaches to using signaling to run sequences out of order using an external PLC:

1. Put multiple Action Sequences into single Subtask using the combine operation on the Task Order screen. Use Ready signals on the Picks to choose which Action Sequence to run.

    a.Counts should be set to infinity for all Picks and Places, since the single subtask never ends and the sequence is being controlled externally.

    b. The Ready signal for a Pick must be held true until the action completes. A way to reliably synchronize is to monitor the Increment Count signal and use that to clear Ready. An alternative approach would be to use the Increment Count on the corresponding Place, which would allow the Pick to repeat if the part was dropped. Which approach is better is highly dependent on the application.

2. Put each Action Sequence into its own Subtask and use the Subtask Skip signal to choose which Subtask to run.

    a. All Subtasks should have their own Skip signal connected. In the idle case, all of the Skip signals should be true.

b. To run a particular Subtask, the PLC should set that Subtask's Skip signal to false. To operate reliably, the signal should remain false until the PLC receives a positive acknowledgment that the Subtask has started. This could be from the Start signal of the first Action, for example.

c. In order to ensure that the Subtask doesn't start again immediately upon completing the Action Sequence, Skip should be cleared immediately upon receiving the indication that the sequence has started. Since Skip is only looked at when no Action Sequence is running, this will allow the current sequence to complete and not restart.

d. Do not use the Subtask Ready signal.

Q: If I invert an output signal (e.g. Done) and have not started the task, what will the output be and when does it become inverted?

A: Inversion takes place as soon as the modification is saved in the task and the changes have time to propagate throughout the system, typically a second or so.

Q: In the case of a HOLD -> PICK -> PLACE, why won't the robot go back to the first HOLD when PICK READY is not enabled?

A: Action Sequences are defined to not start unless there is an available Pick. This is to prevent the robot from getting stuck in a sequence when a better choice might come along. For example, a Skip signal might want to end the Subtask, but that can't happen in the middle of an Action Sequence.

Q: If two input signals become true at the same time (e.g. Pick Ready and Subtask Skip), can I predict what will happen? Is there a way to understand what has a higher probability of getting chosen?

A: Relying on the robot's behavior in this case is fundamentally unreliable system design. This is a classic synchronization problem and there is fundamentally no way to predict which signal will take priority. Whichever one Intera happens to notice first will take effect. Note that even in a procedural language, where you might be checking one signal then the other in a loop in order to decide what to do next, if they change at literally the same time you can't predict which one will be noticed first.

In situations where two signals might change at nearly the same time and predictable behavior is defined and required, we highly recommend that you use a PLC and logic that creates a window in

which both signals are examined and an unambiguous decision is made, which is then communicated to and synchronized with Intera by asserting only one signal representing the required action.

Q: Where can I get the most up-to-date information on signals, Intera 3.1, or anything else related to Baxter?

Please visit our Wiki at: mfg.rethinkrobotics.com

Appendix E: Transfer Tasks from One Baxter to Another

You can copy tasks from one robot and transfer them to another using a USB memory stick. Details of the task are included in the transfer. You only need to update the device referenced. This capability is useful when a factory is using multiple Baxters to perform the same task.

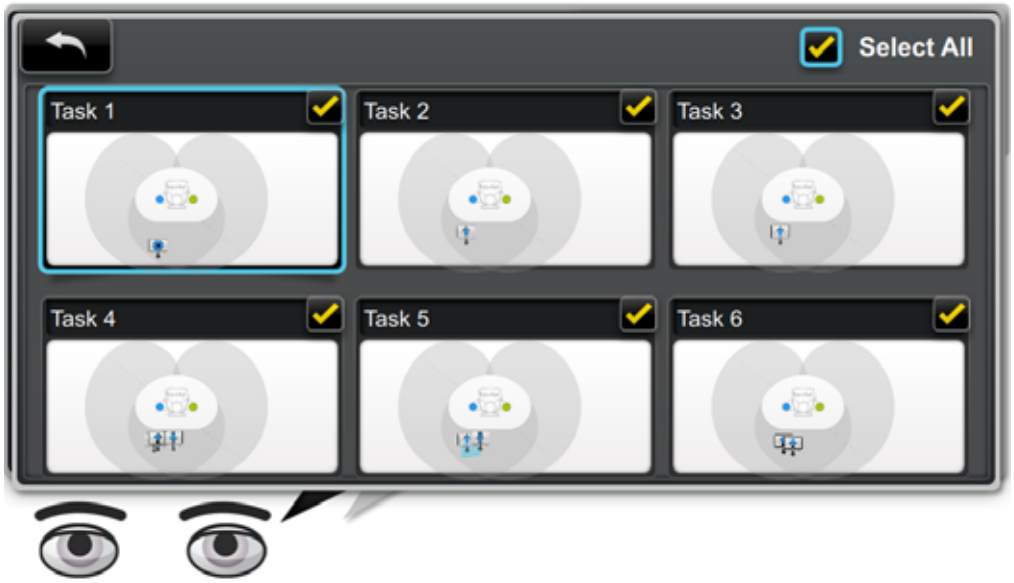
When transferring tasks to a different robot, variability across robots and fiducials are not taken into account.

Note: If you have multiple exports of tasks on the same USB stick, only the most recent set of exported tasks will be imported.

How to Export Tasks from a Robot

1. Insert a USB device, formatted as FAT32, into the USB port on Baxter.
2. On Baxter, go to
3. **Main Screen > Settings > Advanced > Export/Import Tasks**.
4. Scroll to **Export**.

5. Press OK. Baxter displays its tasks. All tasks are selected by default.



6. To select just some of the tasks, scroll to each particular task and select it or deselect it by pressing OK when it is highlighted.

7. When the tasks you want to export are highlighted, press the Rethink button on the Navigator, then select Export.

A bar displays the progress of the export to the USB.

Note: If you press the Back button during the export process, the export will be canceled.

How to Import Tasks to a Robot

1. Insert a USB device that contains exported tasks into the USB port on Baxter.
2. On the Baxter that will receive the copied tasks, go to
3. **Main Screen > Settings > Advanced > Export/Import**.
4. Scroll to **Import**.
5. Press the OK button on the Navigator.

A bar displays the progress of the import.

Note: If you press the Back button during the import process, the import will be canceled.

COPIED TASKS

If Baxter already had a task named “Task1” in its Task Gallery, the newly created name would be incremented by .1, e.g., “Task1.1.”

A TROUBLESHOOTING CHECKLIST FOR IMPORTED AND EXPORTED TASKS

Because the physical world of the two Baxters – the Baxter from which the task was imported and the Baxter to which the copied task was exported – are not identical, you may need to refine these tasks. Here is a checklist of troubleshooting situations you may encounter:

- The grippers may not match.
- Different Baxter heights – The task runs but the robot is missing picks and places because the height of the pedestal is different (the wheels have been adjusted; the original Baxter is mounted to a table) etc.
- The task runs but Baxter’s position from the work surface is different from the original, in distance and/or angle.

- The task runs but the workspace is different from the original in some way. In this case, the operator has to tweak the layout of the workspace or the paths of Baxter's arms.
- The lighting is different. That could affect Baxter's vision. See "How to Change the Lighting Settings for Baxter's Cameras."

Appendix F: Tips & Best Practices

Training Actions

- Before starting to train a Pick action with the parallel gripper, set the fingers in the correct position for the grasp type (inside/outside).
- When training multiple Pick or Place actions in a row, it helps increase performance accuracy to have an object in hand.
- Train locations within the workspace limits.
- To create a valid task, train both a Pick and a Place location for the arm performing the task. Remember: a task must be made up of a pick followed by a place.

Vertical and Non-Vertical Tasks

As of Intera 3 software, it is no longer necessary to train a non-vertical task to take advantage of faster speeds, location-based picks, force sensing, etc. There are no performance differences between vertical and non-vertical tasks. However, vision search is available only for vertical Picks. The camera does not operate for non-vertical tasks.

Workspace and Robot Joint Limits

The ability of Baxter to perform actions at any given location is affected by the physical limits of the arms. When training an action, consider:

- Each of the robot's joints has limits. The closer you are to the edge of these limits, the greater the chance the robot will be unable to train an action.
- If the orientation of the training cuff on demonstration is twisted near a limit, the robot may have trouble when you run the task. If you notice Baxter cannot reach a location, try moving the location closer to the robot, or re-train the location.
- The possible vertical range of an action is reduced as you move closer to the edges of the maximum available workspace of the robot.

Waypoint Wisdom: Tips for Creating Custom Paths

Note: Click here for a Baxter University video tutorial about waypoints and paths.

- The first and last point you create for an action, which becomes the approach and retract point, is important. When creating these points, think about their relation to the picks and places, and make sure their pose makes sense. For example, is there a clear path between the approach point and the pick? It will be a straight line along the gripper. Keep this in mind when planning your approach and retract points.
- As of Baxter software 2.1, it is no longer necessary -- or even desirable -- to define a large number of waypoints when training a path. The more transit points you add, the longer the path and therefore, the more time the task will take. Also, if you train a number of waypoints relatively close together along a path, Baxter's arm movement will become jerky. Therefore, the best practice is to train just those points needed to avoid obstacles that may be in Baxter's path.
- Think Baxter's arm path through before you create it. Do a dry run by manually moving the arm before creating the waypoints. Move the arm through your planned path and don't focus just on the wrist. Instead, take into account the entire length of the arm as you move through the path. Do the joints – including the shoulder and elbow – ever approach their limits? Does Baxter's arm as a whole ever get twisted or distorted? Does the Navigator start on one side of the arm and end up on the other? Baxter will work better when its arm remains relatively untwisted as it moves along its path.
- When you reach the end of your path, it's a good idea to make sure the wrist is still able to rotate easily when it performs the place. Try to make sure the wrist rotation is in the mid-range of its limits.

Grasping Objects

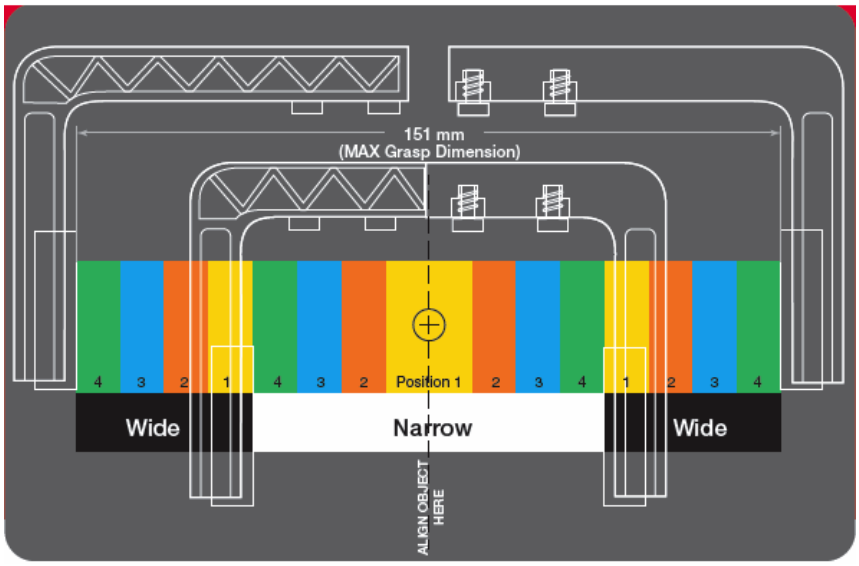
The ability for Baxter to successfully grasp and pick up objects depends on several factors, including:

- Gripper selected and associated components (such as, fingers, finger tips, vacuum cup size)
- Proper gripper configuration
- Grasp position relative to the object's center of gravity
- Grip detection threshold setting
- Consistency of the pickup location on the work surface

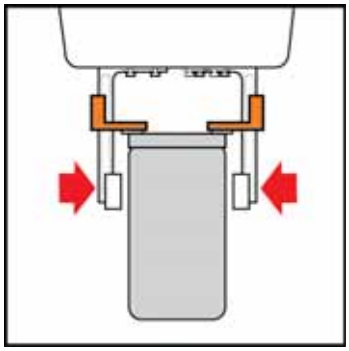
The illustration below (not to scale) shows the *Finger Selection and Position Guide* included in the inside cover of the *Parallel Gripper Kit*. Key concepts to remember when choosing fingers and position are:

1. Place the object in the center of the chart in the same orientation as the robot will grasp it.
2. Use the object's edges to determine the best fingers and position.
   - Consider finger tip thickness, as it will alter grasp range.
   - There should be at least 1 cm of clearance between the part and the finger tips when the gripper is open (outside grasp).
   - If object edges are on the lines of a zone, choose the next position, or next size fingers.
3. Try different finger tips based on the shape and size of the object.
4. Consider adding a limiter to give additional stability.

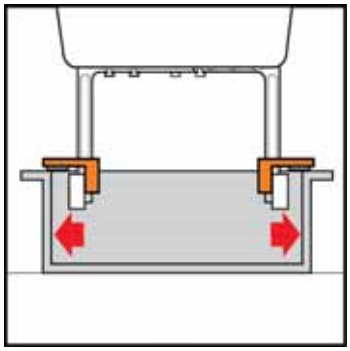
   Also, Consider cutting and adhering the silicon material included in the gripper kit to the flat finger tips to provide a better grip when grasping objects with the flat finger tips.



You may also want to try different locations on the object for grasping. Consider which would be better—an “outside grasp” shown in the left illustration below, or an “inside grasp” shown on the right.



Outside grasp



Inside grasp

Object Training and Visual Search

- Visual search works only for vertical tasks.
- Generally, using a visual search area will take more time to complete a task.
- Keep the work surface clear of clutter.
- Choose solid-color work surfaces.
- Glare from the object or surface can affect object training.
- Aim to have high contrast between an object and the surface.
- Baxter cannot learn an object if it is moving during training.
- See “Training a Pick Using Vision” on page 36 and “Camera Settings” on page 45 for more details about how to effectively train Baxter using vision.

Conveyors

- Pick actions from conveyors require object training and a visual search area; Baxter cannot learn a blind, moving, Pick action.
- Trace the smallest possible visual search area necessary for the robot to be able to find the object and complete the Pick action along the conveyor.
  - **o** If the object is located in the center of the conveyor widthwise, trace a narrower area that runs lengthwise along the conveyor.

- **o** If the location of the object is randomly located anywhere on the conveyor belt, trace an area that is the full width of the conveyor.

Stacks

- When training a stack above the waist, train the bottommost object in the stack and use Contact or First as the Action Control. See “How to Make Detailed Modifications to an Action (Advanced Settings Screen)” on page 71.

Multiple Locations

When training multiple Pick or Place actions in a row, always have an object in hand to increase accuracy in performance.

Appendix G: Safety Mats

Baxter supports the optional use of a safety mat—a 4-wire Normally Open (N.O) configured mat of any size or shape (user-supplied, not included. To connect a safety mat to Baxter, use a terminal block that can connect to the DB15 connector on the I/O panel on the back of the robot's waist, and support a male-configured DB15 connector for the e-stop button.

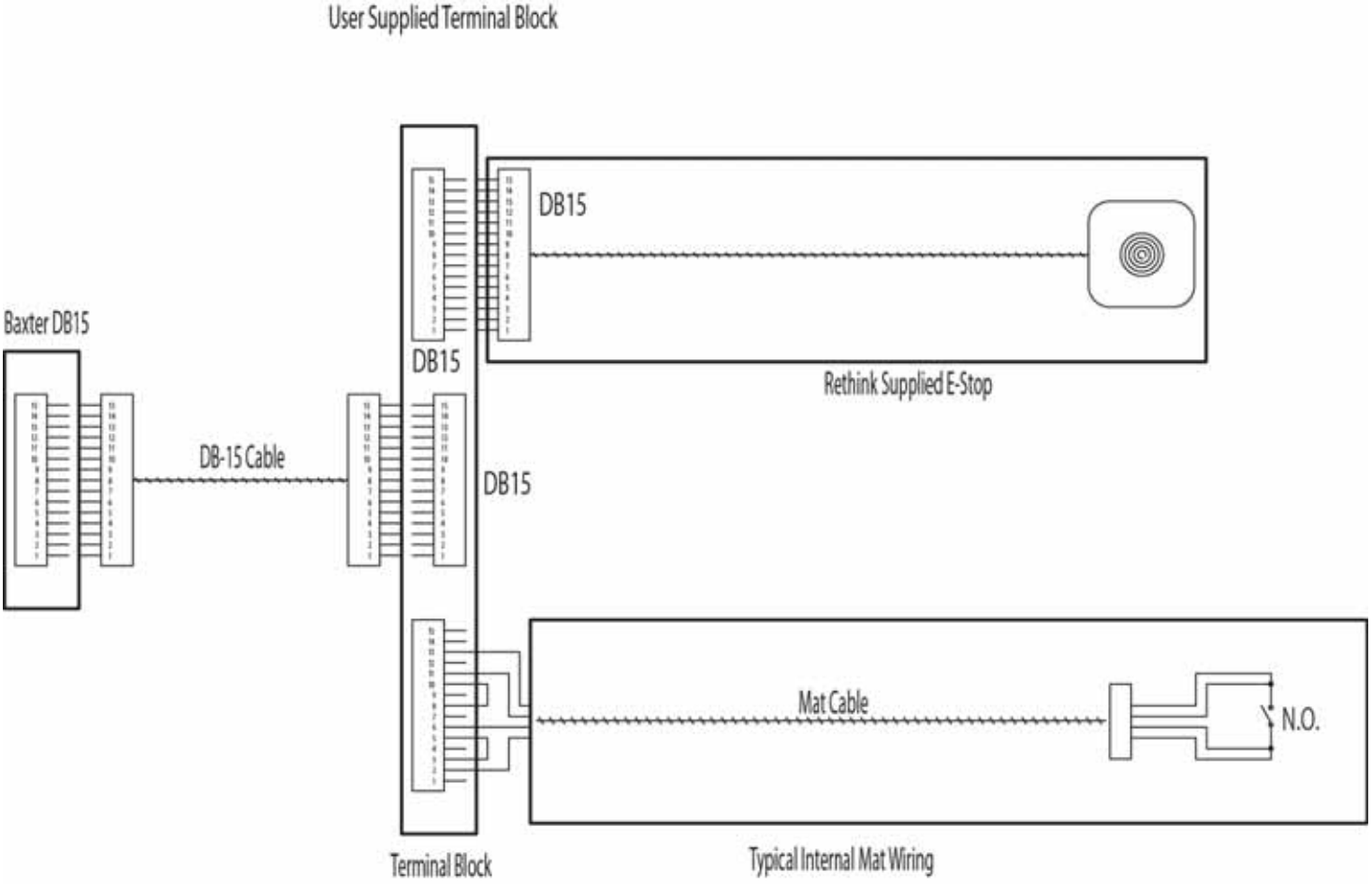
IMPORTANT If e-stop wiring is not properly configured, the Baxter arms will not operate.

To configure the terminal block:

1. Power Baxter down and remove the e-stop assembly.
2. Connect the terminal block connector to the DB15 connector where the e-stop button was originally connected.
3. Run the bare wires from the safety mat into the terminal block, and wire them with appropriate jumpers, as shown in the diagram on the following page. To ensure full e-stop support, pass the e-stop wiring through to the illustrated pins on the extended DB15 connector.
4. Once configured, with the terminal block and e-stop properly connected, power Baxter on per normal operation.

   Note: When Baxter is working, if a user steps on the safety mat, Baxter will slow down and express surprise.

A wiring diagram is included on the following page.



Note: Unless shown as a jumper in the above diagram, all other wiring is pin-for-pin on each connector.

Appendix H: Support & Warranty

The Baxter robot comes with a one (1) year limited warranty.

If there is a problem with your robot and you are unable to resolve it, try shutting down and restarting the robot. If the problem persists, contact your authorized Rethink Robotics service provider for technical support. You will need to provide the model and serial number of the robot experiencing the problem. These can be found on the back of the robot near the power button.

If the product is no longer within the warranty period, the authorized Rethink Robotics service provider will provide an estimate of the technical support or repair costs.