Steering Troubleshooting Guide for OEM

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Revision History

Revision	Date	Description
Draft	4/9/2021	Submitted for Peer Review
01		Initial Release

Definitions, Acronyms, and Abbreviations

Term	Definition
BCM	Brain Control Module
DMM	Digital Multimeter
MAM	Motor Amplification Module
Down Trunk	Cable harness that goes from the down port on the BCM
OEM	Original Equipment Manufacturer
	Examples of commands
	Caution, this might cause serious system problems. Stop and ensure you understand what is being asked.

Overview

This guide provides information on how to troubleshoot steering related issues for any autonomous floor scrubbers powered by BrainOS. In order to effectively troubleshoot any issue, please review this troubleshooting guide in the order given to determine the proper resolution.

When To Use It

Please proceed with this document if you encounter any of the codes below:

Assist
100, 101, 102, 218, 224, 40002, 40004, 40006, 60400, 60461

Errors
501,502, 504, 20003, 20009, 40007

Startup
5010

For more information on the error codes please refer to the OEM Error Code Reference Document

Brain Internal Assist Codes
https://braincorporation.atlassian.net/wiki/spaces/TS/pages/298582085/Error+Codes+and+Error+Inventory

OEM Assist Code Doc
The latest OEM error code document is located in the Zendesk Guide webpage

How To Use It

The Steering Troubleshooting Guide walks you through several important steps in troubleshooting an Autonomous Scrubber:

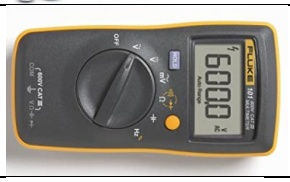
1. Part 1: Check Emerging Issues
2. Part 2: ROC Portal
3. Part 3: Connectivity Testing
4. Part 4: Onsite Tech troubleshooting

Complete the steps in the order they are listed!

The following steps are intended to be performed in the exact order listed in this document. It is essential to collect pictures and take notes throughout the process.

Required Tool List

The following is the list of tools needed to service the Steering? related issues for any autonomous floor scrubbers powered by BrainOS.

Item	Image Details
Hex Drivers • 2 mm • 2.5 mm • 3 mm	
7 mm socket wrench	
Digital Multimeter (DMM, Fluke 101 Model or equivalent)	
Fine Test Leads (Model MICTL-013 or equivalent) or back probes.	
Cable Tie Cutter	
Probing Adaptors (Optional) https://www.amazon.com/EDGELEC-Breadboard-Optional-Assorted-Multicolored/dp/B07GD2BWPY	

OEM Diagnostics

When replacing any steering component, tech must perform a steering calibration. ****Print and update the checklist!****

To assist with troubleshooting, there is a troubleshooting checklist in Appendix A. This checklist needs to be printed, filled out, and submitted along with the pictures and notes.

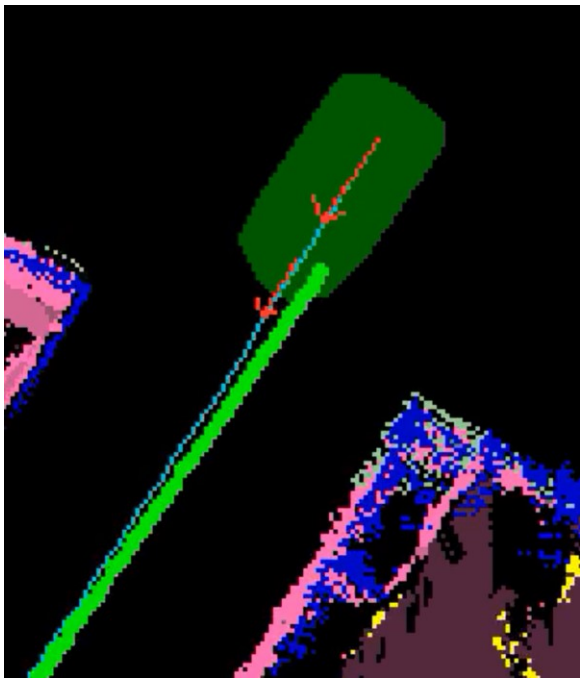
Assists

Below are some example assists that you might run into when having Steering issues. Go to the ROC Portal and review the assists for that specific machine. When reviewing each assist it is really important to look at the images and assist replay to see what triggered this assist to happen. By reviewing assists it allows us to get a better understanding of what type of issues the machine could be having. For the latest list of assist codes please reference the most updated error code document. Make sure to watch the playback as it gives a better understanding of what you are looking at in the static maps.

U-Joint

These assists do not necessarily show that a U-joint if broken. It could be as simple as the set screws or bad calibration.

- The below assist when played shows that the scrubber is always to the right of the trained path. The Scrubber constantly tries to turn left slightly to come back on path.

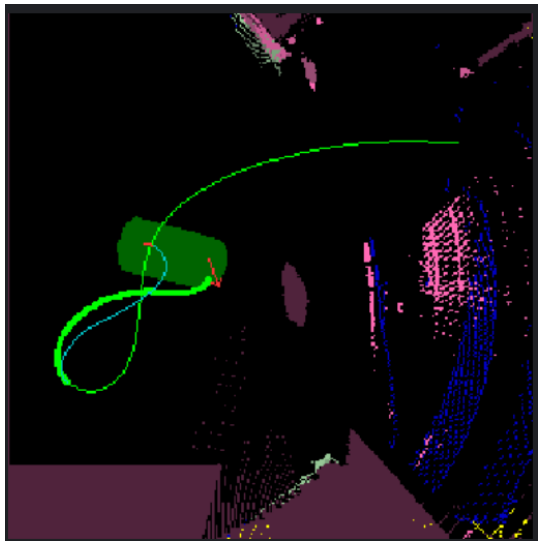


Tennant Link: None

Traction Encoder failed or failing

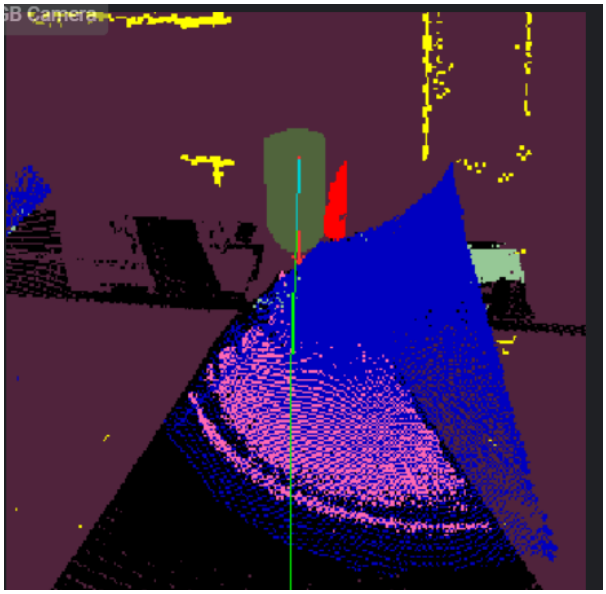
When viewing these assists you will notice that the scrubber sits still while the environment is moving. This will indicate that the traction encoder or cable has failed.

- Failing Traction encoder
  This shows the traction encoder working then at the end of the video the traction encoder stops working. This indicates that the Traction Encoder or cable has failed.



- Tennant Link:
  https://tennant.prod.roc.braincorp.com/assists/3S5ERDYHVSHP7H6C3WD48TPVVT

- Failed Traction Encoder
  This shows the machine from the start of the assist sitting still and the objects are moving in relation to the Robot. This indicates that the Traction Encoder or cable has failed.



- Tennant Link:
  https://tennant.prod.roc.braincorp.com/assists/2VPKCPXWRBMBFCK11KNKMJ9SXC
  https://tennant.prod.roc.braincorp.com/assists/4WAKMQ30AMXX02WBC9QY2J4M9F

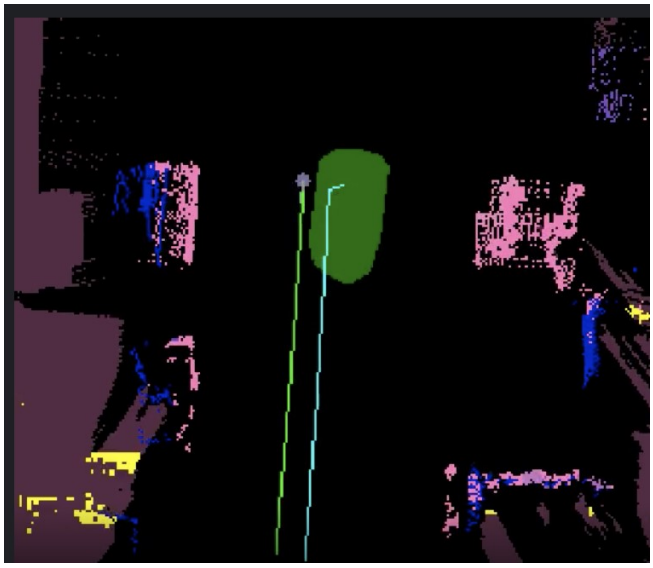
Wheel Slip

In the below assists we have an example of Wheel Slip. You can see places where the Robot thinks it has moved but the shelving moves and stays ahead of the scrubber. We have seen worn pads and broken scrub deck springs cause this issue. This does cause de-localization

- Tennant Link:
  https://tennant.prod.roc.braincorp.com/assists/2E4E9XT7WPSPNTXE8TP2WR3BYG
  https://tennant.prod.roc.braincorp.com/assists/08B8R52AW0M1FWWY5TDAM9AFA6

Loose Steering Encoder

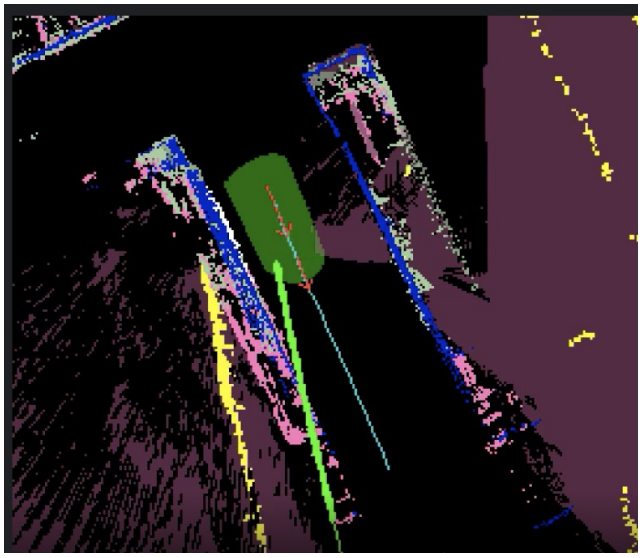
Steering encoder is mounted incorrectly or has set screws loose. Costmap shows an adjusted corrective route compared to straight planned route after turns are not registered entirely or properly



- Tennant Link: None

Steering Encoder Malfunction

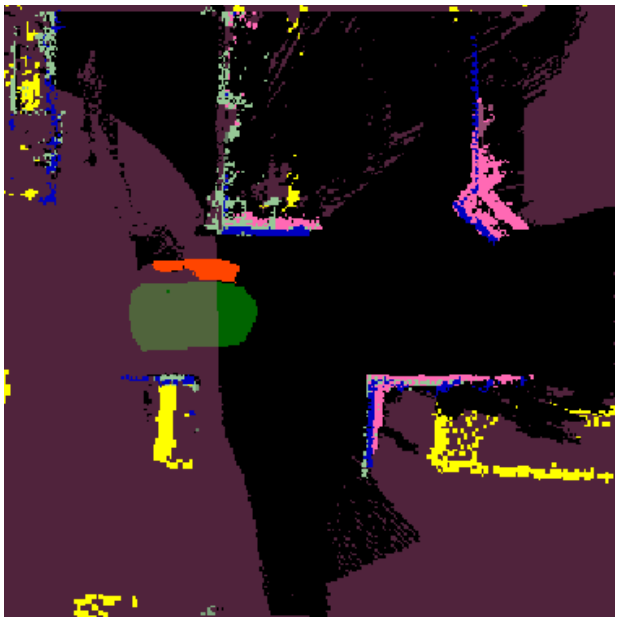
The adjusted route (blue line) shows no suggestions (remains straight) while the planned route(green line) becomes more mismatched in relation to the body of the scrubber. Encoder is not registering turns.



- Tennant Link:
  https://tennant.prod.roc.braincorp.com/assists/1F9GQZ7QYP1K4VYF71MZDQ86JB

Example of an assist with customer driving

This example shows the customer driving the scrubber. You can tell this because there are not any red arrows nor pathing lines.



Tennant Link: None

Tech Diagnostics

Please use the Tech Steering checklist in Appendix A. Submitting this checklist is required.

Hardware Inspection

U-Joint Check

1. Remove the access panel to access the steering column.

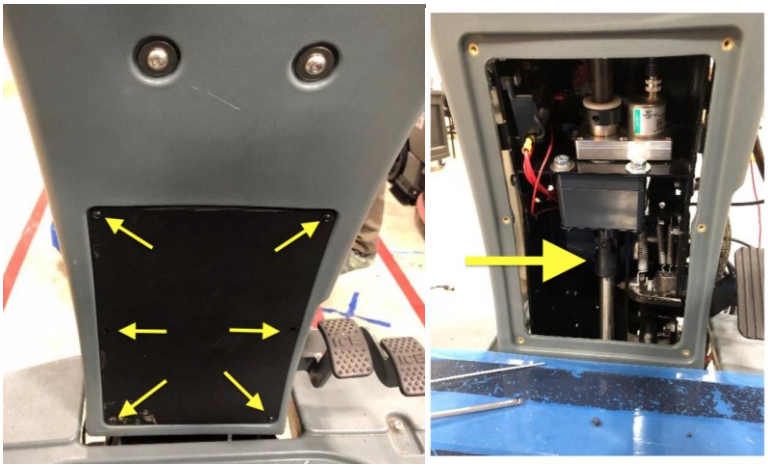


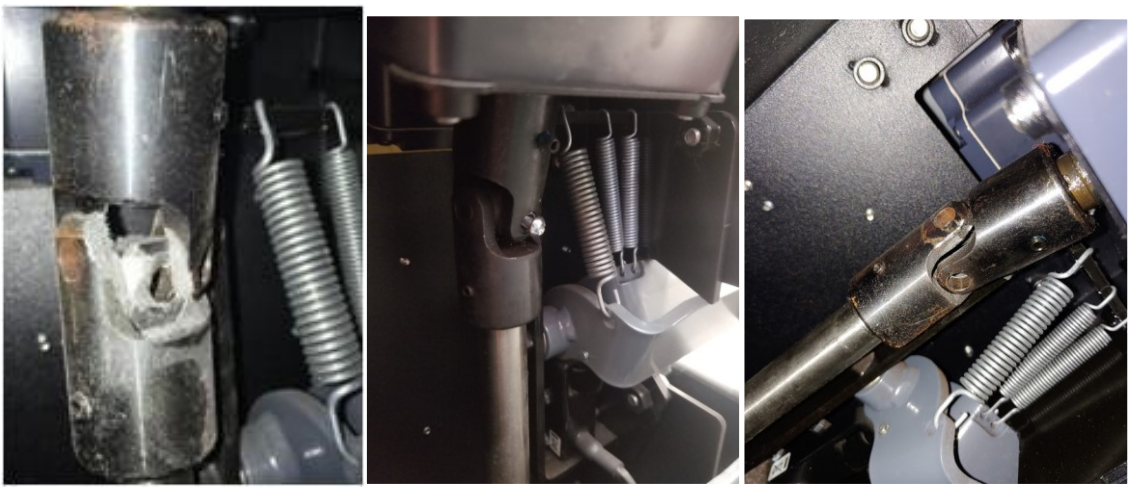
Figure 0: Access Panel

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

📷 Take multiple pictures of the steering U-joint that shows the pins on all sides. 📷

2. Inspect the U-joint for damage, set screws being loose or lost, and other damage. See the pictures below for a reference.

Example of a U-joint in good condition



Example of a broken U-joint

3. Look for slop in the U-joint itself. It may look good, but may be really loose or otherwise worn.
4. 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.
5. If U-joint is broken, worn out or missing a pin, refer to **UJoint-01**

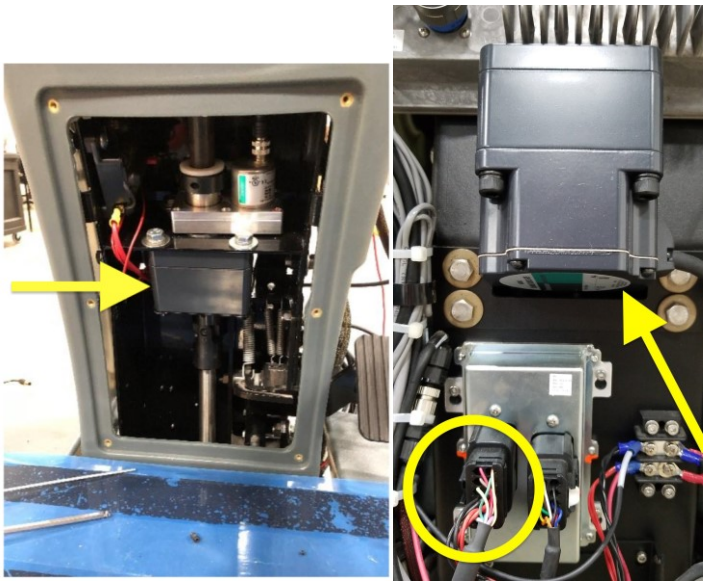
Steering Motor Check

1. Remove both the front and back access panels.

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.



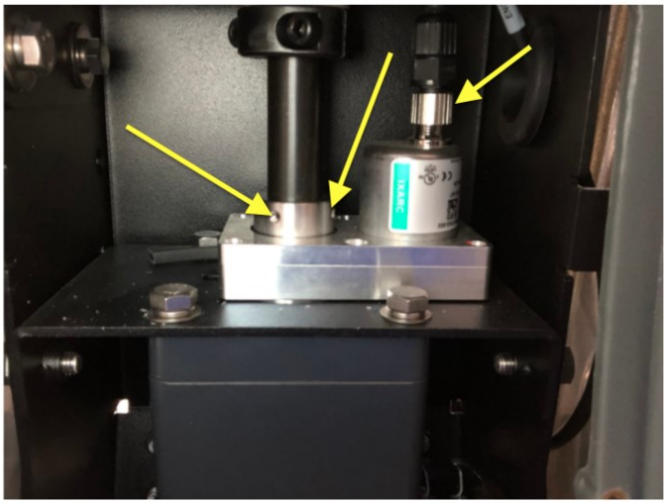
Steering motor – back and front view

7. Steering motor common issues:
    a. If the steering motor is leaking oil, refer to solution code **MOTOR-01**
    b. 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 and properly tightened.
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.



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.*

***NOTE:** The steering encoder pictured above is rotated. Encoder may or may not be broken.*

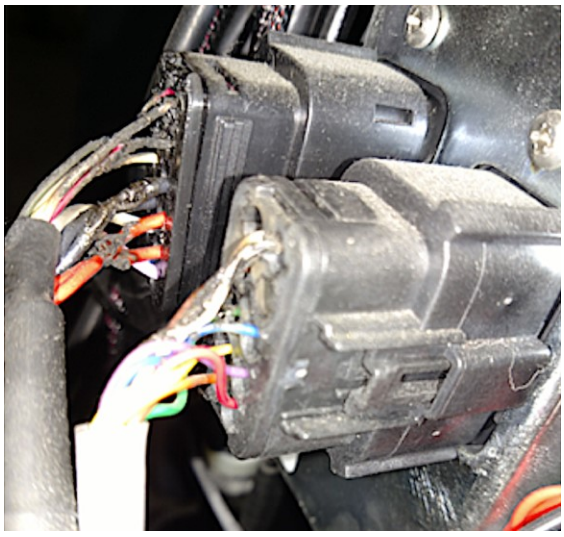
5. Take pictures of the steering encoder that show the overall condition, condition of the wires, and the set screws.
6. Steering Encoder common issues
    a. If the steering encoder is missing set screws, not mounted properly, or is damaged, refer to solution code **STENCODER-01**.

b. If the wiring to the steering encoder is damaged, refer to solution code **Downtrunk-01**

Steering Amplifier Check

1. Remove the front cover from the machine to check the steering motor amplifier module (MAM).
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. Examples
   a. Example of a Good steering amplifier

   b. Example of a Bad Steering amp (Damaged wiring)



6. Steering Amplifier common issue

a. If the wheel is hard to turn, unplug the steering amplifier connection. If the steering is easier, then it is usually a bad steering amplifier. Refer to solution code **AMP-01**.

b. 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**.

c. 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**.

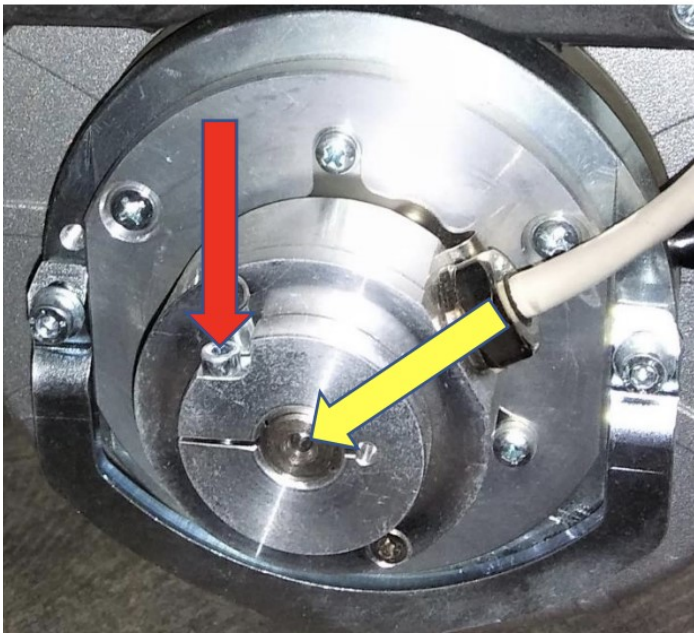
d. If there is a damaged right male connector that has missing pins, refer to solution code **AMP-01**.

e. If there is a damaged left female connector that has any damaged wires or something stuck in the connector, refer to solution code **Downtrunk-01**.

Traction Encoder Check

The Traction Encoder is responsible for tracking the movement (distance) traveled by the scrubber. As the traction wheel spins, the encoder counts ticks and relays that information to the BCM, thereby quantifying and monitoring how much distance the scrubber has moved. The purpose of this check is to ensure the traction encoder is not damaged.

1. Ensure that the hex screw (indicated with the red arrow in the Figure below) is tight. It should enable the encoder to be clamped to the axel. As the unit is driven, the axel (indicated with the yellow arrow in the Figure below) should spin.



2. Inspect the traction encoder cabling for damage (cut or torn).

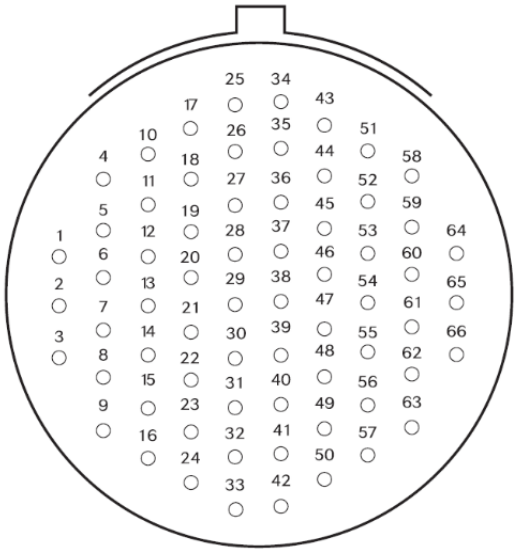
3. Take pictures of the traction encoder and condition of the cables
4. Traction Encoder Common Issues
    a. If the traction cabling is damaged, the traction encoder will need to be replaced. Refer to solution code TRACTION-01
    b. If the traction encoder itself is physically damaged then the traction encoder will need to be replaced. Refer to solution code TRACTION-01

Voltage / Continuity Testing/Swap

- If you suspect wiring use the Chart below to check voltage and continuity

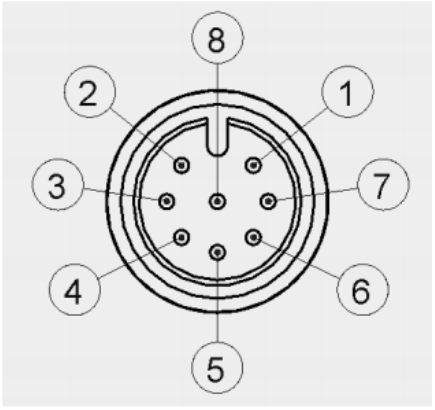
  If continuity testing fails please **Use Solution Code** [Downtrunk-01]

  Down Trunk BCM connector - Notice Pin Numbering



Traction Encoder connector- Notice Pin Numbering

ENCODER CONNECTIONS		
Function	**Cable colour**	**Pin**
0 V	BLACK	7
Z +	BLUE	6 (not used)
B -	ORANGE	5
B +	YELLOW	4
A -	GRAY or BROWN	3
A +	GREEN	1
+ V dc	RED	2
Z -	WHITE	8 (not used)
⏚	SHIELD	CASE



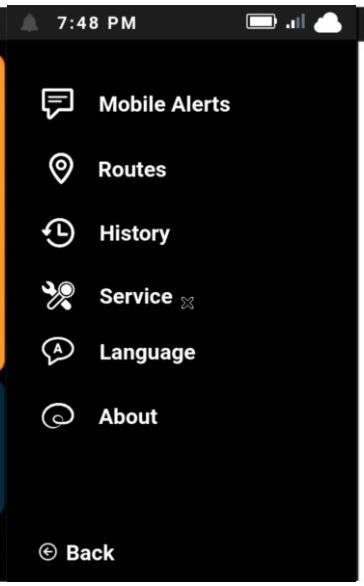
Cable Pairs to check			
Component	**Component Connector**	**Description**	**D38999 Down Trunk**
Steering Encoder	**1**	GND	**15**
	2	P5V	**21**
	3	SPI3 CLK+	**16**
	4	SPI3 CLK-	**24**
	5	SPI MISO+	**8**
	6	SPI MISO-	**9**
Traction Encoder	**1**	ENC1_ACH+	**25**
	2	P5V	**43**
	3	ENC1_ACH-	**26**
	4	ENC1_BCH+	**34**
	5	ENC1_BCH-	**35**
	7	GND	**44**
Steering Motor	**1**	GND	**19**
	2	Unused	
	3	P5V	**17**
	4	P4V3	**18**
	5	PWM_3V3	**6**
	6	DIR_3V3	**5**
	7	Enable MTR driver	**10**
	8	Steer MTR DIS	**12**
	9	STEER_FLT	**11**
	10	STEER_CUR	**4**

UI based diagnostics (OS version 3.1.x +)

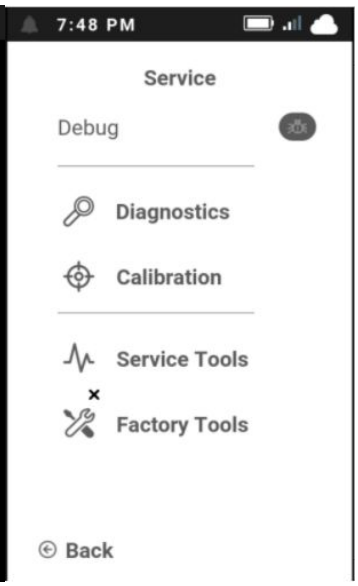
Tech will need to click the following path to get to the steering tests

Settings → Service → Service Tools → Confirm to Launch Service tools

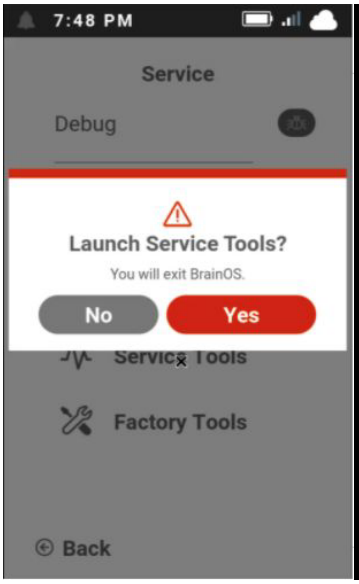
Menu



Settings Menu

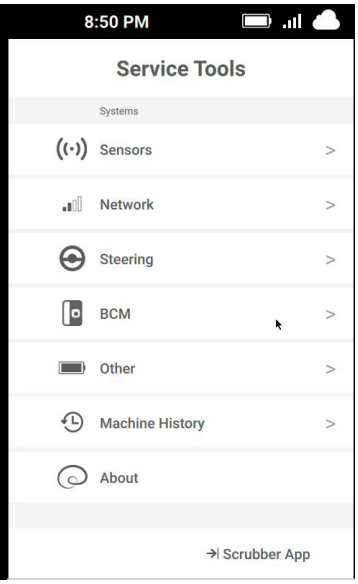


Service Menu



Confirm Y/N

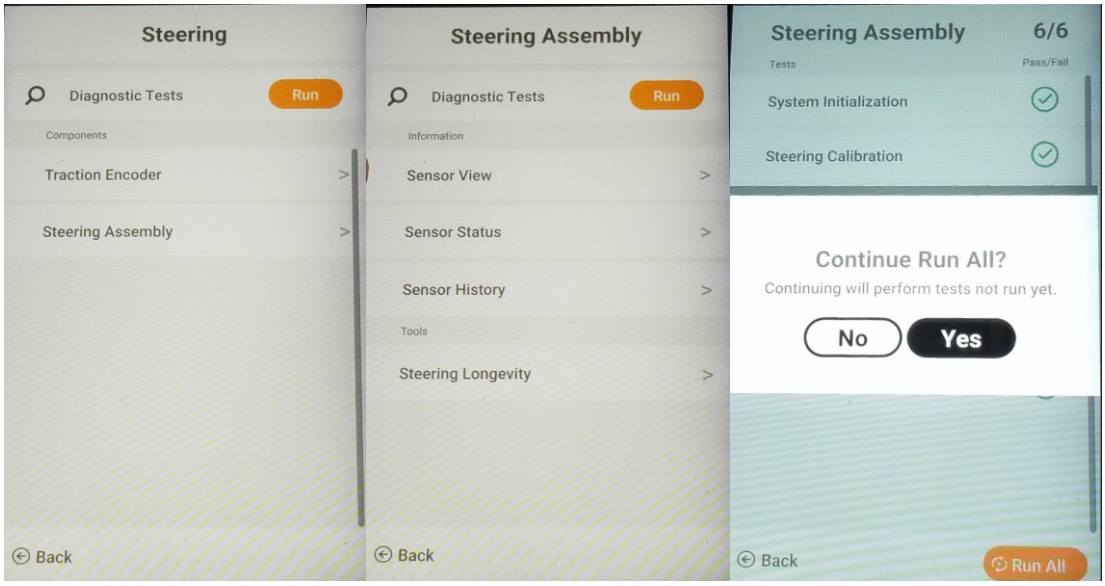
Brain Screen



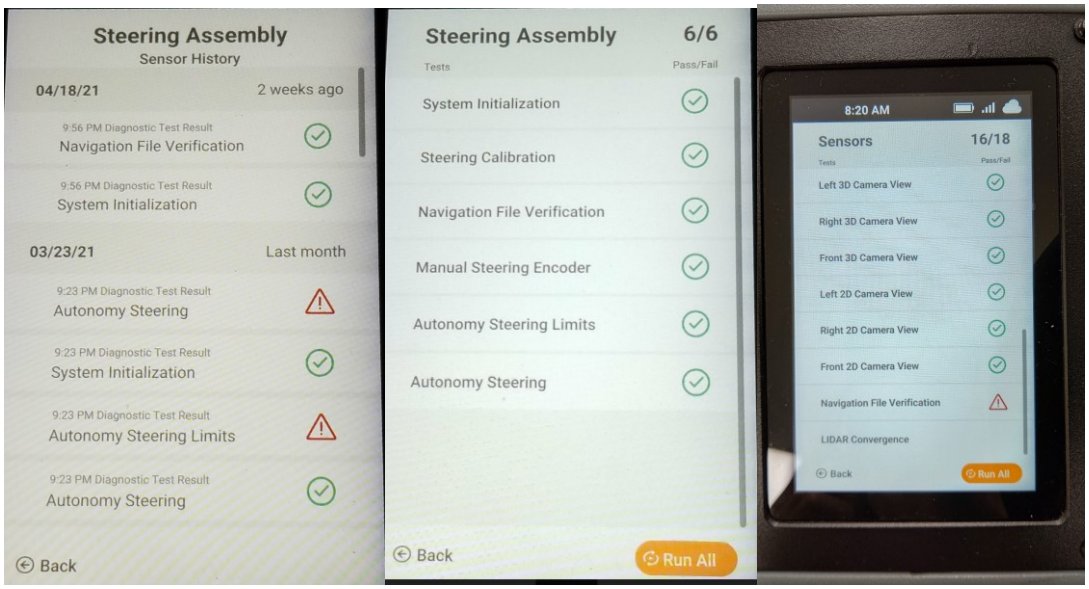
Service Tools

Click Steering → You will now see all the Steering tests.

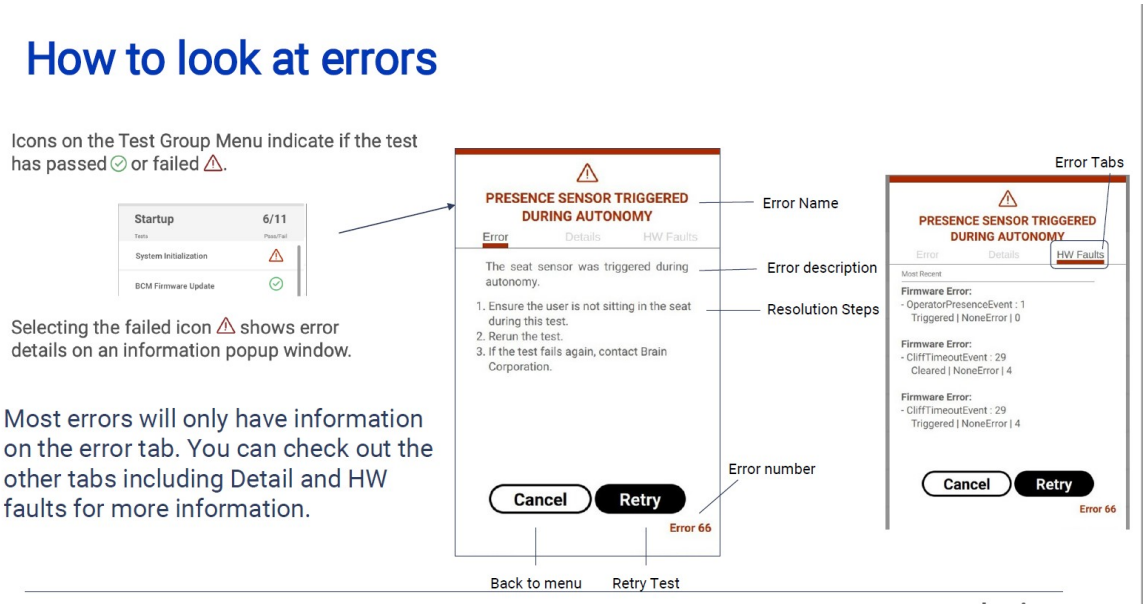
Tech can choose RUN on the main Steering menu which will run all tests for most steering components. Or the tech can choose the specific tests he wants to re-run if necessary.



Both menus where steering tests can be run on and the confirmation screen for running the tests.



History screen of related steering events done on this machine, along with a screen of the tests completed. Note: Please ignore the Navigation File Verification test. This shows as failed but can be ignored without issue for right now.

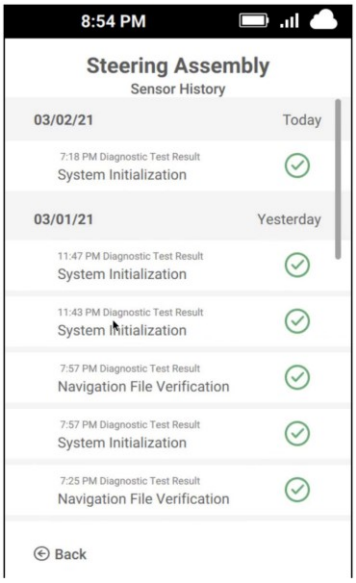


Note: If a test fails there are three tabs of information: Error, Details, and HW Faults.

Sensor History

Provides a history of the sensor, including replacements, disconnects, other issues and normal events.

Settings → Service → Service Tools → Confirm to Launch Service tools→ Steering → Select the STEERING → Sensor History



Steering Service Tests

1. Navigate to the Service Tools Menu. (Settings→Service→Service Pin→Service Tools)
2. Select Steering
3. Press Run
4. Press Run All
5. Pres Yes
6. Follow steps to go through the seven steering tests
7. Take a photo of the finish screen and note if any of the tests returned as failure.
8. Rerun individual tests as necessary by selecting them.

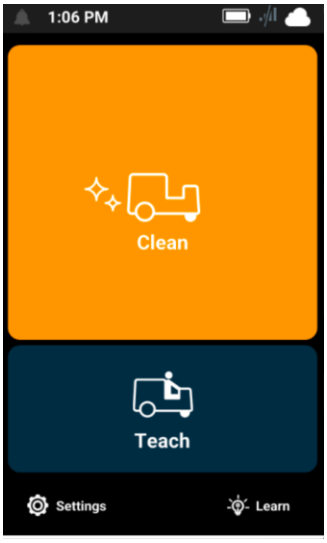
Note: Please ignore the Navigation File Verification test. This shows as failed but can be ignored without issue for right now.

Calibration

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

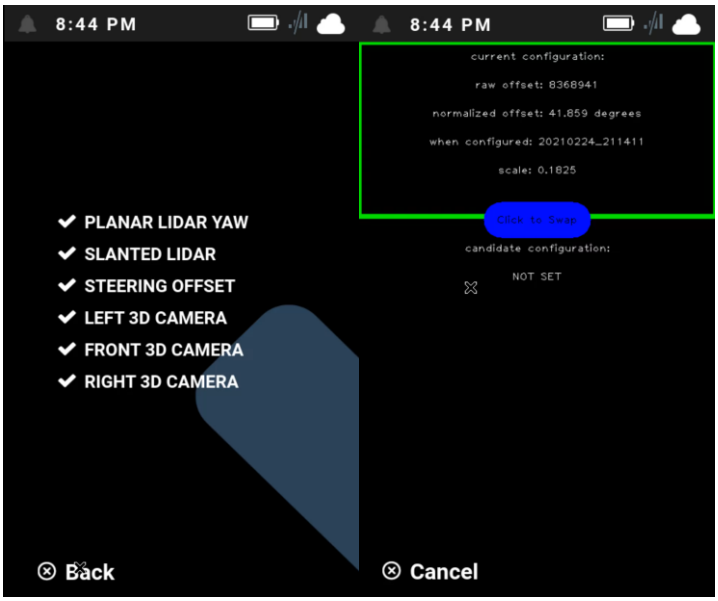
This calibration verifies that the steering is properly aligned. (Settings→Service→Service Pin→Calibration→Steering offset→Click to swap)

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**.



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.

NOTE: If the candidate configuration is not displayed on the screen, train a new route that is at least 5 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 verify the following:
    - Steering is controlled as expected
    - The robot drives straight does not drift to one side or snake back and forth
    - The robot navigates around obstacles as expected
    - The robot does not have any unexpected path blocked assists
    - There are no steering related faults
    - 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

Appendix A - Tech Steering Checklist

Description	Completed (Yes/No)	Results (Pass/Fail/Measurements)
Hardware Inspections		
Check the U-Joint		
Check the Steering motor		
Check the Steering Encoder		
Check the Steering Amp		
Check the Traction Encoder		
UI (touch screen) Diagnostics		
Check the steering angle		
Check the manual steering		
Check manual navigation		
Check automated steering		
Gyro Noise Test		
Record Traction Values		
Perform Steering Calibration Note: This is a **REQUIRED** step when any component is replaced		

Appendix B - Tech Solution Codes

The following tables are provided as individual solutions for issues that were identified in the preceding document.

Tech Solution Codes

Detailed Replacement instructions are located in the Appendix


Solution Code	Recommended Actions

CALIBRATION-01	NOTE: This is **generally a required step** after replacing parts or troubleshooting issues related to the steering system. 1. Train a route that is **at least 5 minutes** with minimal stopping. a. Be sure to teach a route that goes straight and has left turns, right turns, and u-turns. 2. Go to **Service Menu** > **Calibration** > **Steering Offset** 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. 4. Key the unit off and back on **5. Run the newly trained route and monitor for any anomalies** 6. Take a picture of the "**Route Complete**" or "**Route History**" screen. 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.
UJOINT-01	If a u-joint is broken, worn out, or missing a pin, perform the following steps: 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. 2) Place an order for the following part: U-joint (ICE Part Number 8310604). 3) Schedule the next site visit based on the tracking information for the part. 4) Replace the u-joint. 5) **For this service, always perform the required steering calibration in solution code CALIBRATION-01**.

STENCODER-01	If the steering encoder has been damaged in some way (internally or externally), perform the following steps: 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. 2) Place an order for the following part: Steering Encoder (ICE Part Number 8350410) 3) Please schedule the next site visit based on the tracking information for the part 4) Replace the steering encoder 5) **For this service, always perform the required steering calibration in solution code CALIBRATION-01**
STENCODER-02	If the Manual Navigation Check fails, perform the following steps: 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. 2) Place an order for the following part: Steering Encoder (ICE Part Number 8350410) and Harness Down Trunk (ICE Part Number 8350264). 3) Schedule the next site visit based on the tracking information for the part. 4) Replace the steering encoder and down trunk cable. 5) **For this service, always perform the required steering calibration in solution code CALIBRATION-01**.

MOTOR-01	If the steering motor is leaking oil or has a damaged cable, perform the following steps: 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. 2. Place an order for the following part: Steering Motor (ICE Part Number 8350430). 3. Schedule the next site visit based on the tracking information for the part. 4. Replace the steering motor. 5. Perform a steering calibration (for more information on how to perform a steering calibration, refer to the Steering calibration section). 6. **For this service, always perform the required steering calibration in solution code CALIBRATION-01**.
AMP-01	If any of the following occur, perform the following steps: ● The steering wheel is hard to turn. ● There is a damaged left or right male connector. ● The left or right male connector is missing pins. **Solution steps:** 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. 2) Place an order for the following part: Steering Amplifier (ICE Part Number 8350255). 3) Schedule an estimated service date to replace the steering amplifier. 4) Replace the steering amplifier.

AMP-02	If there is a damaged left female connector that has any damaged wires or something stuck in the connector, perform the following steps: 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. 2) Place an order for the following part: Steering Motor (ICE Part Number 8350430). 3) Schedule an estimated service date to replace the steering motor. 4) Replace the steering motor. 5) **For this service, always perform the required steering calibration in solution code CALIBRATION-01**.
DOWNTRUNK-01	If there is a damaged right female connector, and/or any damaged wires or something stuck in the connector, perform the following steps: 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. 2) Place an order for the following part: Downtrunk (ICE Part Number 8350264) 3) Schedule a service date to replace the downtrunk. 4) Replace the downtrunk.

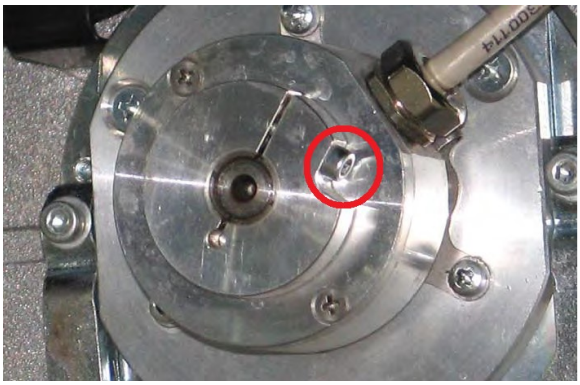
ANGLE-01	If the Steering Angle check is off, perform the following steps: 1) Perform the steps in the Steering Calibration solution code **CALIBRATION-01**. 2) Perform the Steering Angle Check (again). 3) If the unit is **unable to complete running the newly trained route** or it **fails the Steering Angle check again**, proceed to the remaining Software Diagnostics: a) Manual Steering Check b) Manual Navigation Check c) Automated Steering Check d) Gyro Noise Test
BCM-01	If the BCM has failed the Gyro Test multiple times, perform the following steps: 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. 2. Advise Brain Corporation that the unit failed the Gyro Test. 3. For BCM replacement instructions, please see "Troubleshooting Guide for BCM"

TRACTION-01	If the traction value does not increase or decrease as expected, perform the following steps: 1) Place an order for the following part: Traction Encoder (ICE Part Number: 8350266), Traction encoder cable, Down trunk Harness. 2) Send any photos, notes, and/or a filled out Troubleshooting Checklist to Brain Corporation using the e-mail address specified in the work order. 3) Schedule the next site visit based on the tracking information for the part. 4) Disconnect the traction encoder cable from the downtrunk, and connect the new encoder directly to the downtrunk. a) Spin the axle clamp to allow movement to be registered by the BCM. Refer back to the Software Diagnostic Traction Check section to view Traction Reading. i) If the traction encoder reading does not change, replace the Downtrunk Harness and repeat step 4a. ii) If the traction encoder reading does change, un-tether the traction encoder cable and plug it into the new traction encoder and attempt to get a traction encoder reading. iii) If a reading is registered with the new encoder, then replace the existing traction encoder (use a gear puller if necessary). iv) If a reading is not registered, replace the traction encoder cable. b) If the traction encoder reading does change after replacing the downtrunk, then disconnect the new traction encoder and plug the connector back into the existing traction encoder cable. [Troubleshooting complete] c) If the traction encoder reading does NOT change after replacing downtrunk harness, the BCM will need to be replaced (refer to solution code BCM-01).

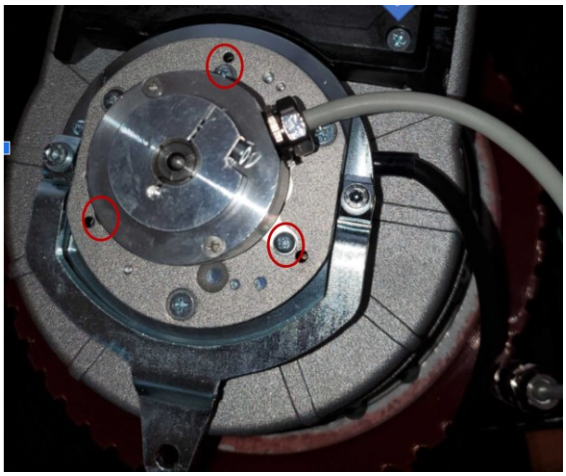
Appendix C - How to replace the Traction Encoder

1. Power down the unit and disconnect the red battery coupling.


2. Turn the steering wheel so the encoder and brake assembly installed on the drive wheel assembly can be easily accessed.
3. Disconnect the encoder cable from the wire harness.
   Note: Photo cable management you will be required to reproduce after replacement.
4. Loosen the hex screw which locks the traction encoder to the axle.



5. Remove the screws that hold the traction encoder



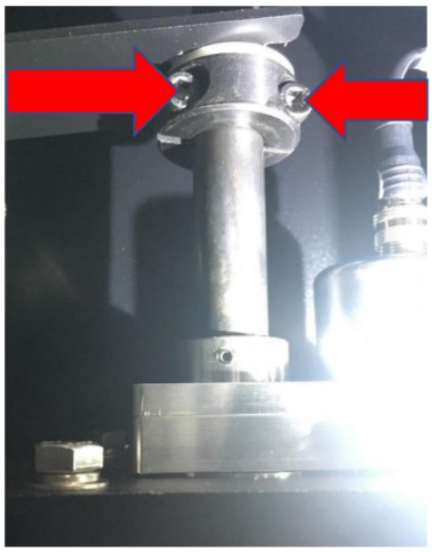
6. The Traction encoder may be difficult to remove and a gear puller will help.
7. Reverse the steps to install.

Appendix D - How to Replace the Steering Motor

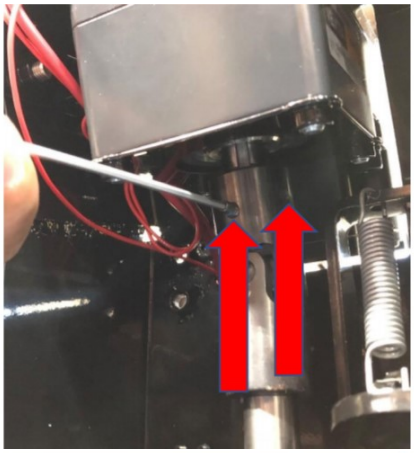
1. Turn the key to power off the scrubber. Raise the seat and disconnect the red battery coupling and the seat sensor connection.
2. Make sure the front wheel is oriented straight ahead. This will be our point of reference.
3. Remove the access panel to access the Steering Column

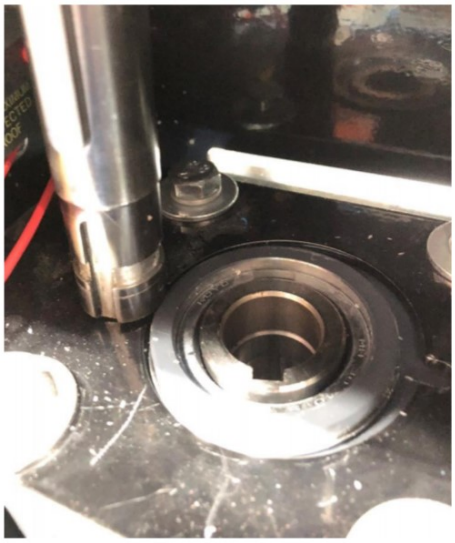

4. Remove the front fascia
   As shown at right, also be sure to remove the six hex screws holding on the main fascia – two on each side, and two at the bottom. Note – there may also be additional, smaller screws to remove on each side.

5. Loosen the collar (2 hex screws) and slide it down

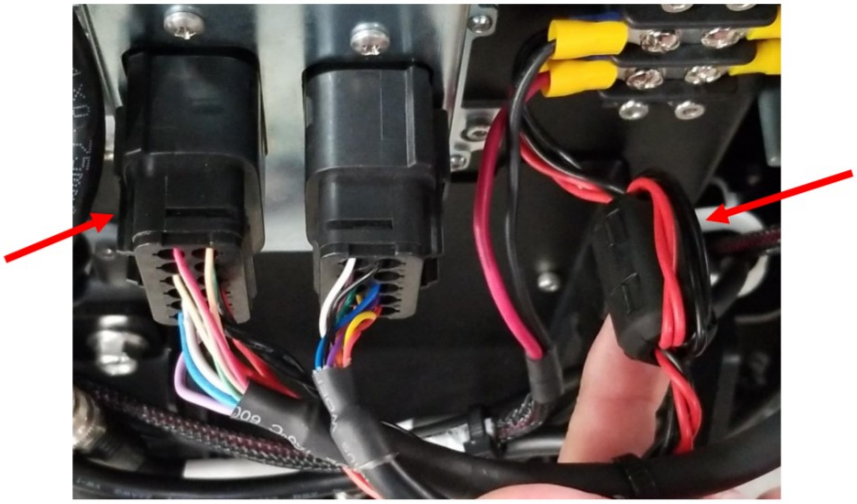



6. Remove the two set screws indicated below, then pull the steering wheel straight up.

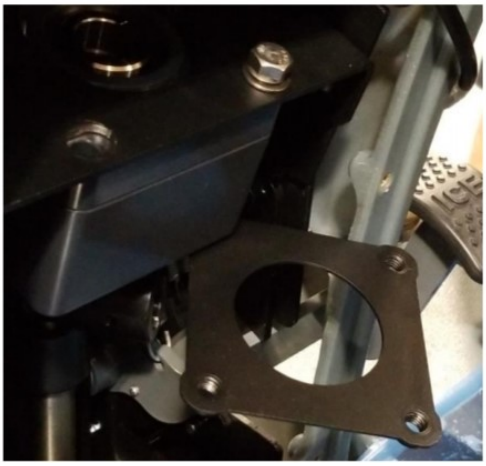


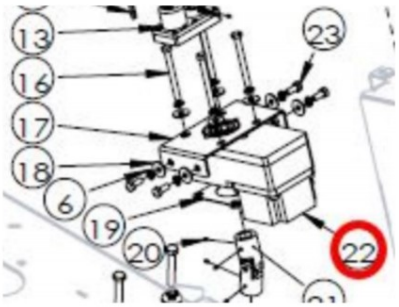
7. Next, unplug the 12-pin connector on the left side of the steering motor amp module (MAM). Ensure the replacement steering motor has both the same 12 pin connector and a ferrite core shown.



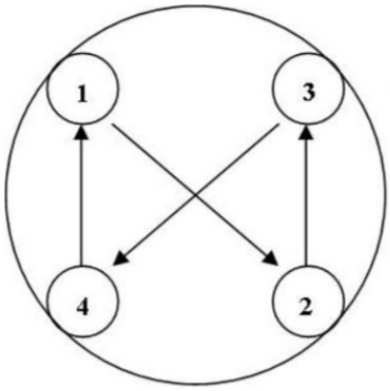
8. Undo all steering motor bolts. Take care to retain all washers, bolts and the mounting plate for reassembly



9. Connect bolts 16 through the replacement drive motor and connect them to mounting plate 19. Note, bolts 6 and 23 may not be present in the Gen2 scrubber.



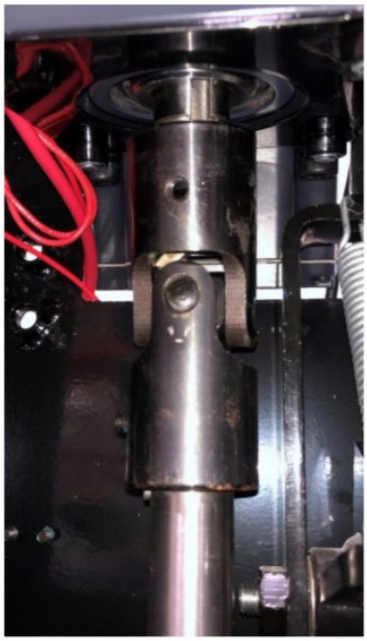
10. When re-tightening the four steering motor bolts, follow a star pattern similar to when changing a tire on a four-bolt car wheel.



11. Installed steering motor as viewed from the front of the scrubber, with BCM immediately above, and steering motor amp module (MAM) located below. Note 12-pin

connector from the steering motor into the MAM.

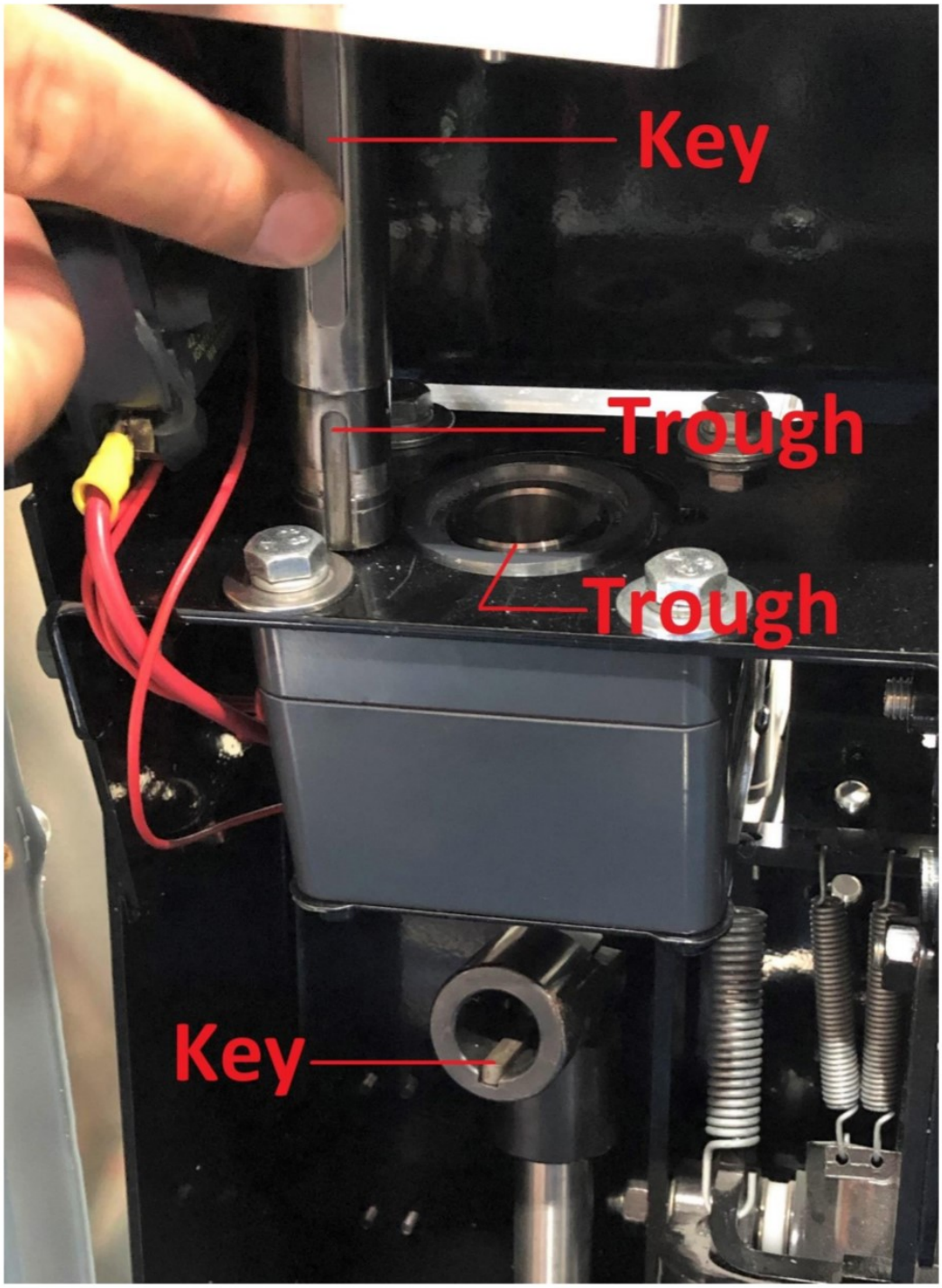
12. Push the steering wheel down to move the shaft into place. It should move through the steering motor and lock into the U joint below. Make sure the keys all line up and the wheel is pushed all the way down before re-securing the four set screws. Raise the collar back up and tighten the hex screws.



13. Verify that the wheel is straight and the logo on the steering wheel lines up properly. If the wheel is straight and the steering wheel logo is misaligned, the steering wheel may be removed and repositioned
14. To do this, use a 3 mm hex to remove the three screws that reside on the underside of the steering wheel. Do not remove the Phillips screws


15. Use a 7/8 socket wrench to remove the nylon nut and washer that secures the steering wheel. Wiggle the steering wheel back and forth and pull up to remove. Once freed, realign and reassemble

Note: Diagram of Keys and trough



Appendix E – U-Joint Replacement

See appendix D. This outlines steps to get to the U-Joint.

Parts required for this service:

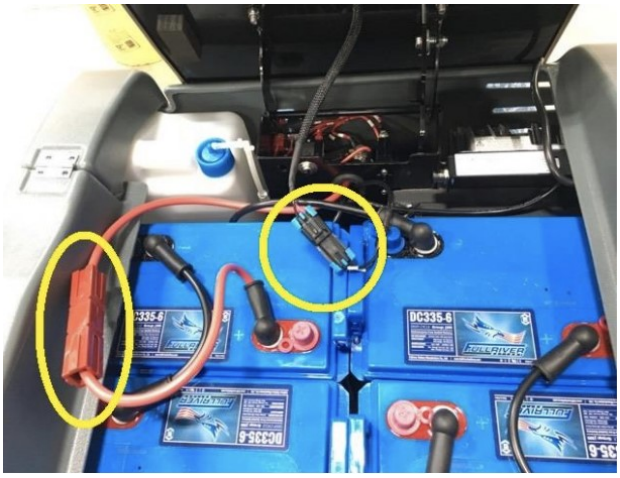
2.5 mm hex

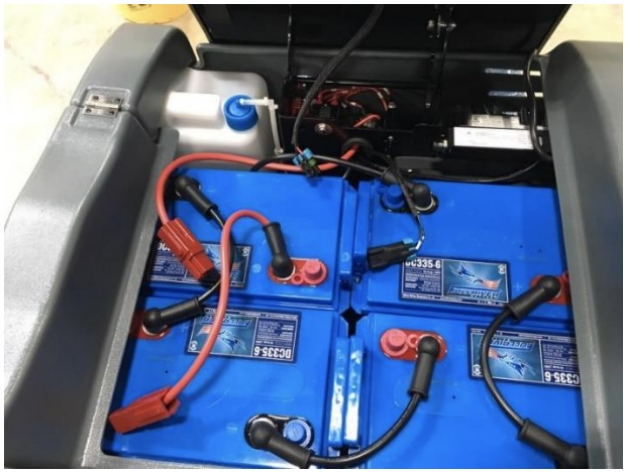
5 mm hex

Replacement U-joint

3 mm hex (optional)

Turn the key to power off the scrubber. Raise the seat and disconnect the red battery coupling and the seat sensor connection.

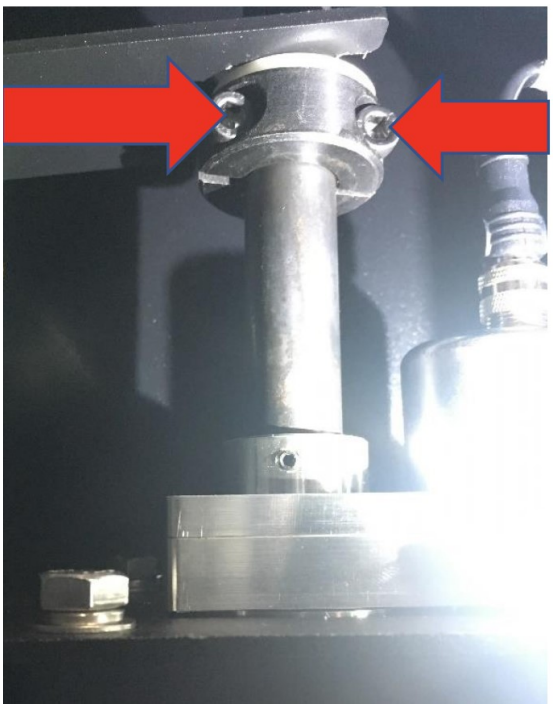




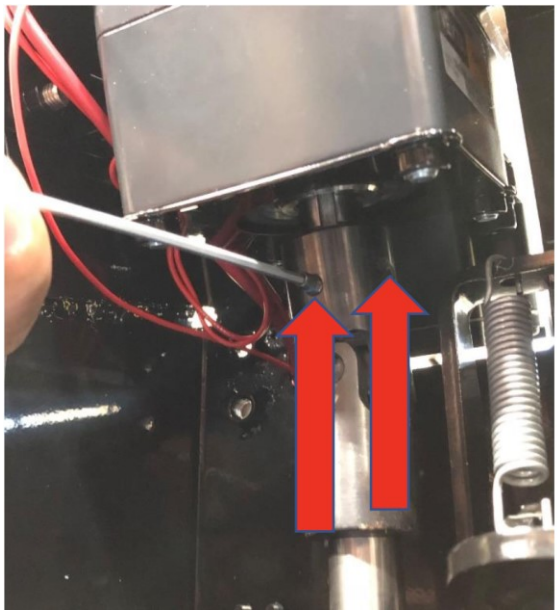
Make sure the front wheel is oriented straight ahead. This will be our point of reference.

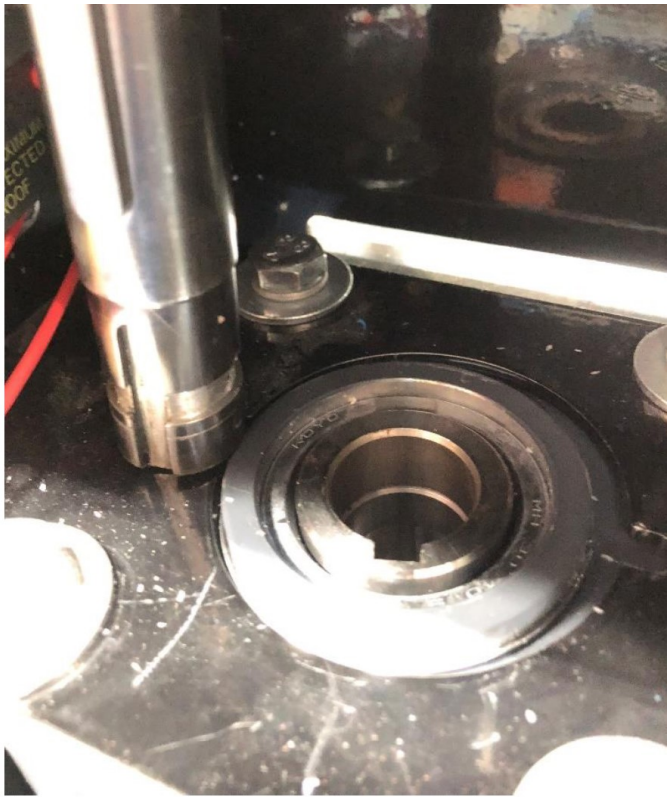
Remove the access panel to access the Steering Column

Loosen the collar (2 hex screws) and slide it down



Remove the two set screws indicated below, then pull the steering wheel straight up.

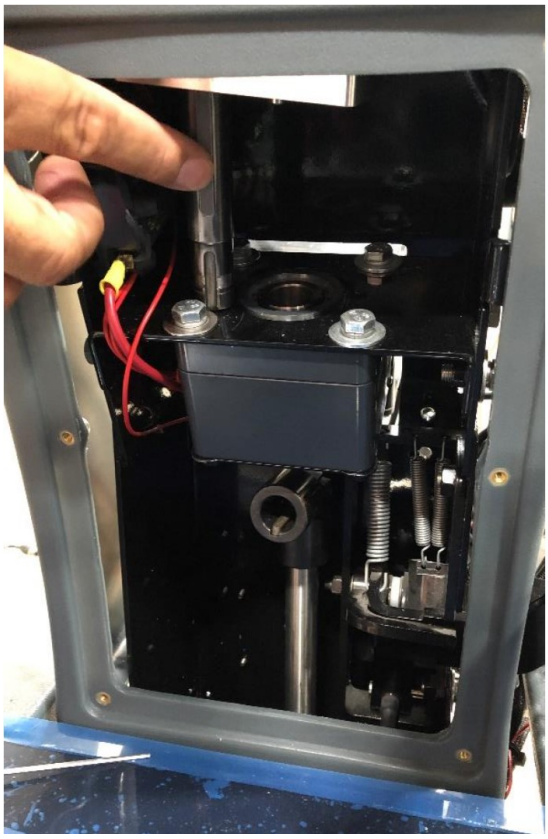


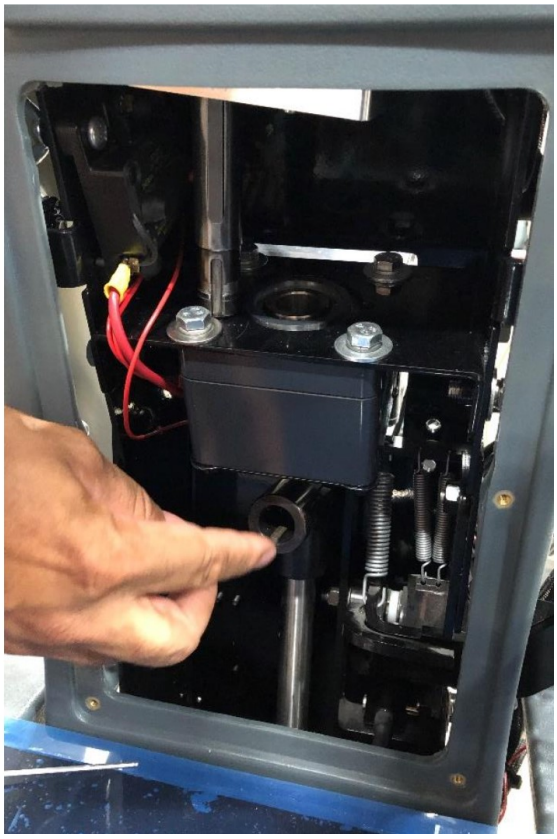


Remove the set screws from the bottom of the U joint so the component can be removed from the shaft.

The replacement U joint can be installed either way, as long as the keys match up.

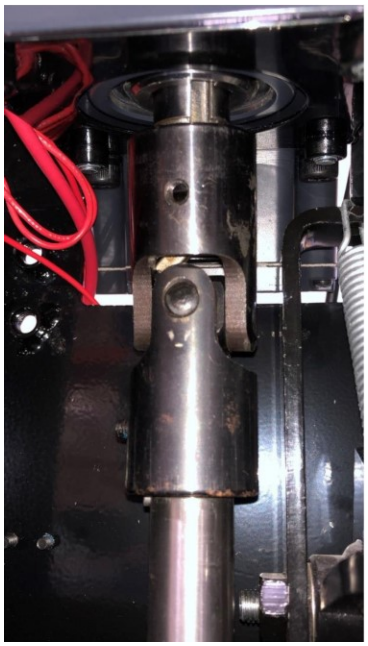
The shaft, U joint and keys should be configured to resemble the images below. See end of document for a high res image.



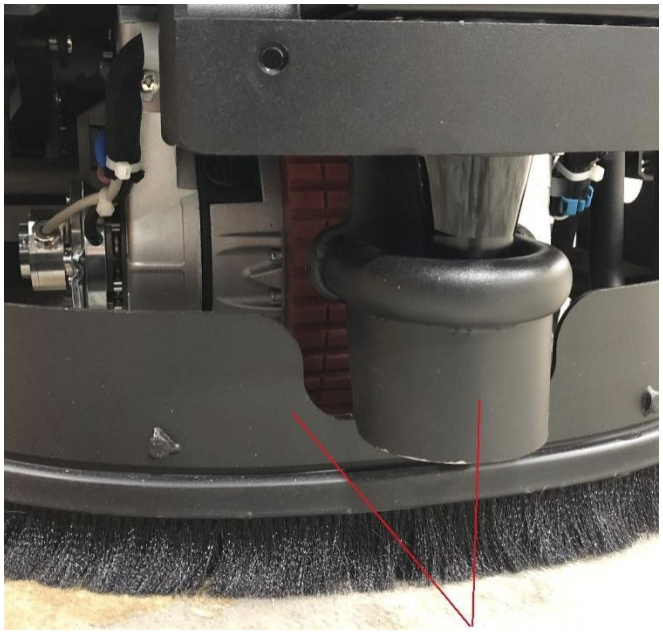


Push the steering wheel down to move the shaft into place. It should move through the drive motor and lock into the U joint below. Make sure the keys all line up and the wheel is pushed

all the way down before re-securing the four set screws. Raise the collar back up and tighten the hex screws.



Verify that the wheel is straight and the logo on the steering wheel lines up properly. If the wheel is straight and the steering wheel logo is misaligned, the steering wheel may be removed and repositioned.



To do this, use a 3 mm hex to remove the three screws that reside on the underside of the steering wheel. Do not remove the Phillips screws.

Use a 7/8 socket wrench to remove the nylon nut and washer that secures the steering wheel. Wiggle the steering wheel back and forth and pull up to remove. Once freed, realign and reassemble.

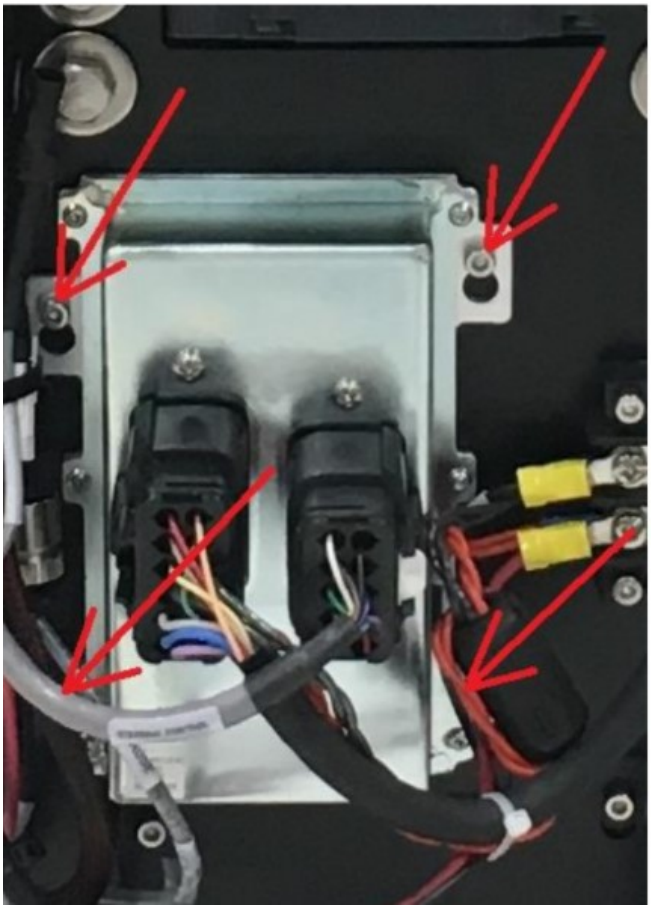
Reconnect the red battery coupling. Turn the key to power on the unit to ensure proper start up and system operation.

Steering Calibration Required after U-joint replacement, please see UI based Diagnostics Section

Appendix F – Steering Amplifier (MAM) replacement

1. Turn off the unit and disconnect the red battery coupling
2. Remove the front cover and place it to the side.

3. Loosen the four 3mm hex screws above the eyelets, decouple the two black plugs and remove the Motor Amplifier (Steering AMP)



4. Connect the new motor and reverse your steps.

Appendix G – Steering Encoder replacement

Parts required for this service:

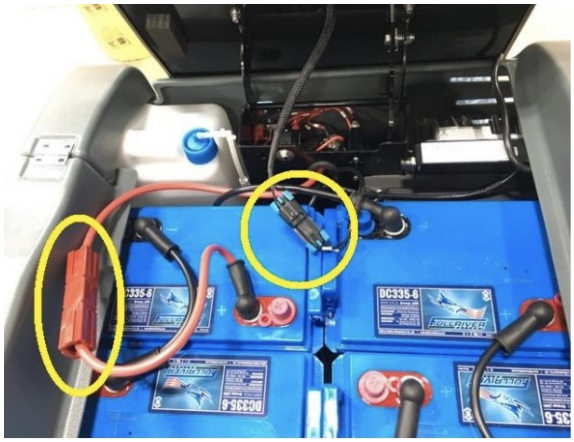
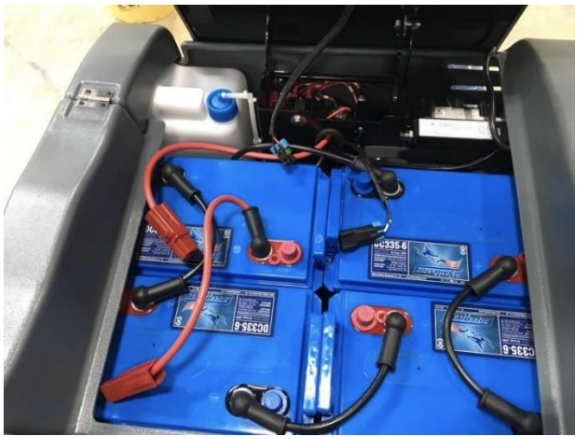
2.5 mm hex

5 mm hex

Replacement Steering Encoder

3 mm hex (optional)

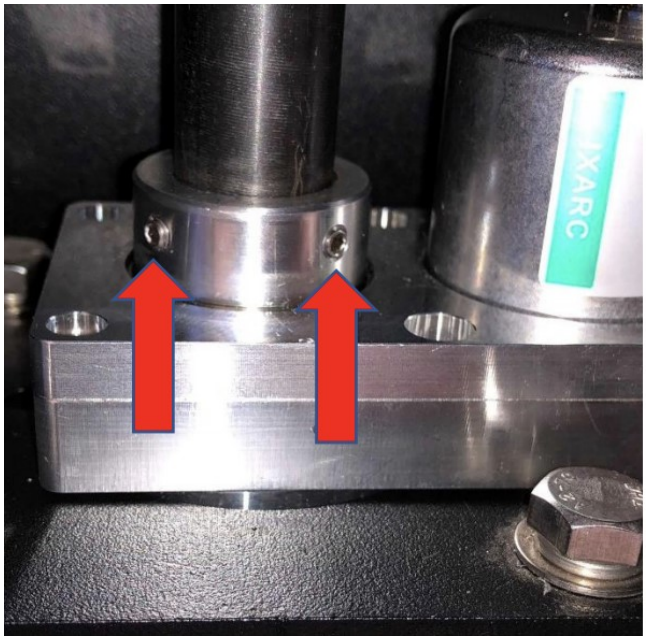
Turn the key to power off the scrubber. Raise the seat and disconnect the red battery coupling and the seat sensor connection (optional).

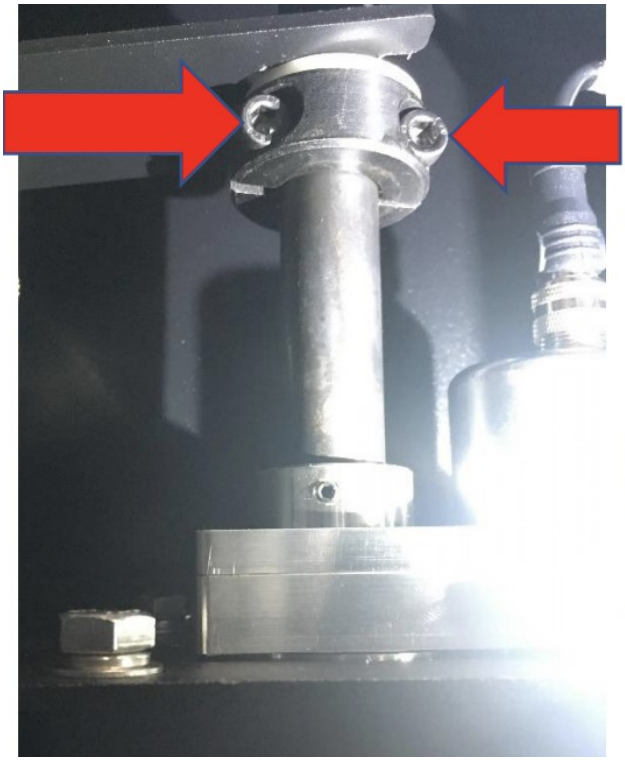
Make sure the front wheel is oriented straight ahead. This will be our point of reference.

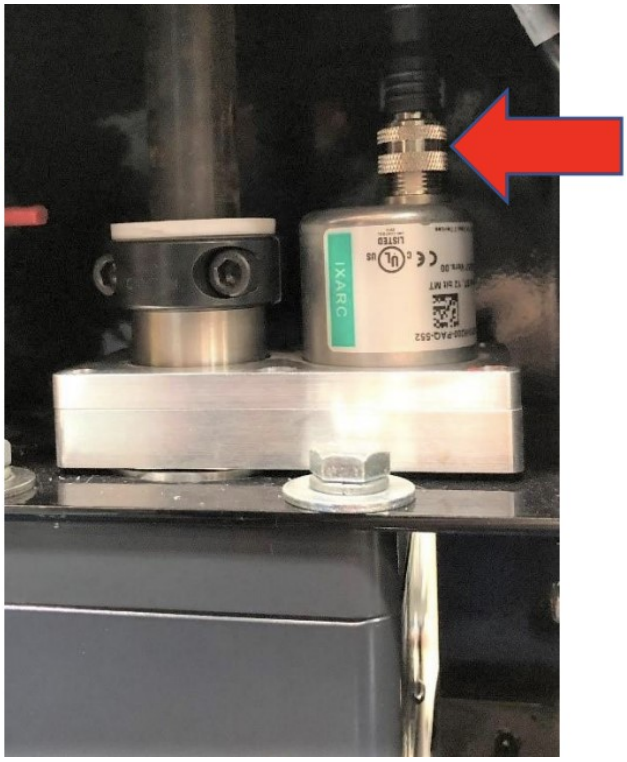
Remove the access panel to access the Steering Column


Spin the wheel to provide access to these two set screws. Loosen them but do not remove completely.

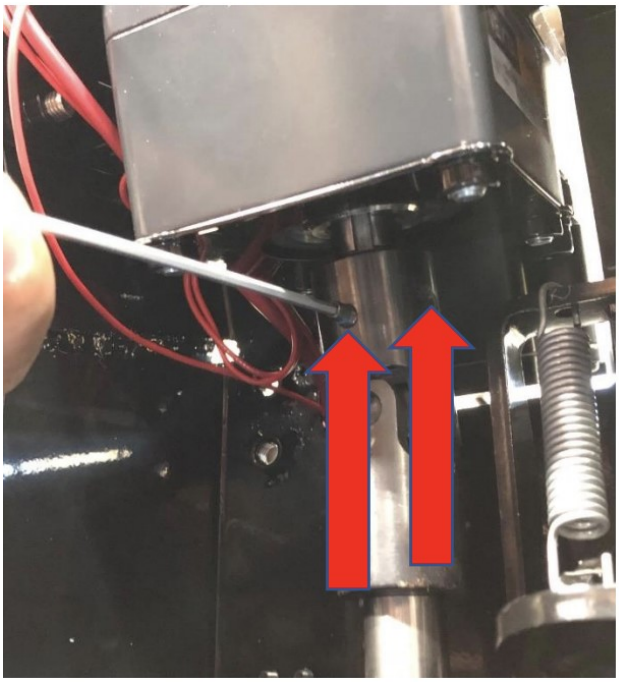


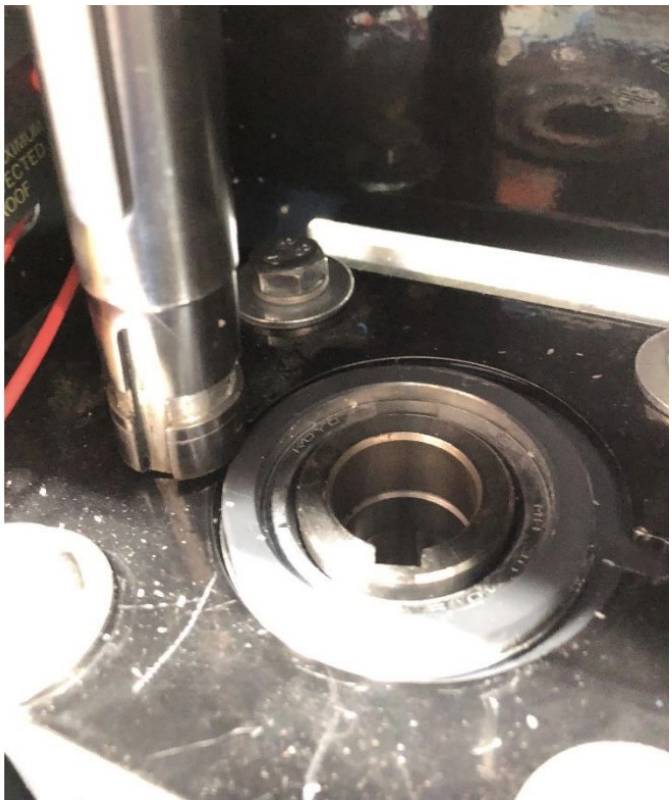
Loosen the collar (2 hex screws) and slide it down. Unplug the Steering Encoder connector.





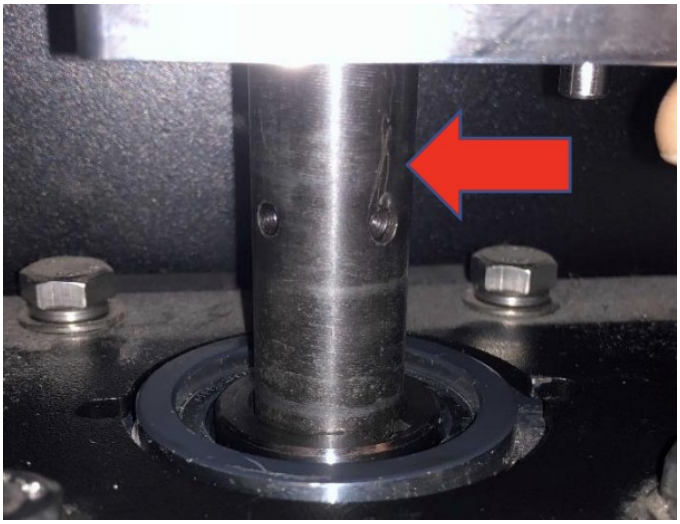
Remove the two set screws indicated below, then pull the steering wheel straight up



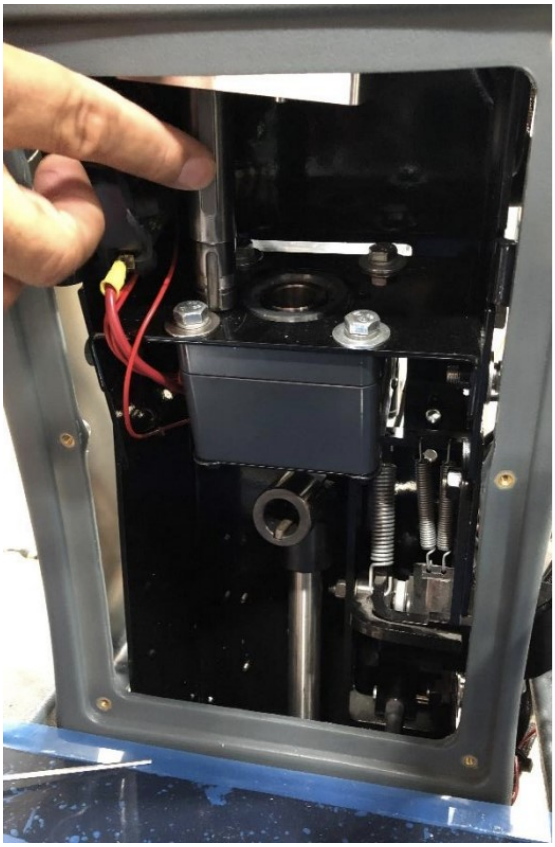


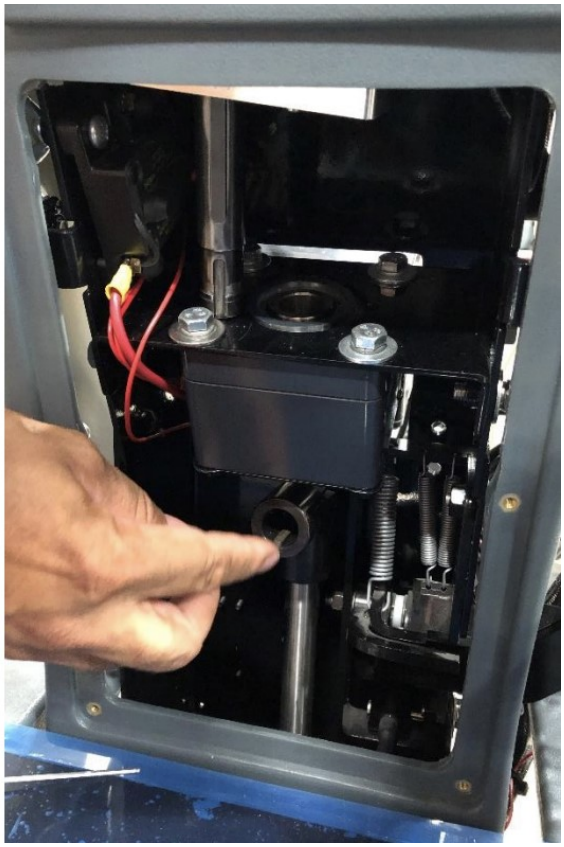
The Steering Encoder can now be slid off from the bottom of the steering shaft and replaced with a new one.

The set screws on the steering encoder need to be aligned with the threaded holes on the steering shaft. Since the holes can't be seen when the encoder is in place, it is useful to indicate their location(s) by scratching or marking the shaft.

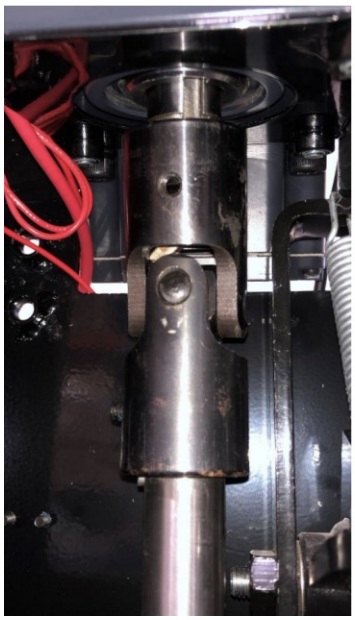


The shaft, U joint and keys should be configured to resemble the images below. See end of document for a high res image.

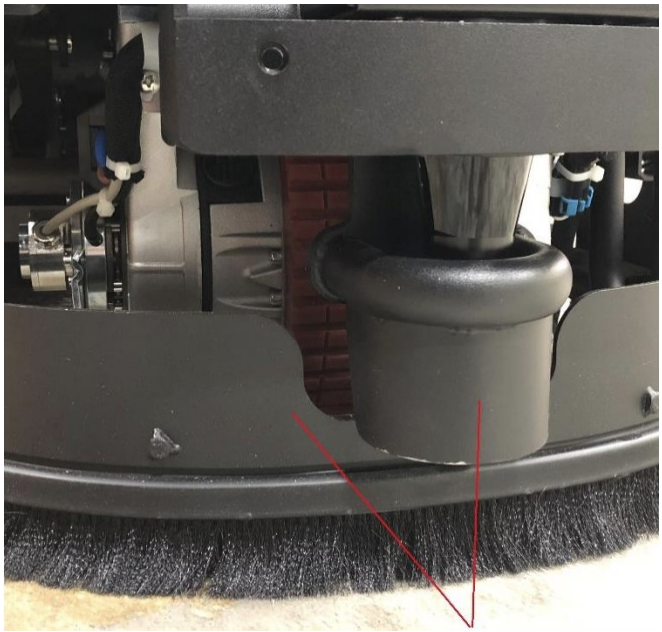




Push the steering wheel down to move the shaft into place. It should move through the drive motor and lock into the U joint below. Make sure the keys all line up and the wheel is pushed all the way down before re-securing the four set screws. Raise the collar back up and tighten the hex screws.




Verify that the wheel is straight and the logo on the steering wheel lines up properly. If the wheel is straight and the steering wheel logo is misaligned, the steering wheel may be removed and repositioned.




To do this, use a 3 mm hex to remove the three screws that reside on the underside of the steering wheel. Do not remove the Phillips screws.

Use a 7/8 socket wrench to remove the nylon nut and washer that secures the steering wheel. Wiggle the steering wheel back and forth and pull up to remove. Once freed, realign and reassemble.

Reconnect the red battery coupling. Turn the key to power on the unit to ensure proper start up and system operation.

Check the Steering Encoder functionality and alignment from the Steering Angle Screen.

The Steering value should change as the steering wheel is rotated left and right.

The green line should move left and right as the steering wheel is rotated and should orient straight up when the wheel is straight.

If these two conditions aren't met, they must be corrected before the steering may be calibrated and the unit used autonomously.

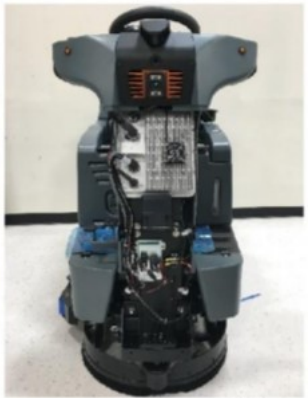
A steering calibration must be performed after the Steering Encoder has been replaced.

Appendix H – Down Trunk Cable replacement

1. The Downtrunk is a wiring bundle that connects the BCM to numerous sensors, encoders and indicators throughout the lower half of the robot.

2. To replace this component, power down the unit, remove the front plastic shield (5 mm) and the screws that hold the control panel (2 mm) in place.



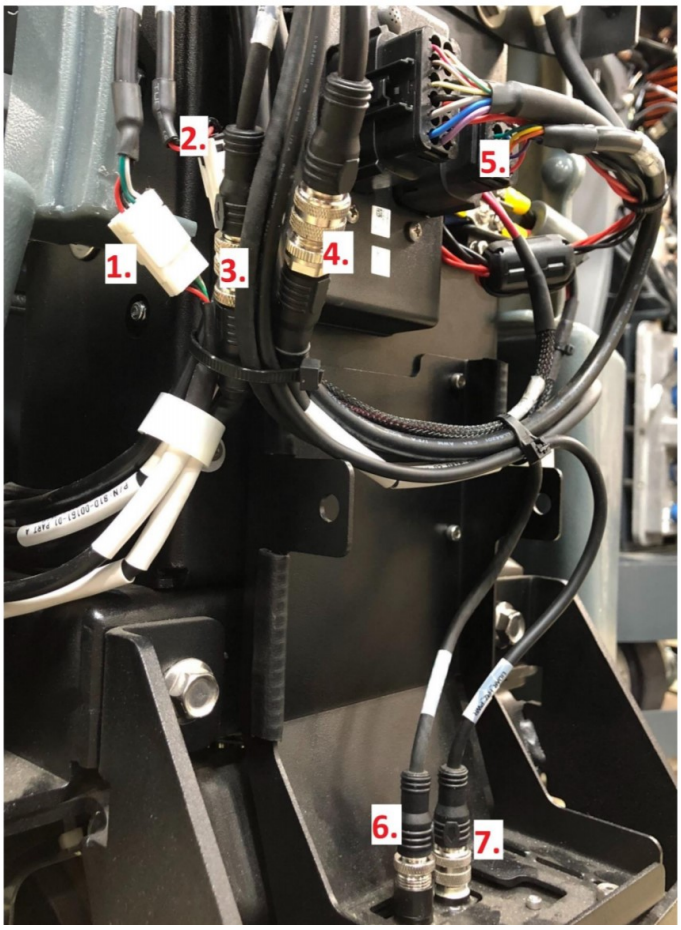



3. Remove the Downtrunk connector by spinning it counter-clockwise.

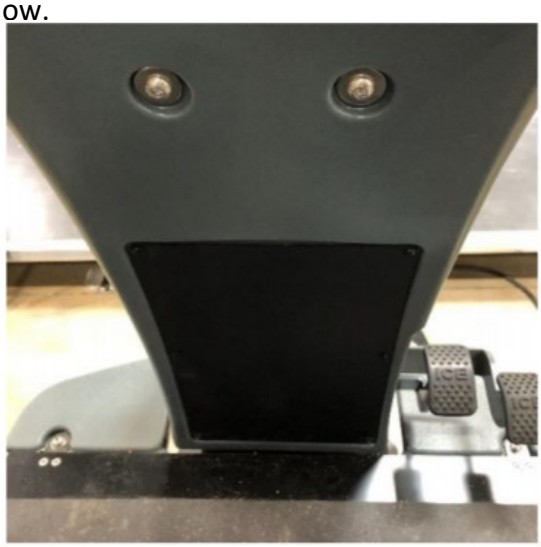

4. Remove any zip ties that secure any of the Down trunk cables
5. The Down Trunk connects to the following devices:

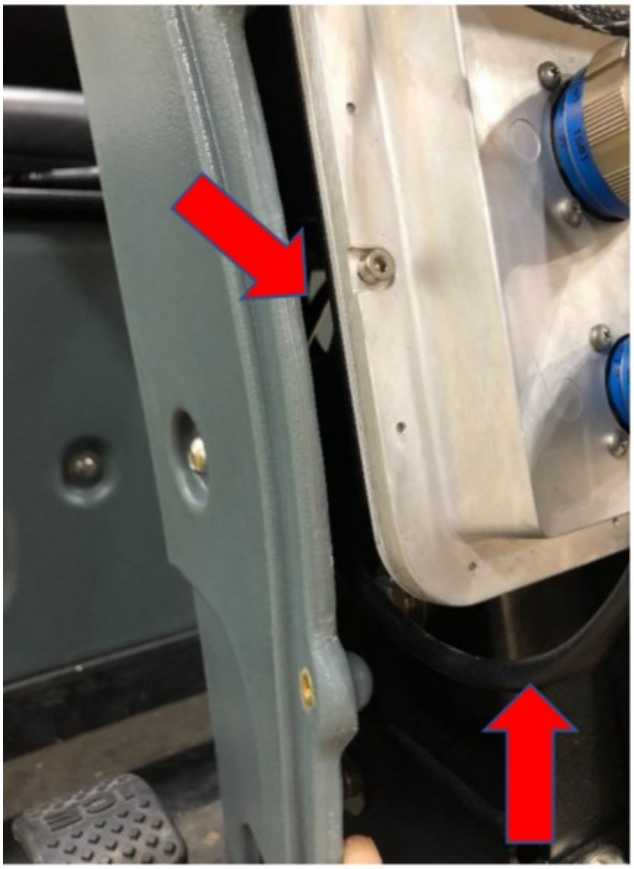
1. START_PAUSE	2. ESTOP
3. SP_ETH (SSH Port)	4. ENC_TRACT1
6. STEERING	7. LIDAR_HRZ_ETH

8. LIDAR_HRZ_PWR 9. ENC_ABS (Steering Encoder)

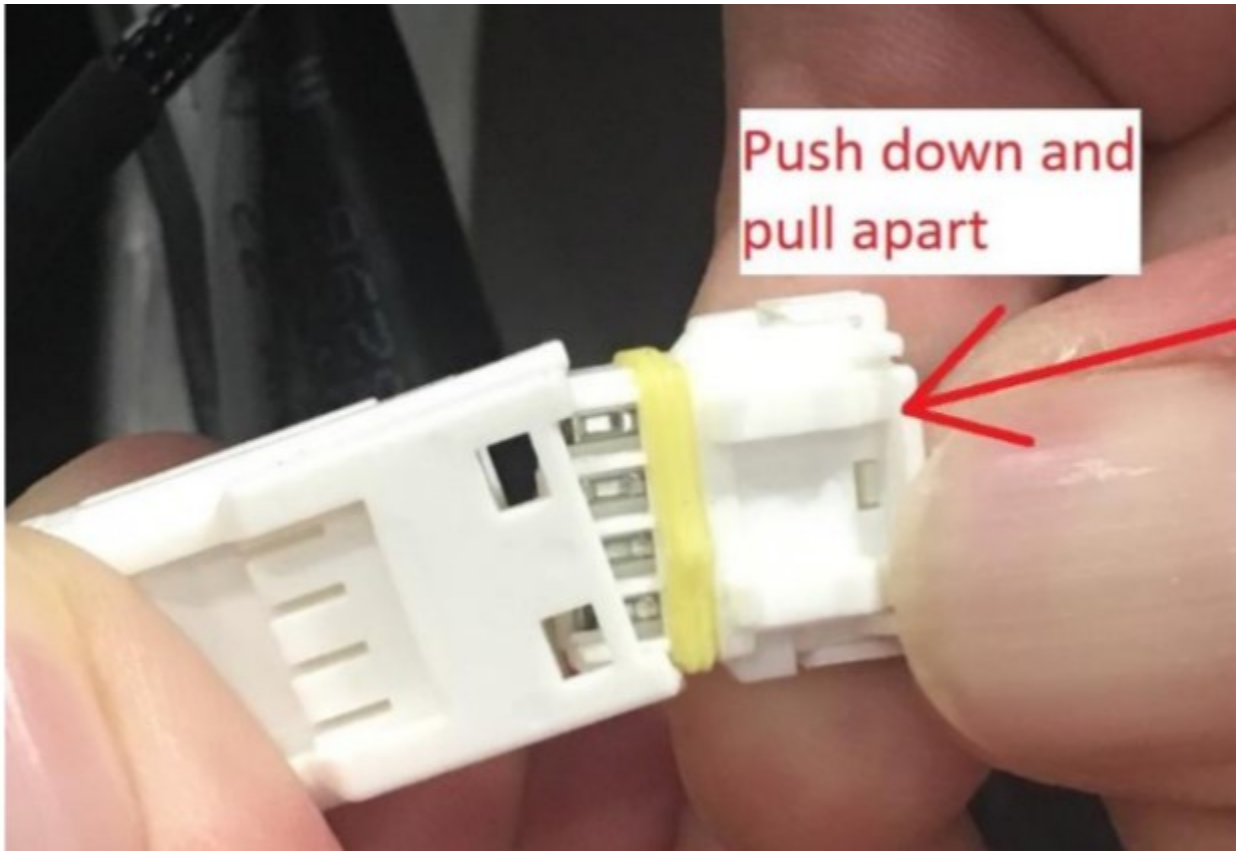


6. Remove the access panel opposite the seat and route the ENC_ABS cable as shown below.






7. To disconnect the START_PAUSE and ESTOP coupling.



8. Use caution when handling the LIDAR_HRZ_ETH and LIDAR_HRZ_PWR cables. When connecting them to the LIDAR sensor, be gentle, as any modification to the sensor's position may result in a necessary recalibration of machine sensors.
9. Reverse the steps outlined in this document to reassemble the scrubber after replacing the Downtrunk, then power on the machine.
10. To verify unit functionality following the Downtrunk replacement: Ensure that the UI screen can display Planar LIDAR signal, the Start/Pause button and E-stop buttons function, the steering and traction encoders change value when driven and the wheel is rotated