

# Steering

## Troubleshooting Guide

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## Revision history

**Table 1: Revision history**

Revision	Notes	ECO number
01	Initial release	ECO-001003
02	Document overhaul (added solution table, comprehensive instructions and reorganized troubleshooting structure)	ECO-001139
03	June 2020 updates	ECO-001165

## Overview

This document is a step-by-step guide to diagnose and resolve steering related issues on a BrainOS-powered autonomous floor scrubber.

### Complete the steps in the order they are listed!

Check all hardware components listed in the **Hardware Inspections** section before using the touchscreen to complete the **Software Diagnostics**.

The following steps are intended to be performed in the order listed in this document, and collecting pictures and notes throughout the process is essential.

### Use the checklist!

To assist with troubleshooting, there is a troubleshooting checklist that should be printed, filled out, and submitted along with the pictures and notes.

### Need assistance?

If the steps in the troubleshooting section of this document **have been completed** and steering issues with the scrubber still occur, include all pictures, checklists, and steps performed, along with any other documentation, when escalating back to Brain Corporation Technical Support.

*NOTE: The screenshots in this document originated from machines running **BrainOS Version v2.11.1**.*

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## Troubleshooting Checklist

Use the following checklist to keep track of the troubleshooting results, referring to the relevant section in this document for details.

**Table 2: Troubleshooting checklist**

Description	Done (Yes/No)?	Result (Pass/Fail/Summary)
<b>Hardware Inspections</b>		
Check the steering U-joint.		
Check the steering motor		
Check the steering encoder		
Check the steering amplifier		

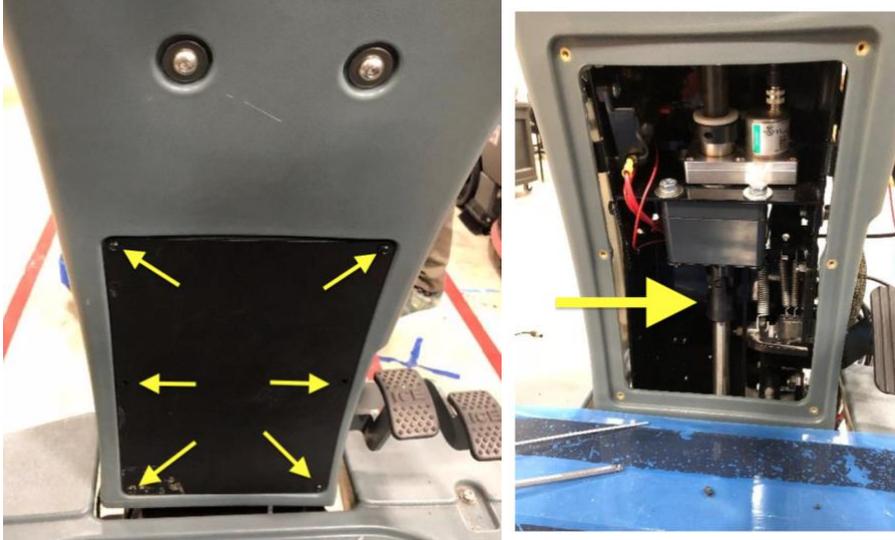
**Table 2: Troubleshooting checklist (Continued)**

Description	Done (Yes/No)?	Result (Pass/Fail/Summary)
<b>Software Diagnostics</b>		
Check the steering angle.		
Check the manual steering.		
Check the manual navigation.		
Check the automated steering.		
Check gyro noise.		
<b>Perform steering calibration</b>  <b>NOTE: this is a REQUIRED step when any component is replaced</b>		

## Hardware Inspections

### Steering U-joint check

1. Remove the access panel that is facing the operator (seat) to access the steering column.



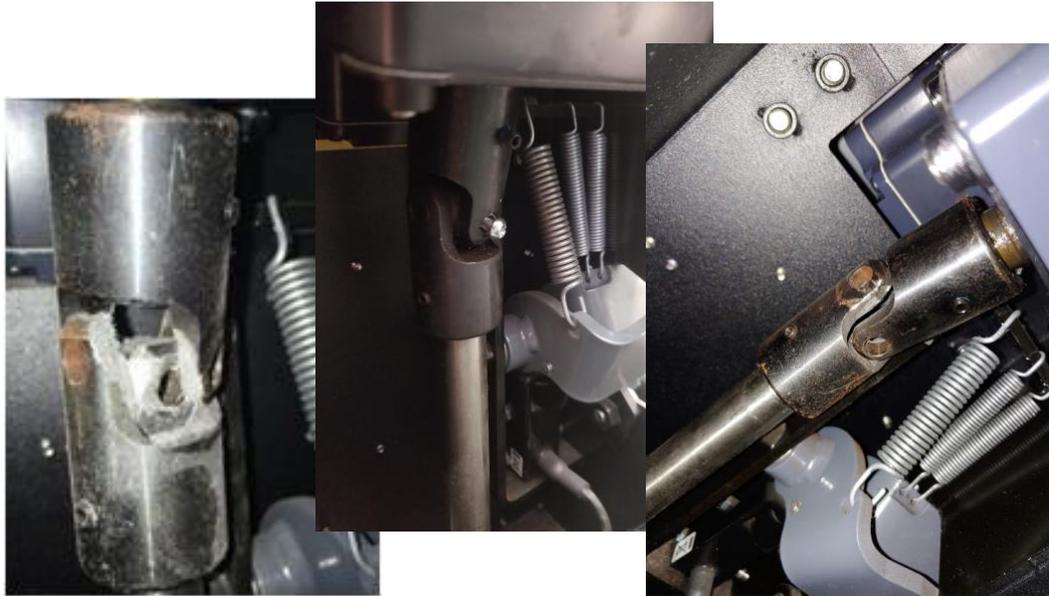
**Figure 0: Remove access panel to access steering column**

*NOTE: When inspecting the U-joint, ensure that the pin is not missing*

2. 📷 Take multiple pictures of the steering U-joint that shows the pins on all sides. 📷
3. See the pictures below for a reference.



**Figure 1: Example of a U-joint in good condition**



**Figure 2: Example of a broken U-joint**

### **Steering U-joint common issues**

This section addresses common issues with the steering u-joint. Reference the issues and solution codes below and the recommended actions located in the Steering U-joint solution table.

Look for slop in the U-joint itself. It may look good, but may be really loose or otherwise worn.

**Verify that ALL of the set screws are present - there are a total of four on ICE and two on Minuteman.** The keys within the U-joint also have to be present and in the proper location.

#### Broken, damaged U-joint or a missing PIN

If a u-joint is broken, worn out or missing a pin, reference solution code [UJOINT-01](#).

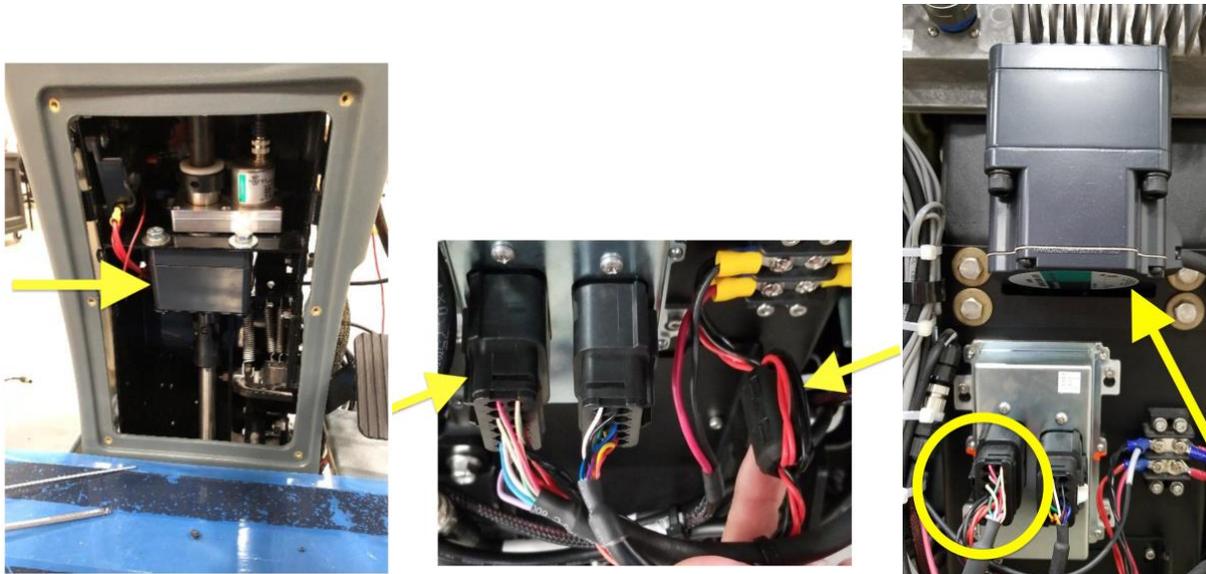
## Steering motor check

1. Remove both the front and back access panels.



**Figure 3: Removing both access panels**

2. Ensure that the steering motor cable and power connector are not loose or damaged.
3. Ensure the presence of the ferrite and it is snapped closed and that it is not broken.
4. Ensure that the steering motor is not leaking oil.
5. 📷 Take pictures of the steering motor from both front and back, along with the steering connection to the motor amp and power. 📷
6. See the pictures below for a reference.



**Figure 4: Steering motor – back and front view**

## Steering motor common issues

This section lists common issues with the steering motor. Refer to the list of issues below and take the recommended actions located in the Steering Motor solution table.

### Steering motor leaking oil

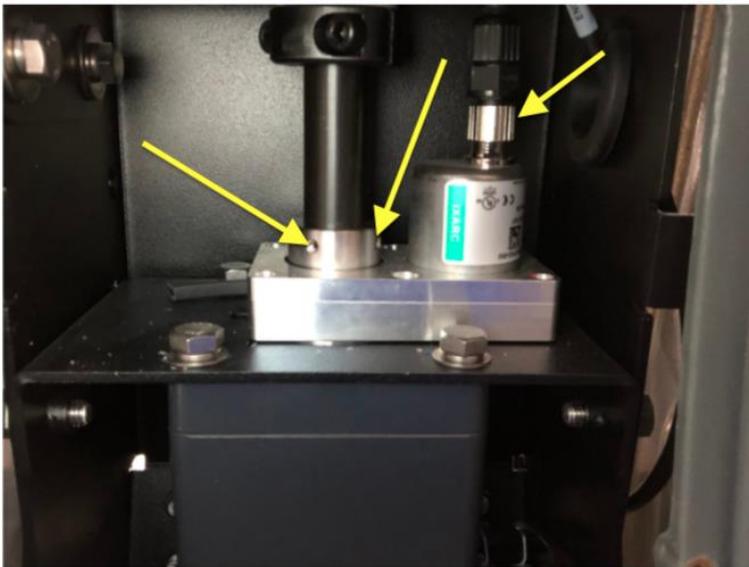
If the steering motor is leaking oil, refer to solution code [MOTOR-01](#).

### Steering motor cable damaged

If the steering motor cable is damaged, refer to solution code [MOTOR-01](#).

## Steering encoder check

1. Inspect the steering encoder and the associated wiring for physical issues.
2. Turn the steering wheel left and right to inspect that all set screws are installed.
3. Unscrew the cable for the steering encoder connected to the right cylinder, inspect the pins, and then screw it tightly back in place.
4. Inspect the steering encoder and ensure that it is properly mounted. Reference Figure 5.
5. 📷 Take pictures of the steering encoder that show the overall condition, condition of the wires, and the set screws. 📷
6. See the pictures below for a reference.



**Figure 5: Steering encoder in good condition/properly mounted**

**NOTE:** Ensure that the steering encoder cable is not loose, and the steering encoder is mounted like the picture above.



**Figure 6: Steering encoder not properly mounted**

**NOTE:** *The steering encoder pictured above is rotated*

### Steering encoder common issues

This section addresses common issues with the steering encoder. If any of these issues below are encountered, reference the solution code and the recommended actions located in the Steering Encoder solution table.

#### Steering encoder not mounted properly, or missing parts/screws

If the steering encoder is missing set screws, not mounted properly, or is damaged, refer to solution code [STENCODER-01](#).

#### Steering encoder wiring damaged

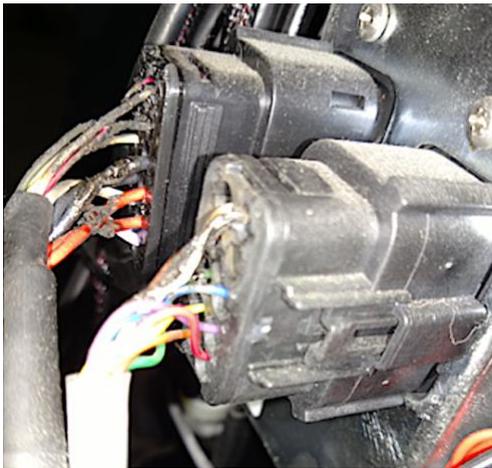
If the wiring to the steering encoder is damaged, refer to solution code [STENCODER-02](#).

## Steering amplifier check

1. Remove the front cover from the machine to check the steering amplifier module.
2. Inspect the steering amplifier and wires for damage.
3. Unplug the connectors, inspect the pins for damage, and plug them back in. Ensure the connectors lock into place.
4.  Take pictures of the steering amplifier and condition of the cables and pins. 
5. See the pictures below for a reference.



**Figure 7: Example of a steering amplifier in good condition**



**Figure 8: Example of a steering amplifier with damaged wires**

## Steering amplifier common issues

This section addresses common issues with the steering amplifier. If any of these issues below are encountered, reference the solution code and the recommended actions located in the Steering Amplifier solution table.

### Difficulty turning the steering wheel

If the wheel is hard to turn, unplug the steering amplifier connection. If the steering is easier, then it is usually a bad steering encoder. Refer to solution code [AMP-01](#).

### Damaged left male steering AMP connection

If there is a damaged left male connector that has missing pins, a broken connector housing or a broken retention clip, refer to solution code [AMP-01](#).

### Damaged left female steering AMP connection

If there is a damaged left female connector that has any damaged wires, a broken connector housing a broken retention clip or something stuck in the connector, refer to solution code [AMP-02](#).

### Damaged right male steering AMP connection

If there is a damaged right male connector that has missing pins, refer to solution code [AMP-01](#).

### Damaged right female steering AMP connection

If there is a damaged left female connector that has any damaged wires or something stuck in the connector, refer to solution code [AMP-03](#).

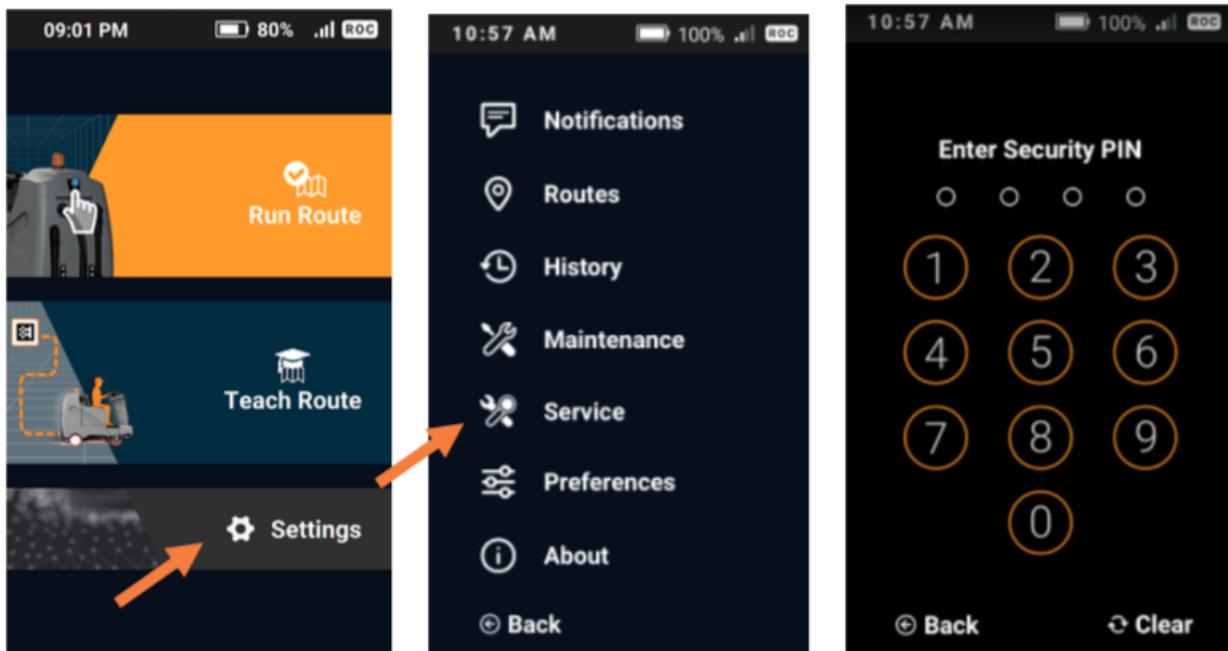
## Software Diagnostics

**IMPORTANT:** Ensure that the entire Hardware Inspection section is completed prior to proceeding with software diagnostic tests.

### Steering angle check

The purpose of this check is to ensure the steering wheel alignment matches the steering encoder reading.

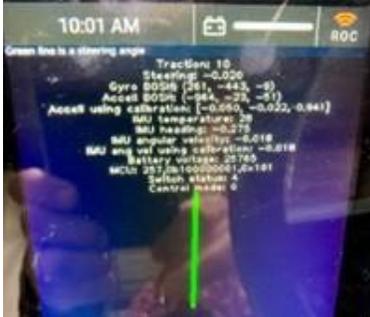
1. Verify that the machine's front wheel and steering wheel are both centered.
2. To turn on the machine, insert the ignition key and turn to the right (clockwise).
3. Wait for the screen to initialize.
4. Enter the 4-digit PIN (1337) on the screen. Upon successful PIN entry, the screen displays the main menu.
5. Select **Settings > Service > Service PIN (different from normal PIN)**.



**Figure 9: Settings > Service option > Service PIN**

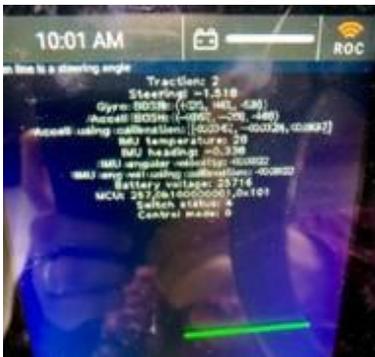


8. Center the steering wheel once again, and take a picture of the screen (visually verify that the front wheel is centered, as the steering wheel logo may not always align). Verify the position of the green line at the bottom of the screen, as shown below.



**Figure 13: Picture of center steering-angle check**

9. Turn the steering wheel all the way to the right and take a picture of the screen. Verify the position of the green line at the bottom of the screen, as shown below.



**Figure 14: Picture of right steering-angle check**

10. Attach these pictures to the case.
11. Reboot the machine.

## Steering angle common issues

If the green line does not match the angle of the steering wheel, refer to solution code [ANGLE-01](#).

## Manual steering check

This check verifies that the BCM and firmware can control steering autonomously. This check should be performed three times.

1. Verify that the machine's front wheel and steering wheel are both centered.
2. Go back to the Service menu (**Settings > Service > Service PIN**).
3. Select **Factory Diagnostics**.

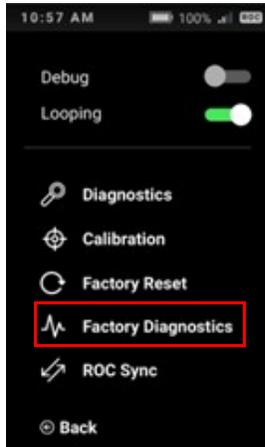


Figure 15: Factory Diagnostics option

4. Wait a moment for the machine/BCM Type confirmation screen to appear.
5. Select **Yes** to proceed with Factory Diagnostics.

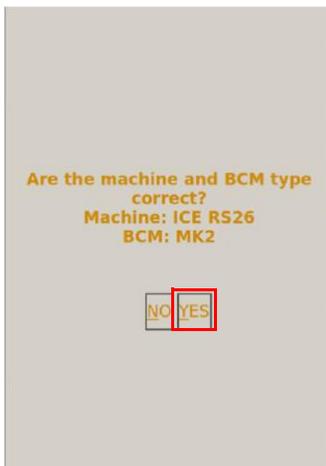


Figure 16: Machine/BCM Type confirmation screen

6. Select **Tools** > **Steering Manual Check**.



Figure 17: Tools > Steering Manual Check option

***IMPORTANT: Keep both hands away from the steering wheel for the following two steps. The steering wheel turns forcefully during this test.***

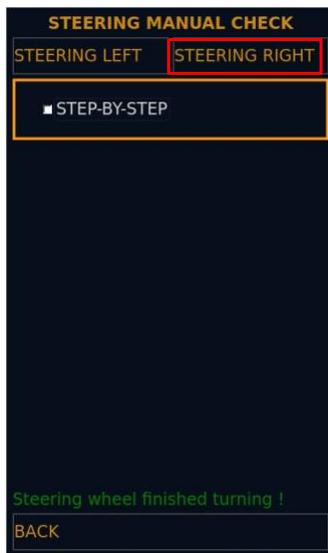
7. Select **Steering Left**. Verify that the steering wheel turns to the extreme left. When complete, there will be an indication on the bottom of the screen: “steering wheel finished turning” after a few seconds. Once this message displays, the wheel will not recenter, but it will unlock. If the steering wheel did not turn to the left, record the exact behavior in your note



Figure 18: Steering Manual Check screen – Steering Left option

8. Select **Steering Right**. Verify that the steering wheel turns to the extreme right. When complete, there will be an indication on the bottom of the screen: “steering wheel finished turning” after a few seconds. Once this message displays, the wheel will not recenter but

it will unlock.  
If the steering wheel did not turn to the right, record the exact behavior in your notes.



**Figure 19: Steering Manual Check screen – Steering Right option**

9. Perform the Steering Manual Check (left and right) three times. Each time, ensure the test passes as expected. If it does not, record the exact behavior.
10. Press the **Back** button and select **Close** from the Tools submenu to return to the Factory Diagnostics menu.

### Manual steering check failure

If the steering wheel does not turn in the same way every time, note this failure and record the test details. Refer to solution code [AMP-01](#).

### Manual navigation check

This check verifies that the front wheel is actually turning, and is communicating with the steering encoder.

1. Verify that the machine's front wheel and steering wheel are both centered.
2. Select **Manual Navigation Tests**.



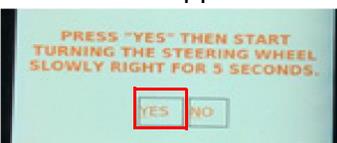
**Figure 20: Manual Navigation Tests option**

3. Select **Run Wheel Right Test**.



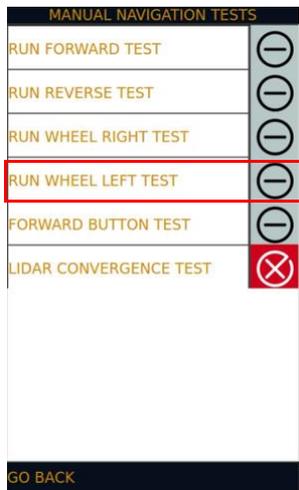
**Figure 21: Run Wheel Right Test**

- a. Select **Yes** on the next screen, and then start turning the steering wheel slowly to the right for an approximate duration of 5 seconds.

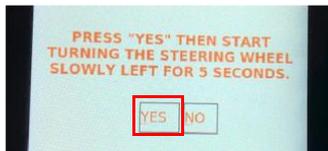


**Figure 22: Steering Wheel Right confirmation screen**

- b.  Take a picture of the result. 

4. Select **Run Wheel Left Test**.**Figure 23: Run Wheel Left Test**

- a. Select **Yes**, and then start turning the steering wheel slowly to the left for an approximate duration of 5 seconds.

**Figure 24: Steering Wheel Left confirmation screen**

- b.  Take a picture of the result. 

5. Select the **Back** button to return to the Factory Diagnostics menu.**Manual navigation test failure**

If one or both of these tests failed, note the failure and details. Repeat this test three times. If the test fails further attempts, refer to solution code [STENCODER-02](#).

## Automated steering check

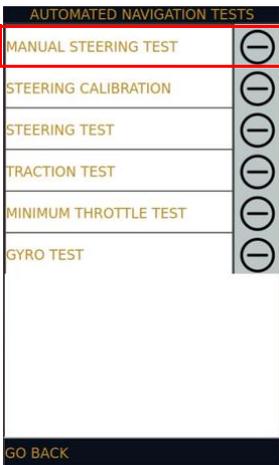
This check verifies that the steering wheel is actually turning.

1. Verify that the machine's front wheel and steering wheel are both centered.
2. Select **Automated Navigation Tests**.



**Figure 25: Automated Navigation Tests option**

3. Select **Manual Steering Test**.



**Figure 26: Manual Steering Test**

**IMPORTANT: Keep both hands away from the steering wheel for the following steps. The steering wheel turns forcefully during this test.**

4. Select **Yes** to proceed with the first part of the test.



**Figure 27: Hands-off steering wheel reminder**

5. Verify that the steering wheel turns to the right.
  - If the steering wheel turns to the right, select **Yes**.
  - If the steering wheel does not turn to the right, select **No** and note this in the case.



**Figure 28: Steering-wheel right-turn confirmation screen**

6. Select **Yes** to proceed with the second part of the test.
7. Verify that the steering wheel turns to the left.
  - If the steering wheel turns to the left, select **Yes**.
  - If the steering wheel does not turn to the left, select **No** and note this in the case.
8. Perform this Steering Manual Test (left and right) three to five times. Each time ensure the test passes as expected. If it does not, record the exact behavior in the notes.
9. Select the **Back** button to return to the Factory Diagnostics menu.

## **Automated steering test failure**

If the steering wheel does not turn in the same way every time, refer to solution code [AMP-01](#).

## Gyro noise test

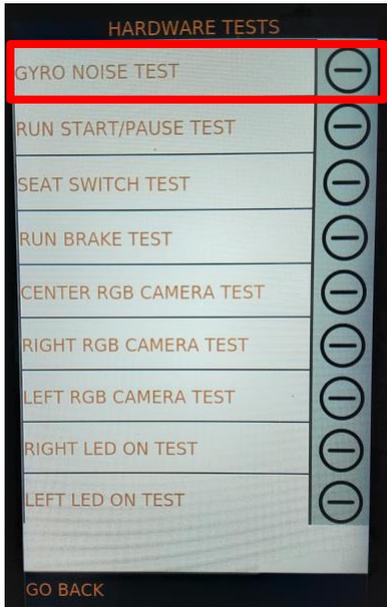
This test verifies that there is no gyroscope noise that could impede navigation.

1. Verify that the machine’s front wheel and steering wheel are both centered.
2. Select **Hardware Tests**.



**Figure 29: Hardware Tests**

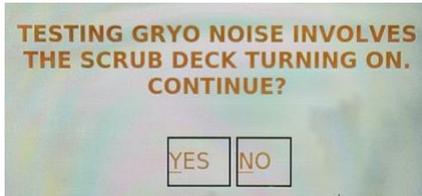
3. Select **Gyro Noise Test**.



**Figure 30: Gyro Noise Test**

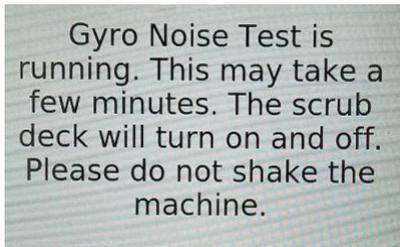
**IMPORTANT: Keep both hands away from the steering wheel for the following steps. Do NOT sit on the scrubber.**

4. Click **Yes** to acknowledge the scrubber is in an area where the scrub deck can turn on.



**Figure 31: Enable scrub deck confirmation**

**Note:** While the test is running, the following text displays on the screen, indicating that it is still in progress.



**Figure 32: Test in progress screen**

5. Perform the Gyro Noise Test three times. Each time, ensure that the test passes as expected. If it does not, record the exact behavior in the notes.
6. 📷 Take a picture of each result. 📷
7. Key off the machine to turn power off to the scrubber. When it is fully off, key on the machine again.
8. When the machine boots to the Main Menu, proceed to the next section.

### **Gyro noise test failure**

If the gyro noise test fails consistently, refer to solution code [BCM-01](#).

## Steering calibration

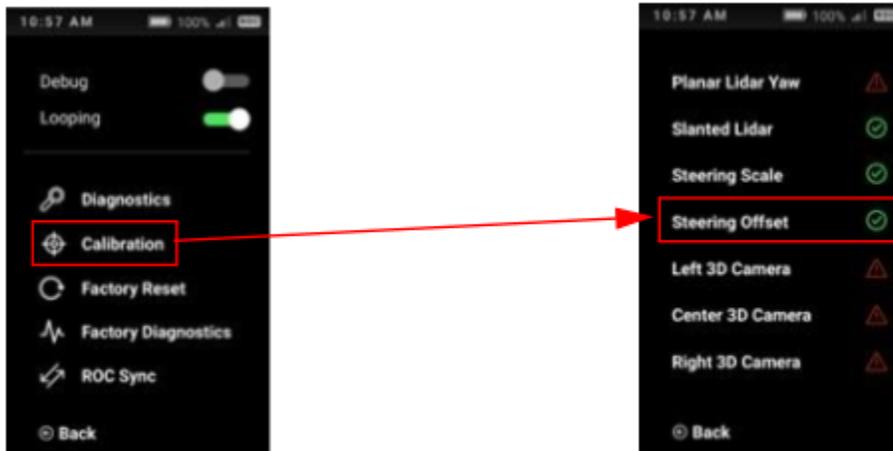
**IMPORTANT:** This is a **REQUIRED** procedure, to be performed after any steering component change.

This calibration verifies that the steering is properly aligned.

1. Go to the Home Screen > Teach Route. If you are still in the Factory Settings menu, you will need to key the machine off and back on.



2. Train a 5-minute route with minimal stopping. Be sure to teach a route that goes straight and has left turns, right turns, and u-turns.
3. Go back to the **Service** menu.
4. Select **Calibration > Steering Offset**.



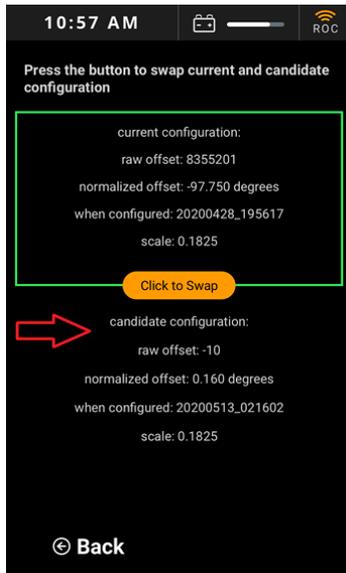
**Figure 33: Calibration > Steering Offset option**

The machine displays two configurations: current and candidate.

- The top configuration is the current configuration, which is what the machine is using at the moment.
- The bottom configuration is the candidate configuration, which is associated with the new route that was just trained above.



Take a picture of these configurations and attach it to the case.



**Figure 34: Picture of current configuration**

*NOTE: If the candidate configuration is not displayed in the screen, train a new route that it is longer than 6 minutes.*

5. Press the middle of the screen to swap the candidate and current configuration. Moving the new configuration to the top ensures that the latest (candidate) calibration is being used.
6. Key the unit off and back on.
7. Go back to the **Service** menu.
8. Select **Calibration > Steering Offset**.
9. Verify that the new “current configuration” is the one that was just created. If the configuration is different, take a picture and note this in the case.
10. Run the saved route. When running the route, perform the following substeps:
  - a. Walk to the front of the machine to make sure it slows down upon approach before stopping.
  - b. Walk up to the machine from each side and make sure the machine stops

- c. Place a stationary obstacle in the machine's route to make sure it goes around the obstacle
- d. Observe the machine to make sure the turn signals are working properly.
- e. Pause and start the machine using the Start/Pause button.
- f. Take a picture of the "Route Complete" or "Route History" screen.

# Solution Tables

## Steering Calibration

Solution code	Recommended actions
<p><b>CALIBRATION-01</b></p>	<p>NOTE: This is <b>generally a required step</b> after replacing parts or troubleshooting issues related to the steering system.</p> <ol style="list-style-type: none"> <li>1. Train a route that is <b>at least 5 minutes</b> with minimal stopping.             <ol style="list-style-type: none"> <li>a. Be sure to teach a route that goes straight and has left turns, right turns, and u-turns.</li> </ol> </li> <li>2. Go to <b>Service Menu &gt; Calibration &gt; Steering Offset</b></li> <li>3. Tap the button to swap the “Candidate” configuration to move to the top of the screen, then hit the “Back” button to save it.</li> <li>4. Key the unit off and back on</li> <li>5. <b>Run the newly trained route and monitor for any anomalies</b></li> <li>6.  Take a picture of the “<b>Route Complete</b>” or “<b>Route History</b>” screen. </li> <li>7. Send any photos, notes, and/or a filled out Troubleshooting Checklist to Brain Corporation using the e-mail address specified in the work order.</li> </ol>

## Steering U-Joint

Solution code	Recommended actions
<b>UJOINT-01</b>	<p>If a u-joint is broken, worn out, or missing a pin, perform the following steps:</p> <ol style="list-style-type: none"><li>1) Send any photos, notes, and/or a filled out Troubleshooting Checklist to Brain Corporation using the e-mail address specified in the work order.</li><li>2) Place an order for the following part: U-joint (ICE Part Number 8310604).</li><li>3) Schedule the next site visit based on the tracking information for the part.</li><li>4) Replace the u-joint.</li><li>5) <b>For this service, always perform the required steering calibration in solution code <a href="#">CALIBRATION-01</a>.</b></li></ol>

## Steering Encoder

Solution code	Recommended actions
<b>STENCODER-01</b>	<p>If the steering encoder has been damaged in some way (internally or externally), perform the following steps:</p> <ol style="list-style-type: none"> <li>1) Send any photos, notes, and/or a filled out Troubleshooting Checklist to Brain Corp using the e-mail address specified in the work order.</li> <li>2) Place an order for the following part: Steering Encoder (ICE Part Number 8350410 )</li> <li>3) Please schedule the next site visit based on the tracking information for the part</li> <li>4) Replace the steering encoder</li> <li>5) <b>For this service, always perform the required steering calibration in solution code <a href="#">CALIBRATION-01</a></b></li> </ol>
<b>STENCODER-02</b>	<p>If the Manual Navigation Check fails, perform the following steps:</p> <ol style="list-style-type: none"> <li>1) Send any photos, notes, and/or a filled out Troubleshooting Checklist to Brain Corporation using the e-mail address specified in the work order.</li> <li>2) Place an order for the following part: Steering Encoder (ICE Part Number 8350410 ) and Harness Down Trunk (ICE Part Number 8350264).</li> <li>3) Schedule the next site visit based on the tracking information for the part.</li> <li>4) Replace the steering encoder and down trunk cable.</li> <li>5) <b>For this service, always perform the required steering calibration in solution code <a href="#">CALIBRATION-01</a>.</b></li> </ol>

## Steering Motor

Solution code	Recommended actions
<b>MOTOR-01</b>	<p>If the steering motor is leaking oil or has a damaged cable, perform the following steps:</p> <ol style="list-style-type: none"><li>1. Send any photos, notes, and/or a filled out Troubleshooting Checklist to Brain Corporation using the e-mail address specified in the work order.</li><li>2. Place an order for the following part: Steering Motor (ICE Part Number 8350430).</li><li>3. Schedule the next site visit based on the tracking information for the part.</li><li>4. Replace the steering motor.</li><li>5. Perform a steering calibration (for more information on how to perform a steering calibration, refer to the <a href="#">Steering calibration</a> section).</li><li>6. <b>For this service, always perform the required steering calibration in solution code <a href="#">CALIBRATION-01</a>.</b></li></ol>

## Steering Amplifier

Solution code	Recommended actions
<b>AMP-01</b>	<p>If any of the following occur, perform the following steps:</p> <ul style="list-style-type: none"><li>● The steering wheel is hard to turn.</li><li>● There is a damaged left or right male connector.</li><li>● The left or right male connector is missing pins.</li></ul> <p><b>Solution steps:</b></p> <ol style="list-style-type: none"><li>1) Send any photos, notes, and/or a filled out Troubleshooting Checklist to Brain Corporation using the e-mail address specified in the work order.</li><li>2) Place an order for the following part: Steering Amplifier (ICE Part Number 8350255).</li><li>3) Schedule an estimated service date to replace the steering amplifier.</li><li>4) Replace the steering amplifier.</li></ol>

<b>AMP-02</b>	<p>If there is a damaged left female connector that has any damaged wires or something stuck in the connector, perform the following steps:</p> <ol style="list-style-type: none"> <li>1) Send any photos, notes, and/or a filled out Troubleshooting Checklist to Brain Corporation using the e-mail address specified in the work order.</li> <li>2) Place an order for the following part: Steering Motor (ICE Part Number 8350430).</li> <li>3) Schedule an estimated service date to replace the steering motor.</li> <li>4) Replace the steering motor.</li> <li>5) <b>For this service, always perform the required steering calibration in solution code <a href="#">CALIBRATION-01</a>.</b></li> </ol>
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Solution code	Recommended actions
<b>AMP-03</b>	<p>If there is a damaged right female connector, and/or any damaged wires or something stuck in the connector, perform the following steps:</p> <ol style="list-style-type: none"> <li>1) Send any photos, notes, and/or a filled out Troubleshooting Checklist to Brain Corporation using the e-mail address specified in the work order.</li> <li>2) Place an order for the following part: Downtrunk (ICE Part Number 8350264)</li> <li>3) Schedule a service date to replace the downtrunk.</li> <li>4) Replace the steering downtrunk.</li> </ol>

## Steering Angle Check

Solution code	Recommended actions
<b>ANGLE-01</b>	<p>If the Steering Angle check is off, perform the following steps:</p> <ol style="list-style-type: none"><li>1) Perform the steps in the Steering Calibration solution code <a href="#">CALIBRATION-01</a>.</li><li>2) Perform the Steering Angle Check (again).</li><li>3) If the unit is <b>unable to complete running the newly trained route</b> or it <b>fails the Steering Angle check again</b>, proceed to the remaining Software Diagnostics:<ol style="list-style-type: none"><li>a) Manual Steering Check</li><li>b) Manual Navigation Check</li><li>c) Automated Steering Check</li><li>d) Gyro Noise Test</li></ol></li></ol>

**BCM**

<b>Solution code</b>	<b>Recommended actions</b>
<b>BCM-01</b>	If the BCM has failed the Gyro Test multiple times, perform the following steps: <ol style="list-style-type: none"><li>1. Send any photos, notes, and/or a filled out Troubleshooting Checklist to Brain Corporation using the e-mail address specified in the work order.</li><li>2. Advise Brain Corporation that the unit failed the Gyro Test.</li></ol>