LIQUID ROBOTICS
A Boeing Company

CCU & Thrudder Compass Calibration Procedure

On-Shore and In-Water

Revision D
Item Number: 09502

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Revision History

Document Part Number	Revision	Publication Date	Changes
09502	A	February 2018	This is the initial release of this document.
	B	March 2018	Updated dependencies to indicate the procedure applies only to Regulus 1.1.3.
	C	January 2020	Updated to include V300 scripts, as well as compatibility with Regulus 3.2.2
	D	January 2021	Updated to include pass/fail tolerance per Liquid Robotics MPI 09160 in Section 4.3 Deviation Criteria. Updated language grammar (low impact, no content changes) Updated SV3 v300 HW PN 08316 from Rev 04 to 05 (Superseded). Updated PN 10260 From Rev 6 to Rev 7 (Superseded).

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1 Introduction

There are several Wave Glider subsystems that utilize magnetic compasses. The compasses are sensitive to nearby ferrous material, as well as local geomagnetic effects. For optimal performance, the compasses must be calibrated to account for them. The two most critical compasses are located in the Sub Thrudder and Float CCU. The Thrudder compass is fundamental to system navigation. This procedure applies to both compasses.

Note: The system should be in its final physical configuration during calibration.

2 Dependencies

This procedure applies to systems with the following components.

2.1 SV3 V100/V200

Note: This procedure does not apply to all V100's; they must have a Thrudder 1.5 w/ External Compass.

2.1.1 Hardware

Part Description	Part Name	Part Number (PN)
Thrudder 1.5	ASSY, THRUDDER, SV3, 1.5 version	07555 Rev 05
External Compass	ASSY, REMOTE COMPASS, INTERNAL SPINE ASSM, AHRS, REMOTE COMPASS	08518 Rev 05 *OR* 06737 Rev 03

2.1.2 Software/Firmware

Regulus 1.1.3 or 3.2.2

IGM Firmware:

Name: FW, AMPS IGM2 07496, Version: 0x00004CEE, Filename: IGM-07496-0x0008-4CEE, PN: 08219 Rev E

OR

Name: FW, AMPS IGM, Version: 0x00004CEE, Filename: IGM-04469-0x0008-4CEE, PN: 05498 Rev C

2.2 SV3 V300

2.2.1 Hardware

Thrudder 3.0: PN 08316 Rev 05, ASSY, THRUDDER 3.0

Float AHRS (Twist Counter): PN 08997 Rev C, PCBA, AMPS TWIST COUNTER

2.2.2 Software/Firmware

Regulus 3.2.2

Thrudder F/W: 0x00000049, Filename: Flounder-09946-0049, P/N: 10260 Rev 7

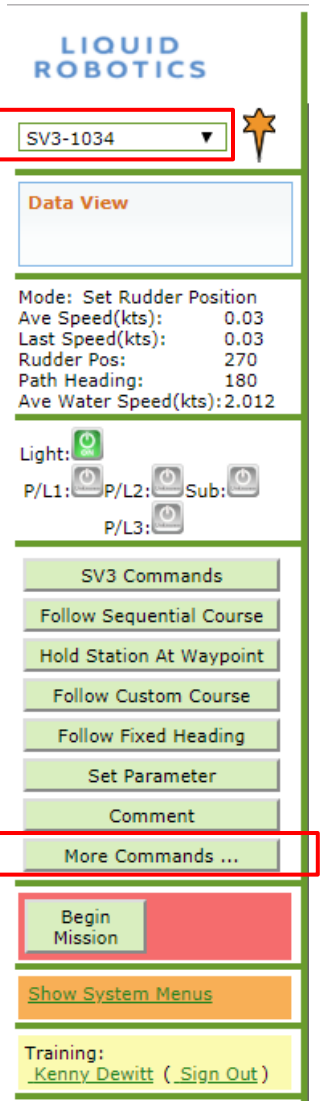
Float AHRS F/W: 0x00000009, Filename: FloatAHRS-08997-0009, P/N: 10326 Rev 02

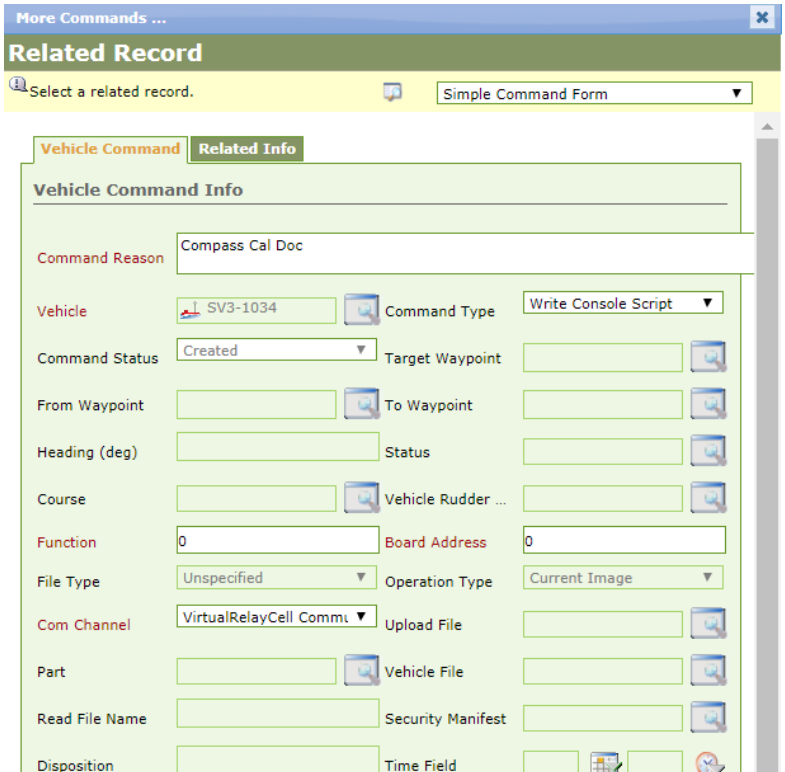
3 How To Send Write Console Scripts (WGMS)

To conduct this calibration procedure, Write Console Scripts will have to be sent to the vehicle. There are various ways these can be sent; the process for doing so on WGMS is shown below.

1. Login to WGMS Org and click Piloting (this example = training.wgms.com)
2. Select vehicle in Vehicle Dropdown list (see image to right)
3. Click on "More Commands" from the Common Commands List in the Dashboard Sidebar (see image to right)
4. The "More Commands…" dialog box will appear. Fill it in as follows (see image below):
    - Command Reason: Enter text reason (e.g. Compass Cal)
    - Command Type: Select "Write Console Script" from dropdown list, will be towards the bottom of the list.
    - Leave Function = 0
    - Type "0" (zero, not the letter O) into Board Address
    - Select appropriate Com Channel (Cell if available)
    - Enter or copy-paste (recommended) script into Script Buffer, do not forget the % character at the beginning of the script.

Note: When copy-pasting scripts, to avoid syntax errors any quotation marks will need to be retyped in the WGMS dialog box.





4 On Shore Calibration

On Shore calibration must be done with the Wave Glider's Float and Sub co-aligned (typically installed in the vehicle's stand). This procedure should be done away from large metal structures such as buildings or rebar in concrete.

4.1 SV3 V100/V200 On-Shore

1. Retrieve existing calibration parameters from CCU & Thrudder:

   %amps.portDump("Thrudder-2", 2, 2, 34, 3)

   %amps.portDump("Host", 32, 4, 11, 3)

2. Start calibration routines on devices:

   %amps.writePortField("Thrudder-2", 2, 2, 0, 1128352817)

   %amps.oneShot("Host", 32, 4, 0, "CAL1")

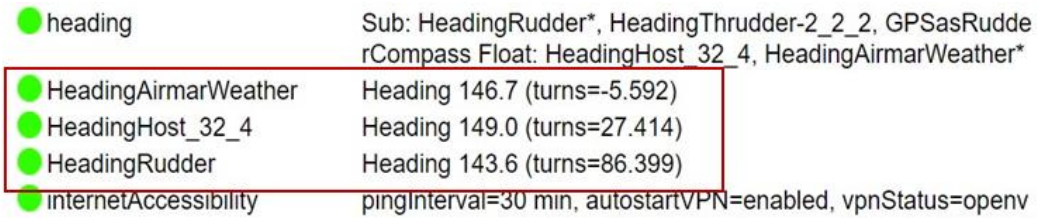
3. Rotate the vehicle through two or three complete circles over 1-2 minutes.

4. Stop the Thrudder and CCU calibration routines:

   %amps.writePortField("Thrudder-2", 2, 2, 0, 1128352816)

   %amps.oneShot("Host", 32, 4, 0, "CAL0")

5. With the vehicle on shore with access to the vehicle web page, check the "Overall Vehicle Status" page to verify the float and sub headings are aligned at all cardinal directions (0, 90, 180, 270 degrees). The fields "HeadingHost_32_4" and "HeadingRudder" should be similar and should match the physical heading of the vehicle. If the system is configured with a weather station, the HeadingAirmarWeather value can be used for reference as well.



6. Retrieve the new Thrudder and CCU compass calibration values:

   %amps.portDump("Thrudder-2", 2, 2, 34, 3)

   %amps.portDump("Host", 32, 4, 11, 3)

4.2 SV3 V300 On-Shore

1. Retrieve existing calibration parameters from CCU & Thrudder

```
%amps.portDumpNCData("host", 13, 2, 11, 3)
%amps.portDumpNCData("thrudder-3", 1, 8, 11, 3)
```

2. Start calibration routines on devices

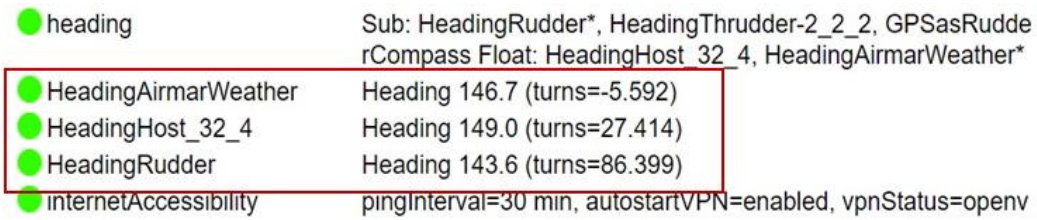
```
%amps.oneShot("host", 13, 2, 0, "CAL1")
%amps.oneShot("thrudder-3", 1, 8, 0, "CAL1")
```

3. Rotate the vehicle through two or three complete circles over 1-2 minutes.

4. Stop calibration routines on devices

```
%amps.oneShot("host", 13, 2, 0, "CAL0")
%amps.oneShot("thrudder-3", 1, 8, 0, "CAL0")
```

5. With the vehicle on shore with access to the vehicle web page, check the "Overall Vehicle Status" page to verify the float and sub headings are aligned at all cardinal directions (0, 90, 180, 270 degrees). The fields "HeadingHost_32_4" and "HeadingRudder" should be similar and should match the physical heading of the vehicle. If the system is configured with a weather station, the HeadingAirmarWeather value can be used for reference as well.



6. Retrieve new calibration parameters:

```
%amps.portDumpNCData("host", 13, 2, 11, 3)
%amps.portDumpNCData("thrudder-3", 1, 8, 11, 3)
```

4.3 Compass Deviation Criteria

Note: When performing vehicle calibration of the thrudder, a maximum of 20 degrees offset is allowable. This offset value must also be consistent throughout the 360 deg rotation of the vehicle while performing the calibration. If the value of the offset jumps erratically during the 360 rotation, then this is an indication of an unacceptable condition that needs resolution.

5 In Water Calibration

In Water calibration should be done soon after launch, while the vehicle is navigating properly. The vehicle shall be in an area large enough to complete the calibration without risk of running aground or colliding with other vessels. If you can afford to increase the telemetry report rate, it is recommended to set it to 1-2 minutes while the calibration is taking place, and return it to the on-mission report rate after.

5.1 SV3 V100/V200 In-Water

1. Retrieve existing calibration parameters from CCU & Thrudder

```
%amps.portDump("Thrudder-2", 2, 2, 34, 3)
%amps.portDump("Host", 32, 4, 11, 3)
```

2. Initiate heading polygon (8 sides, 2 minutes per side, 15 minutes total) –
   NOTE: Auto-avoid will not take effect in this navigation mode.

```
%ffn.headingPolygonCommand("2m", 8, 0)
```

3. Start calibration routines on devices:

```
%amps.writePortField("Thrudder-2", 2, 2, 0, 1128352817)
%amps.oneShot("Host", 32, 4, 0, "CAL1")
```

4. Allow the vehicle navigate through two complete octagons.
5. Stop calibration routines on devices:

```
%amps.writePortField("Thrudder-2", 2, 2, 0, 1128352816)
%amps.oneShot("Host", 32, 4, 0, "CAL0")
```

6. Perform cardinal heading test (fixed heading navigation 0, 90, 180, 270 degrees for 4 telemetry reports each). In a scenario where there are no currents, the vehicle would travel in the same direction as the given fixed heading. However, currents will skew the path over ground.

   SV3 Commands -> Services -> Navigator (Expert Commands) -> Fixed Heading (sub heading)

7. Retrieve the new Thrudder and CCU compass calibration values:

```
%amps.portDump("Thrudder-2", 2, 2, 34, 3)
%amps.portDump("Host", 32, 4, 11, 3)
```

8. Put vehicle on course.
9. Return the telemetry rate to the on-mission value.

5.2 SV3 V300 In-Water

1. Retrieve existing calibration parameters from CCU & Thrudder

```
%amps.portDumpNCData("host", 13, 2, 11, 3)
%amps.portDumpNCData("thrudder-3", 1, 8, 11, 3)
```

2. Initiate heading polygon (8 sides, 2 minutes per side, 15 minutes total) – NOTE: Auto-avoid will not take effect in this navigation mode.

```
%ffn.headingPolygonCommand("2m", 8, 0)
```

3. Start calibration routines on devices

```
%amps.oneShot("host", 13, 2, 0, "CAL1")
%amps.oneShot("thrudder-3", 1, 8, 0, "CAL1")
```

4. Allow the vehicle navigate through two complete octagons.
5. Stop calibration routines on devices

```
%amps.oneShot("host", 13, 2, 0, "CAL0")
%amps.oneShot("thrudder-3", 1, 8, 0, "CAL0")
```

6. Perform cardinal heading test (fixed heading navigation 0, 90, 180, 270 degrees for 4 telemetry reports each). In a scenario where there are no currents, the vehicle would travel in the same direction as the given fixed heading. However, currents will skew the path over ground.

   SV3 Commands -> Services -> Navigator (Expert Commands) -> Fixed Heading (sub heading)

7. Retrieve new calibration parameters:

```
%amps.portDumpNCData("host", 13, 2, 11, 3)
%amps.portDumpNCData("thrudder-3", 1, 8, 11, 3)
```

8. Put vehicle on course.
9. Return telemetry rate to the on-mission value.