

Falkor 2017 UHDAS installation and ADCP evaluation

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Revision History

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1 Introduction

R/V *Falkor* has two Doppler current profilers made by Teledyne RDI. These instruments are used to determine ocean currents beneath the ship. Data acquisition and processing at sea will be performed by “UHDAS”, a data acquisition and processing system written at the University of Hawaii. This document describes UHDAS and the installation of the computer system on the Falkor as of early June, 2017. The ADCP and other aspects of the installation were evaluated during a 5-day Sonar Shakedown cruise starting in Portland,OR and ending in Astoria,OR. Further evaluation will take place during postprocessing of subsequent cruises.

1.1 ADCPs

The R/V *Falkor* has two ADCPs, one Workhorse Mariner (300kHz) and one Ocean Surveyor model (75kHz), referred to in this document as WH300 and OS75. The OS75 can ping in broadband mode or narrowband mode (those pings are referred to as OS75BB and OS75NB, respectively). Both ADCPs are mounted in a gondola, to reduce the effects of bubble sweep-down.

Both ADCPs were replaced during this long in-port period, which included a dry-dock period during which the ship was out of the water and the ADCPs were accessible. In 2015, the previous WH300 had failed, and later in the year the OS75 failed. A new installation scheme was designed to allow the ADCPs to be changed out when the ship was floating,

should that become necessary. This required wet-mateable connectors and access by divers. The cables provided by RDI are not really designed to be submerged, so this new approach required new cable designs. Hopefully it should also lessen the likelihood failure due to flooding.

Both ADCPs were tested for communication and as much other functionality as possible during each stage of the installation. They were dry-tested for communication prior to installation; they were also tested by submerging the transducer faces (allowing more testing than when dry – OS75 should not be pinged in the air). They were tested for communication after installation in the gondola. Finally, after the ship was floating, they were tested again.

When the UHDAS team arrived, the WH300 refused to communicate. RDI said the WH300 was set to RS422 communication, but even a new specially-built cable for RS422-RS232 communication, tested with success with the OS75, did not result in any communication with the WH300. It did not communicate via RS232 either, at any common baud rate. Apparently the WH300 died during its first few weeks in the water. We carried out the rest of the tests with the OS75.

Prior to installation, the unconventional OS75 cable design resulted in a last-minute decision due to a shorted wire: which would we rather sacrifice -- beam 4? or temperature? We chose to sacrifice temperature. Therefore temperature is recorded as 0deg C and soundspeed is hardwired at 1500m/s. This change only affects nominal depths, not horizontal velocities.

Testing began as the ship departed Portland. Bottom track data was acquired with the OS75 in Broadband mode until the ship reached 450m with the Multibeam off, at which point EM710 and EM302 were enabled.

UHDAS ADCP data acquisition was generally only possible during opportunistic periods, but a few specific periods of testing were dedicated to the ADCP systems to assess data quality at multiple speeds and headings, and to compare OS75BB and OS75NB ping types. Tests included a determination of orientation of the transducers in the hull, ocean depths at which bottom tracking could be used, the effect of ship speed on range, the effect of heading (relative to oncoming seas) on range.

1.2 Computer

UHDAS ADCP data acquisition for both ADCPs is performed by a single computer purchased by Schmidt Ocean Institute specifically for UHDAS data acquisition and processing. SOI purchased two computers to be used as a “primary” and a “cold spare”. At present **currents58fk** is the primary UHDAS acquisition computer for the 2017 season; **currents59fk** is the cold spare. UHDAS was installed on the two computers at Univ. Hawaii, which were then shipped to *Falkor* in Portland. Initial configuration took place in Portland before the Sonar Acceptance Cruise FK170602. Final configuration took place during the cruise.

UHDAS logs and timestamps ADCP data, heading (gyro, Seapath, POSMV), and GPS positions (Seapath, POSMV, CNav), and writes them to disk. During the processing stage, ADCP beam velocities are transformed into horizontal velocities and referenced to earth prior to automated editing and averaging. The UHDAS software includes averaging and display of various variables, accessible within the ship's network. A daily email is automatically generated and sent to Univ Hawaii personnel who look for problems. The daily email contains a snippet of processed data as well as diagnostics related to data acquisition,

processing and computer system health. The UHDAS computer is using a shipboard NTP server for accurate time and an SMTP server at Univ Hawaii to send out email.

1.2.1 Incoming Data Feeds

UHDAS uses one process per incoming data feed for data acquisition. The input streams are filtered by message, timestamped, and written to a directory named after the instrument being logged. More than one NMEA string can be acquired from a given serial stream. If the rate of repetition is too high, messages may be subsampled prior to recording. The file `/home/adcp/config/sensor_cfg.py` contains settings for data acquisition, including ports, baud rates, and message strings. This file is included with the data distribution. (NOTE that indentation must be respected when editing `sensor_cfg.py`, as it is written in Python).

CODAS processing requires position and heading. We try to log all required input types from multiple sources, to allow for reprocessing (in case of gaps or failure in the primary data feed).

| Serial (raw) directory | instrument | suffix | messages | serial port /dev/tty/ |
|------------------------|------------------|-------------------|--|-----------------------|
| wh300 | wh300 | raw, log, log.bin | (binary adcp data + log files) | USB2 |
| os75 | RDI ADCP (75kHz) | raw, log, log.bin | (binary adcp data + log files) | USB0 |
| posmv | POS/MV | 'gps', 'pmv' | '\$INGGA', '\$PASHR' | USB4 |
| seapath | Seapath320 | 'gps_sea', 'sea' | '\$INGGA', '\$PSXN,20', '\$PSXN,23' | USB1 |
| cnav | CNAV-3050 | gps | '\$GPGGA', '\$GNGGA', '\$INGGA', '\$GLGGA' | USB5 |
| gyro | Sperry | hdg | \$HEHDT | USB7 |
| soundspeed | soundspeed | spd | (floating point numbers) | USB6 |
| tsg | flowthrough TSG | tsg | (Falkor format) | USB3 |

Two processes start on boot: one to allow access to GPS positions even when UHDAS is not actively recording data (zmq position), and one to provide a web-based readout of the ship's speed through the water (speedlog).

ON BOOT

| feed | input | output |
|--------------|--|---|
| zmq position | cnav, ttyUSB5 | tcp://127.0.0.1:38000 |
| speedlog | tcp://127.0.0.1:38020 (only active if UHDAS is logging data from specified instrument) | http://10.23.10.58:38020 web socket; goes out IP associated with ethernet port "eno1" |

1.2.2 CODAS processing settings

Settings for heading and position source, and transducer angle are:

| heading (reliable) | best position | heading correction (accurate) | transducer angle os75 | transducer offset from Seapath MRU |
|-----------------------|--------------------|----------------------------------|--------------------------|--|
| gyro \$HEHDT | Seapath \$GPPGA | seapath \$PSXN,20/PSXN,23 | 44.47 | dx=1 dy=16 |

If necessary, processing of UHDAS data can be redone at a later date using different supporting serial strings. A scale factor (multiplying measured velocities) is theoretically unnecessary with Ocean Surveyors, but they actually typically do require a multiplier of about 1.003-1.004. Further refinement of these values will occur as we gain experience with the instrument. Should there be a need, reprocessing of UHDAS data on the *Falkor* should be able to use appropriate settings chosen from:

| instrument | position/time | reliable heading | accurate heading |
|------------|---------------|------------------|---------------------|
| Seapath | \$GPGGA | | \$PSXN,20;\$PSXN,23 |
| POSMV | \$GPGGA | | \$PASHR |
| gyro | | \$HEHDT | |

Additional information about CODAS processing and UHDAS can be found here:
http://currents.soest.hawaii.edu/docs/adcp_doc/index.html

Other reports are stored on line at http://currents.soest.hawaii.edu/reports/ship_reports/

1.3 ADCP Evaluation

Bottom track data was collected for a brief period as the ship left the Columbia River (down to about 450m. The transducer angle was very close to the manufacturer's recommendation of 45deg, coming in at 44.47deg.

The range of the OS75 was less than expected, but we will evaluate that over the course of future cruises. This could be related to latitude and the scattering conditions of the water; it is too early to tell. There is no window, so that is not the cause. The OS75 is in a gondola and should be more immune to bubbles than many ships, so we would have expected stellar range (such as in the previous installation). The range is not alarmingly low – it is on the smaller end of what other OS75 instruments have seen in the region. We will evaluate when we have more data.

Because the temperature is unknown, we are hardwiring the speed of sound at 1500m/s. This affects the vertical bin size a bit, but a quick test of 'depth' (comparing the OS75

backscatter with the EM302 during the groom) indicates that the ADCP depths are not grossly incorrect.

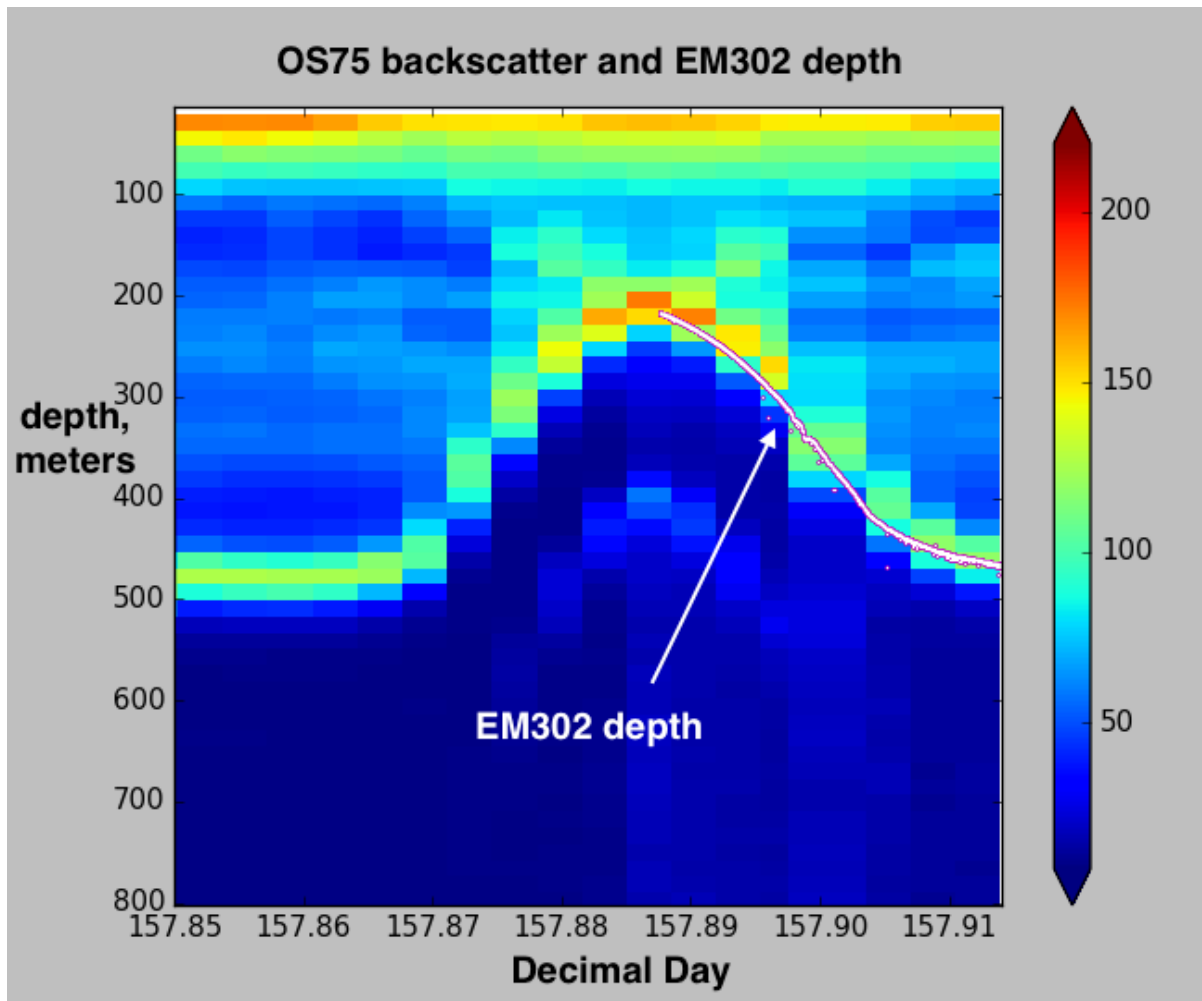


Figure 1: ADCP depths are estimated using a fixed speed of sound based on the transducer temperature and an equation for soundspeed in seawater. On Falkor, we are hardwiring the soundspeed at 1500m/s. This figure illustrates that the depths are not off by more than a bin.

We were warned that time was tight, so we only requested 4 hours of dedicated testing, with the understanding that we would try and run the ADCPs during any opportunity when other testing did not require that it be secured. We were allowed to run the ADCP during the transit to the first Multibeam test, with bottom tracking on, to get the transducer angle calibration value. Beyond that, there were only 5 opportunities with over 1 hour of continuous data logging; all the rest were below 1 hour. We accumulated almost 24 hours of data, which let us conclude:

- the transducer angle and horizontal offsets are close (will be refined on the next cruise)
- the range was about 600m for that cruise
- the range was not affected by sea state (only a small swell at the time)
- broadband and narrowband modes agree (no bias in one compared to the other)

Further refinements and understanding will come in future cruises.

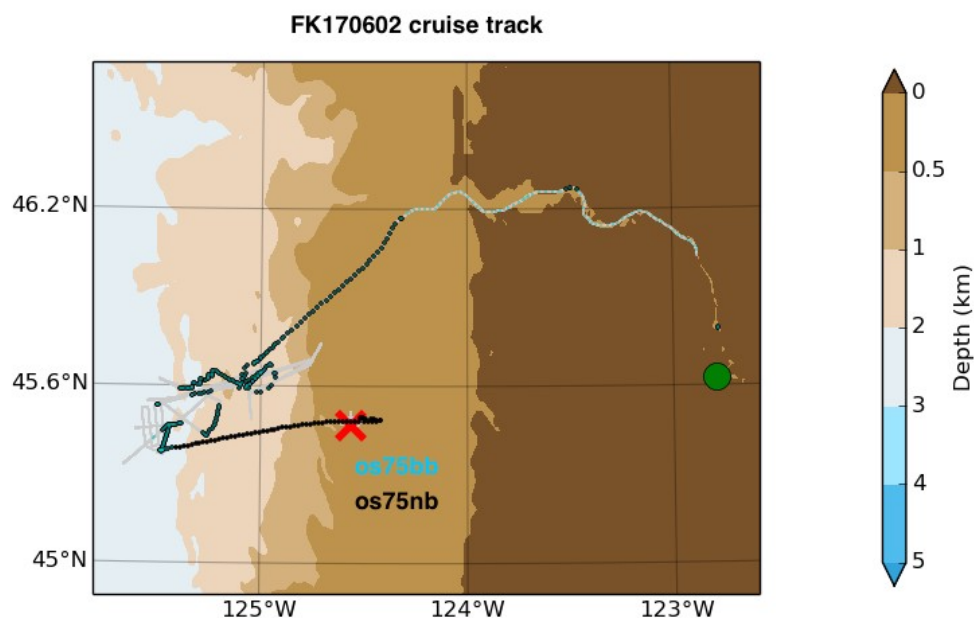


Figure 2: Cruise track in gray, two ping types of OS75 (broadband and narrowband) are shown in teal and black, respectively.

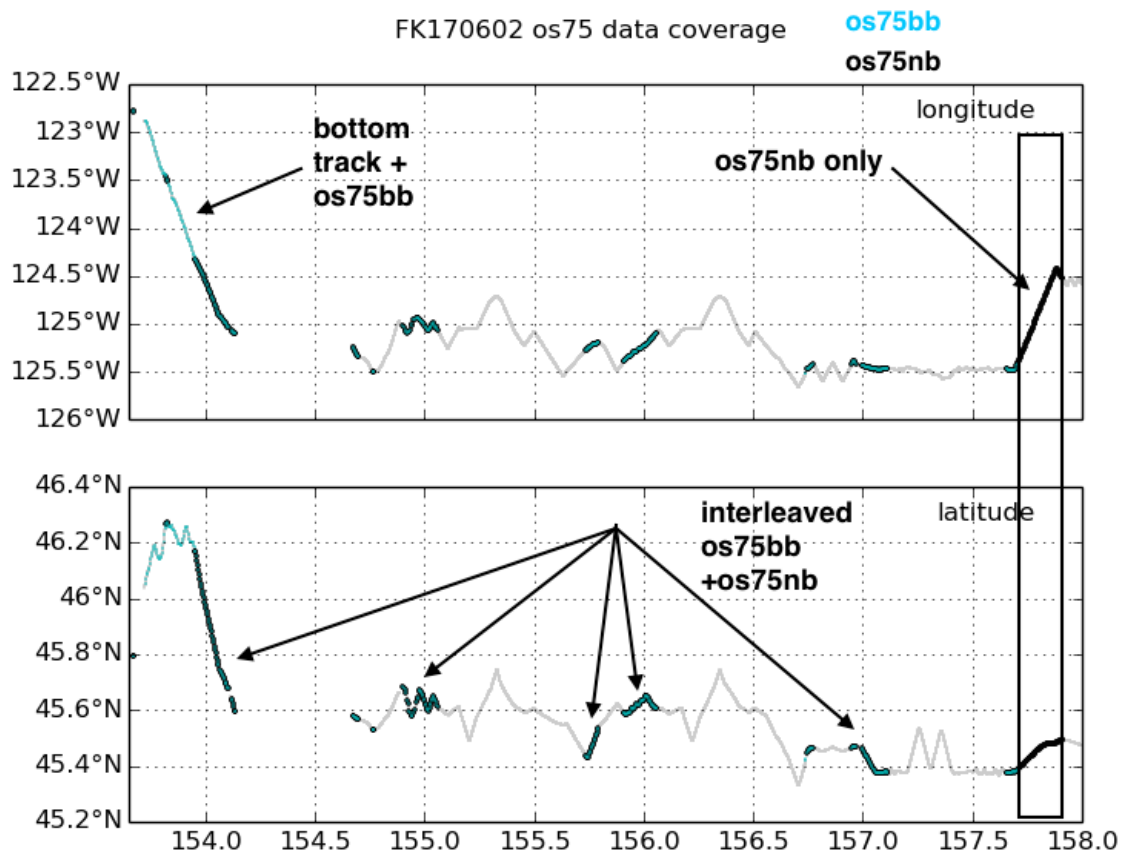


Figure 3: Periods of ADCP data logging are shown in teal (broadband mode) and black (narrowband mode).

1.3.1 Sync (K-Sync) triggering

Shipboard sonars rely on backscattered sound, but use it in different ways. ADCPs measure the Doppler shift caused by the component of velocity measured along each of the 4 beams. Given typical ocean velocities, this is a small quantity that can be difficult to isolate, particularly from the weak returns at the edge of the instrument's range. Therefore, the measurement is inherently noisy, and many pings (on the order of 50 to 300 in a 5 minute averaging period) are needed to adequately determine ocean velocities.

Since these various sonars can interfere with each other, it is natural to try timing their pings in such a way as to minimize this interference. Falkor has a device (a Kongsberg K-Sync) designed to enable this. Unfortunately this approach can also damage the data. For the ADCPs there are several problems :

- 1) It reduces the number of pings. Since the Doppler measurement is inherently noisy, reducing the ping rate increases the uncertainty of the results. If the number of pings drops too low, the data become essentially worthless.
- 2) If there is still interference, synchronized ping timing ensures that the interference is always at the same depth. This means there will be no valid data at all from that depth. If the interference is shallow, the single-ping editing might interpret that as "the bottom" and remove all data below it.
- 3) Instruments with long pulses (eg. EM710) can distort or confuse the top portion of the ADCP data, if both are pinging at the same time.

Since interference can usually be edited out by the automatic processing, the ADCPs acquired with UHDAS work better with the pseudo-randomly distributed noise from uncoordinated pinging, even if the total amount of interference is greater.

If there is no science mandate otherwise, the ADCPs should not be synchronized to other devices. If there is a scientific need to run the ADCPs and synchronize them with other devices (eg. EK60), proper settings should be used. There was insufficient time during these tests to learn what settings are most appropriate.

The OS75 and EM710 do not play well together. It is not clear what kind of compromise might be reasonable for a cruise which wants both. There may be better solutions with the EK60, and the EM302 doesn't seem to care very much. For opportunistic data logging, try using the EM302 for bathymetry in the presence of the OS75, and don't use the KSync.

1.4 Recommendations

1.4.1 Operations

Defaults will be set to OS75NB (16m) and OS75BB (8m). If a specific science mission requires it, these settings could be altered. Bottom tracking should remain OFF.

Please run the ADCP whenever possible, and certainly at least one consecutive 24-hour period for each cruise. This will help us keep an eye on the instrument's health.

Do not synchronize the ADCPs unless the scientific mission requires it.

1.4.2 Troubleshooting UHDAS UDP and ZMQ feeds

During the boot process, `web_speedlog.py` and `zmq_publishers` are started. These processes can be found in the process table with:

```
ps -ef | grep web_speedlog
zmq_publisher.py --query          # shows zmq_publisher ports used
```

To monitor the incoming serial data on one of the zmq feeds, use (for instance)

```
zmq_monitor.py tcp://127.0.0.1:38000
```

The serial ports used by `zmq_publisher` are locked using a lockfile naming convention `/var/LOCK/LCK. .xxxxxx` (for device `xxxxx`). When logging data, UHDAS also uses lockfiles to signify that a port is in use. Before troubleshooting a broken feed, make sure that the UHDAS GUI is not logging data: the safest thing to do is

1. Stop Recording
2. End Cruise
3. Kill the UHDAS GUI window

Then proceed with the troubleshooting. A Python terminal emulator is available on the command line (`tk_terminal.py`), as well as `minicom` and `screen`. Any changes to `/home/adcp/sensor_cfg.py` should be made with the GUI closed and no active cruise. After making any changes, restart the UHDAS GUI window so the new values in `sensor_cfg.py` are re-read. If changes are made that involve the zmq feeds, the `zmq_publishers` will need to be restarted. One clean way to do this is to reboot (and then wait an additional 60sec for the timers to go off and start `zmq_publishers`) before proceeding.

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