LIDAR
Field Calibration Procedures

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Contents

Revision history

Table 1 Revision history

Revision #	Description
01	Initial Release

Intended audience

This document is intended for internal Brain Field Service Engineers (FSEs), OEMs, external service providers, and anyone else involved in the replacement and recalibration of LIDAR sensors on a BrainOS-powered floor scrubber.

Overview

This document details the planar (lower) LIDAR calibration and slanted (upper) LIDAR calibration procedures for OEMs when working in the field.

After the LIDAR replacement and alignment adjustments, the OEM field technician trains multiple routes, which are then used to calculate the sensor locations relative to the base link.

Determining which calibrations to perform

After replacing one or both LIDARs in the field, the machine needs to be recalibrated accordingly.

On the technician's first visit to determine if a LIDAR is damaged, the technician needs to record the calibration method used to previously calibrate the LIDAR that is being replaced. The Print Calibration screen in the BrainOS software is used to determine which calibration procedure to use in the field for the new LIDAR:

- If the method of the previous calibration is 'semigloss' or 'auto', the technician performs calibration on the LIDAR being replaced.
- If the method of the previous calibration is [blank], the calibration procedure depends on which sensor is being replaced:
    - For slanted (upper) LIDAR replacements, the technician performs upper LIDAR calibration using the corresponding procedure in this document.
    - For planar (lower) LIDAR replacements, the technician contacts Brain Corporation for assistance with the calibration procedures.

To determine which type of calibration was previously performed on this machine, use the following steps:

1. On the main menu, select **Settings > Service** from the main menu.

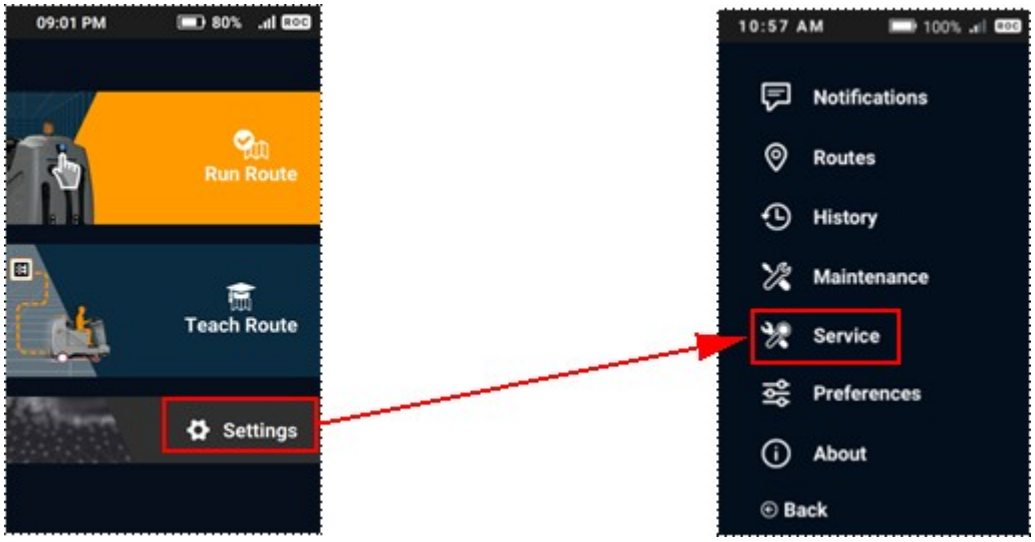

*Figure 1 **Settings** > **Service** option*

2. Enter the 4-digit service PIN (this is different than the PIN used for normal operation).

Figure 2 Enter Security PIN screen

3. Select **Diagnostics** from the Service menu.

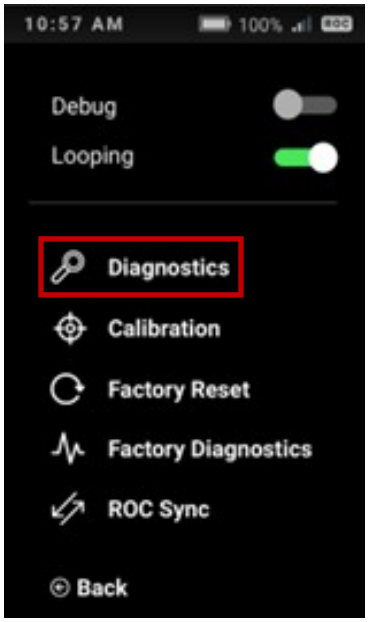

*Figure 3 **Diagnostics** option*

4. Select the **Print Calibration** option.

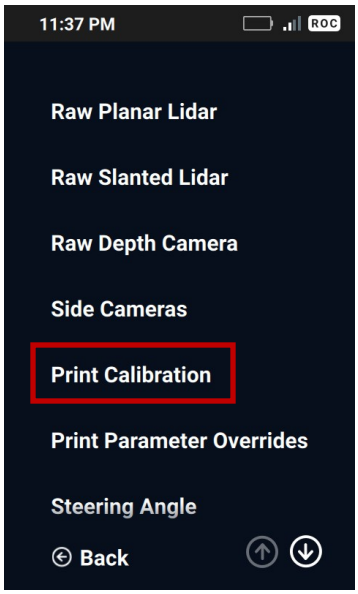

*Figure 4 **Print Calibration** option.*

5. Press the left or right side of the screen until the **slanted_lidar_config.yaml** or **planar_lidar_config.yaml** file is visible at the top of the screen.

   ***NOTE:** There are invisible buttons on the sides of the Print Calibration screen. Keep pressing different parts of the left or right side of the screen until it changes.*

6. Verify the entry in the **method** field of the relevant YAML file: **semigloss**, **auto**, or the entire field is missing (resulting in a blank line).

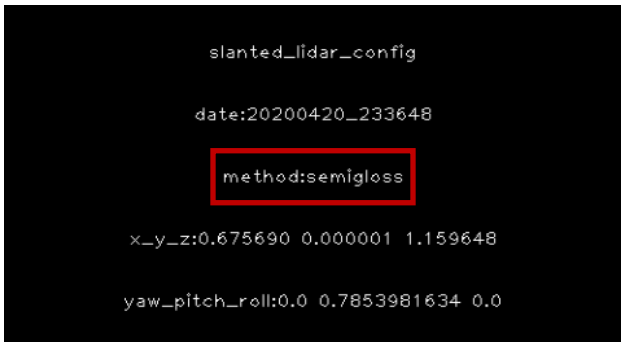

Figure 5 YAML file method = semigloss

Figure 6 YAML file method = auto

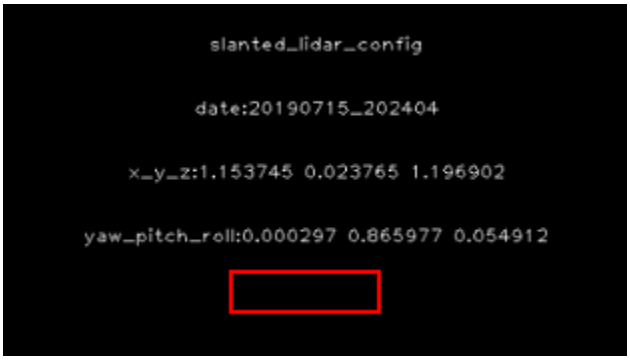

Figure 7 No line for YAML file method (blank line)

7. Refer to the following table to determine which calibrations can be performed by the OEM field technician.

Table 2 Required field calibrations

Sensor being replaced	Method is semigloss or auto	Method is [blank]
Slanted (upper) LIDAR	OEM (see *Upper LIDAR field calibration procedure*)	OEM (see *Upper LIDAR field calibration procedure*)
Planar (lower) LIDAR	OEM (see *Lower LIDAR field calibration procedure* and *Lower LIDAR yaw field calibration procedure*)	**Brain technician (contact Brain Corporation)**

Lower LIDAR field calibration procedure

Required equipment/tools

- IR goggles
- Tape measure (> 2 meters)
- 3 targets with limits at 17 and 20 cm, or LED LIDAR beam detectors
- Front 3D camera cover (to shield IR light)
- Metric hex keys: 1.5, 2.5, and 3 mm
- 3 mm ball-end hex key

NOTE: *The upper LIDAR and lower LIDAR have unique IP addresses associated with the hardware, and are therefore not interchangeable.*

Procedure

To perform lower LIDAR field calibration on a machine, use the following steps:

1. Replace the lower LIDAR sensor using the machine's service manual.
2. Move the machine to an area with the following characteristics:
   - A floor with 2 meters of open space in front of the machine, and on each side of the machine.
   - A floor without steps, holes, transitions, or damage. The floor should be level as well. If in doubt, measure the floor with a laser floor level.
   - An area without reflective surfaces, including storefront glass.
3. Turn on the machine.

4. Cover the front 3D camera with thick cardstock or cardboard.

Figure 8 Front 3D camera – covered

5. Align the scrubber to LIDAR targets at 90-degree angles, as shown in the figure below. The lower LIDAR-to-target distance should be 6 feet, 7 inches (2 meters).

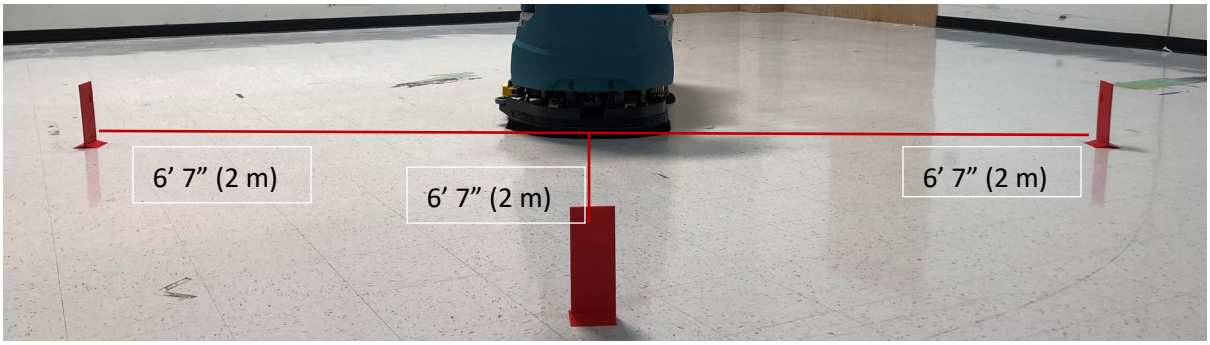

Figure 9 Lower LIDAR-to-target distance

6. Refer to the following figure for the next three steps.

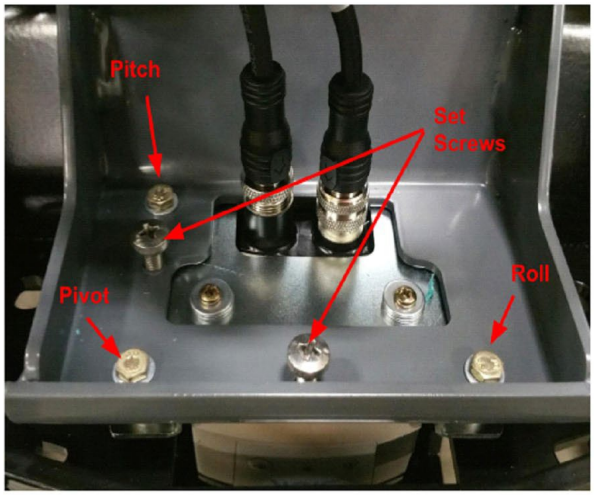

Figure 10 Lower LIDAR set screws and adjustment screws

7. Use a 1.5 mm hex key to rotate the two set screws counterclockwise until approximately 4 to 5 threads are exposed.

Figure 11 Lower LIDAR flush with lower LIDAR protector

8. Using a 3 mm hex key, rotate all three adjustment screws clockwise until they are each hand-tight.
9. Using a 3 mm hex key, rotate all three adjustment screws counterclockwise two turns each to loosen them.
10. Using the IR goggles, ensure that the LIDAR IR beam appears as a 2 cm-wide band of flashing white light, as shown below.

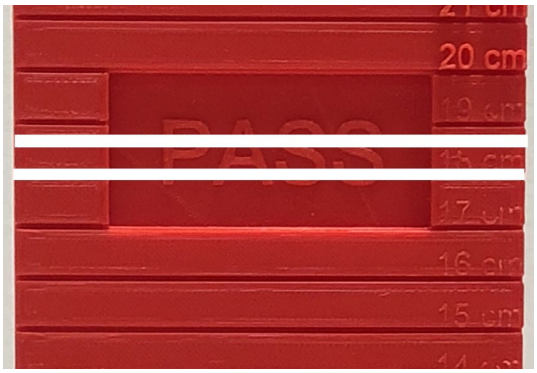

Figure 12 View of LIDAR IR beam – using IR goggles

11. Loosen the pitch and roll adjustment screws as necessary until the IR beam is within the acceptable range on all targets, as shown and described below.

NOTE: *Do not loosen the pivot adjustment screw unless instructed to do so by a Brain technician.*

- The beam on the front target must be within the acceptable range (17 cm to 20 cm).
- The beam on the left and right targets must be at the same height, with an absolute minimum value of 13.5 cm (see *Troubleshooting*).

Figure 13 Lower LIDAR front and side targets

NOTE: *Damage to the lower LIDAR may render traditional adjustments ineffective, as shown below.*

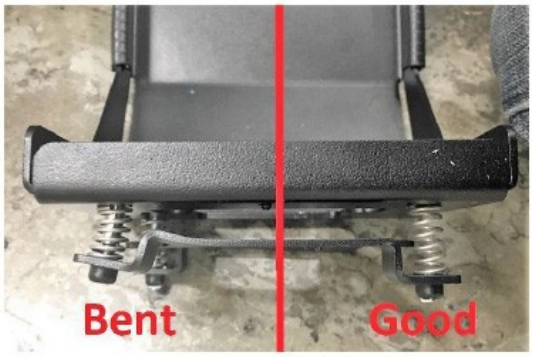

Figure 14 Damaged lower LIDAR vs. undamaged lower LIDAR

12. Tighten the set screws. Fine tune the adjustment screws to keep the beam within the acceptable ranges.
13. Ensure that the bottom of the lower LIDAR is still flush with the upper part of the teeth of the lower LIDAR protector.

Troubleshooting

The following scenarios may occur during lower LIDAR field calibration:

- **The beam cannot be seen:** Move the targets to 1.5 meters or find a spot with less ambient light.
- **The beam appears split into two narrow beams, with a small gap between them:** This is normal.
- **The sides cannot be adjusted to be within the nominal range:** This is normal. Only the front needs to be within the nominal range (17 cm to 20 cm). The sides must be equidistantly away from the nominal range (in other words, their values should match), and must be above 14 cm (13.5 cm is the absolute lowest value). If either of the side target values is below 13.5 cm, replace the lower LIDAR and redo the lower LIDAR calibrations.
- **Turning the adjustment screws does not move the beam:** Push on the center of the plate with a finger, or tighten the set screws during the procedure.
- **Many rotations are needed on one or more of the adjustment screws (more than 8 full rotations):** Inspect the brackets for damage or bent parts.
- **The beam moves when tightening the set screws:** This is normal. Fine tune the adjustment screws as the set screws are being tightened.

Lower LIDAR yaw field calibration procedure

To perform lower LIDAR yaw field calibration on a machine, use the following steps:

1. On the machine, select **Settings > Service** from the BrainOS main menu.
2. Enter the 4-digit service PIN (this is different than the PIN used for normal operation).
3. Select **Calibration**.

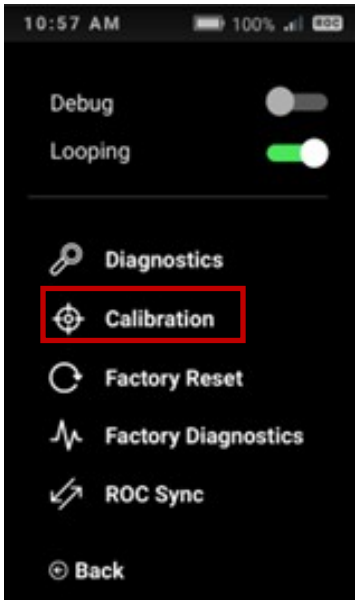

*Figure 15 **Calibration** option*

4. Select **Planar LIDAR Yaw**.

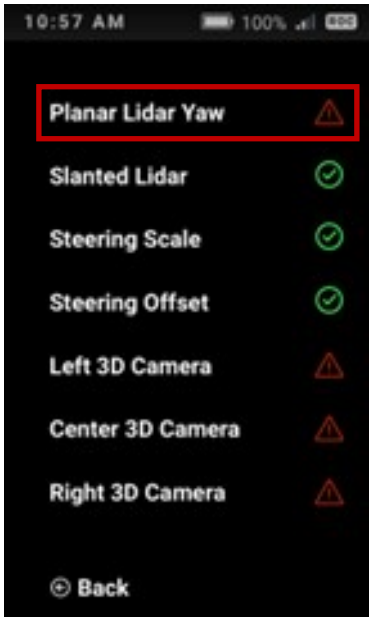

*Figure 16 **Planar LIDAR Yaw** option*

NOTE: The screen requests confirmation to reset the planar LIDAR.

5. Confirm the reset.

Figure 17 Lower LIDAR yaw reset confirmation

6. Select **Back** to return to the BrainOS main menu.

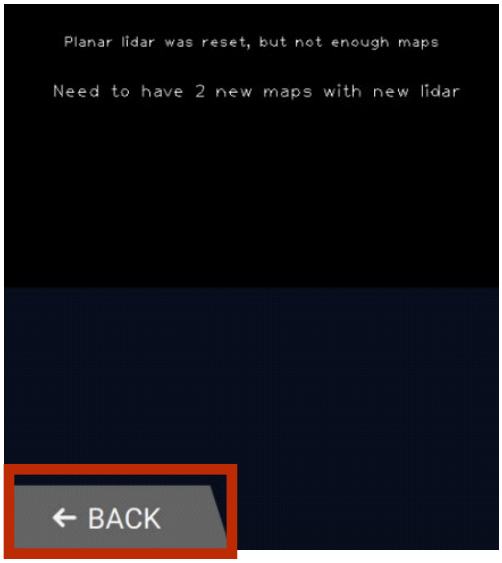

Figure 18 Lower LIDAR yaw reset – not enough maps

7. Train two routes that are each at least 10 minutes in length. Use the following recommendations to optimize these routes for the subsequent field calibration:
   - The best routes to train are against concave corners.
   - Convex corners also work well.
   - If convex corners are still not enough, use vertical walls.
   - Run the routes repeatedly close to straight walls and corners.
   - Avoid open spaces.
   - Avoid irregular environments such as areas with foot traffic, chairs, desks, and open shelves.

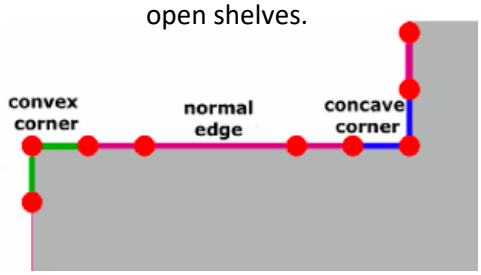

Figure 19 Recommended corners for training calibration routes

8. After training and saving both routes, select **Settings** > **Service** > **Calibration** > **Planar LIDAR Yaw.** The screen requests confirmation to use the last maps made after a reset.
9. Confirm this request.

10. During this time, auto calibration may produce one or more errors.
    - The maps may be insufficient. The solution is to train at least one more 10-minute route.

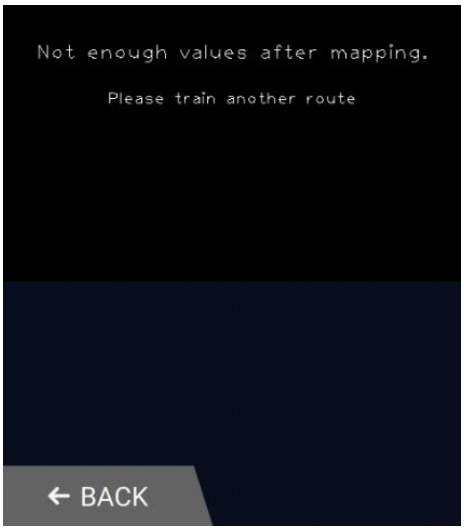

Figure 20 Lower LIDAR yaw calibration error – train another route

- The calculations do not match up, as indicated by the displayed results. In this case, perform another reset and train two more 10-minute routes.

Figure 21 Lower LIDAR yaw calibration error – reset and train routes again

11. After calibration is finished, reboot the machine.

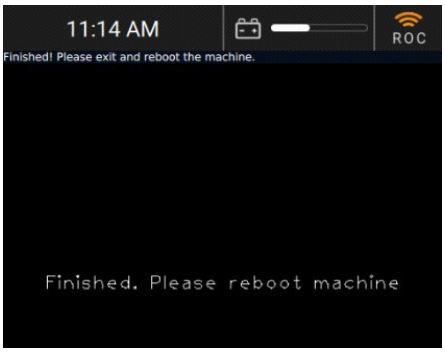

Figure 22 Lower LIDAR yaw calibration finished

Upper LIDAR field calibration procedure

NOTE: *The upper LIDAR and lower LIDAR have unique IP addresses associated with the hardware, and are therefore not interchangeable.*

To perform upper LIDAR field calibration on a machine, use the following steps:

1. Replace the upper LIDAR sensor using the machine's service manual.
2. Select **Settings > Service** from the BrainOS main menu.
3. Enter the 4-digit service PIN (this is different than the PIN used for normal operation).
4. Select **Calibration**.
5. Select **Slanted LIDAR**.

NOTE: *The screen requests confirmation to reset the slanted LIDAR.*

6. Confirm the reset.

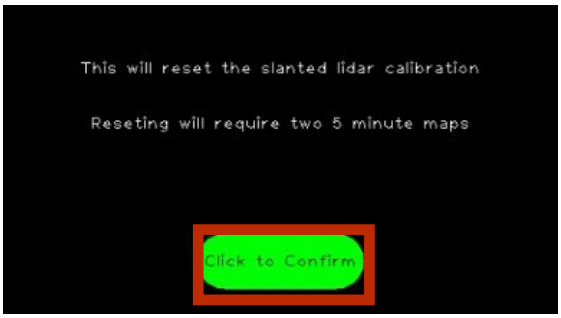

Figure 23 Upper LIDAR reset confirmation

7. Select **Back** to return to the BrainOS main menu.

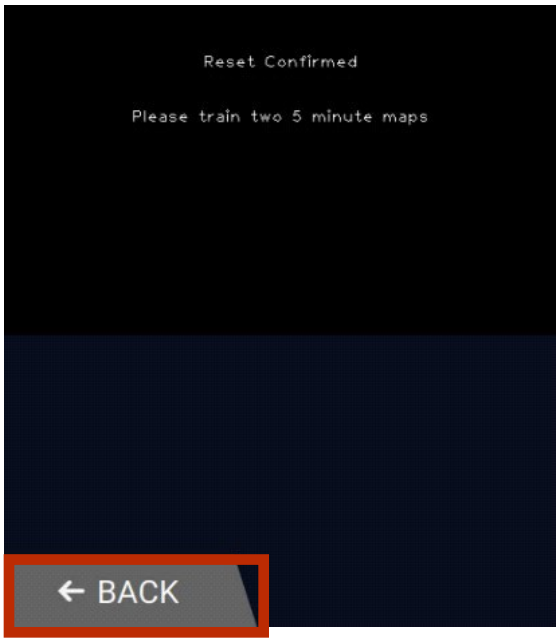

Figure 24 Upper LIDAR reset – train routes

8. Train two routes that are at least five minutes in length. Use the following recommendations to optimize these routes for the subsequent field calibration:
   - The best routes to train are against concave corners.
   - Convex corners also work well.
   - If convex corners are still not enough, use vertical walls.
   - Run the routes repeatedly close to straight walls and corners.
   - Avoid open spaces.
   - Avoid irregular environments such as areas with foot traffic, chairs, desks, and open shelves.

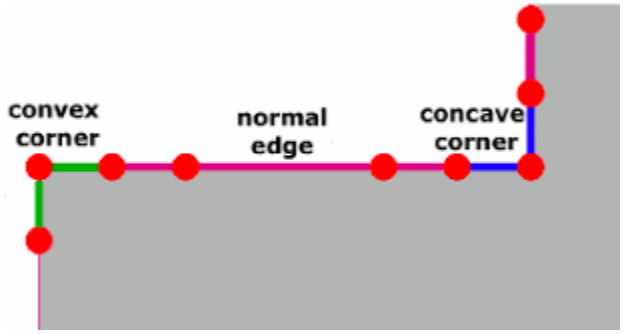

Figure 25 Recommended corners for training calibration routes

9. Select **Settings** > **Service** > **Calibration** > **Slanted LIDAR**.

NOTE: *The screen requests confirmation to use the last maps made after a reset.*

10. Confirm this request.

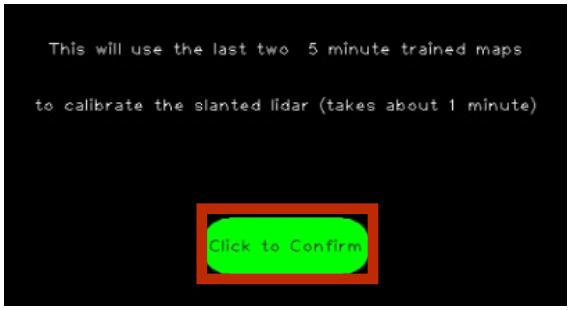

Figure 26 Upper LIDAR calibration confirmation

NOTE: Auto calibration may take a few minutes to calculate, as noted in the screen below.

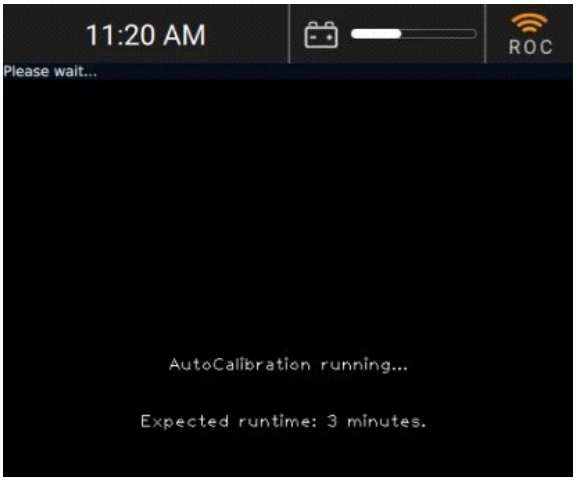

Figure 27 Upper LIDAR calibration running

11. During this time, auto calibration may produce one or more errors:
    - The maps may be insufficient. The solution is to train at least one more five-minute route.

***NOTE:** After calibration is finished, there is an option to swap the current configuration. It is possible that auto calibration (the candidate) is worse than the current calibration.*

12. Determine the quality of the auto calibration compared to the previous calibration.
    - The primary metric to compare is floor thickness. The lower the score, the better.

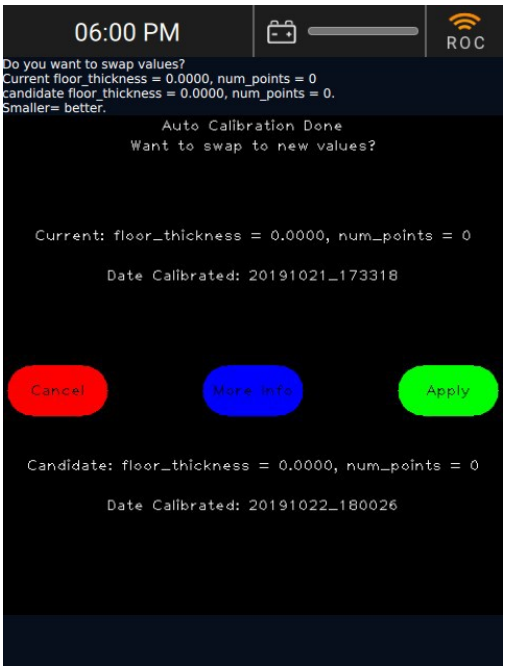

Figure 28 Upper LIDAR calibration complete – comparison to old values

    - Select **More Info** to analyze more information regarding the calibrations. This option displays the actual yaw, pitch, roll and x, y, z of the upper LIDAR for both the previous and current calibration.
13. Choose to either apply the calculated calibrations (**Apply**) or discard them (**Cancel**).
14. After calibration is finished, reboot the machine.

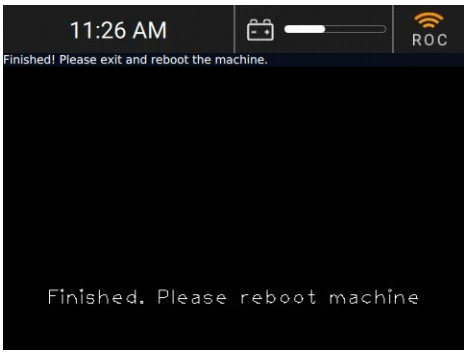

Figure 29 Upper LIDAR calibration applied – reboot machine

Post-calibration procedures

To ensure that all sensors are working properly, perform the following steps after the field calibration has been successfully run

1. Reboot the machine.
2. Run one of the routes that was created during field calibration. It is recommended that the technician chooses a route with walls on both the right and left side of the machine.
3. Walk to the front of the machine and ensure that it slows down before stopping.
4. Walk up to the machine from each side and ensure that the machine stops.
5. Place an approximately 5-inch tall, 2.5-inch diameter stationary obstacle at least two meters in front the machine's intended path, and ensure that the machine goes around this obstacle.

   NOTE: *A standard-sized soda can is an effective obstacle for this last step.*