Multibeam Advisory Committee: Recap of investigation into Atlantis EM122 transient depth artifact

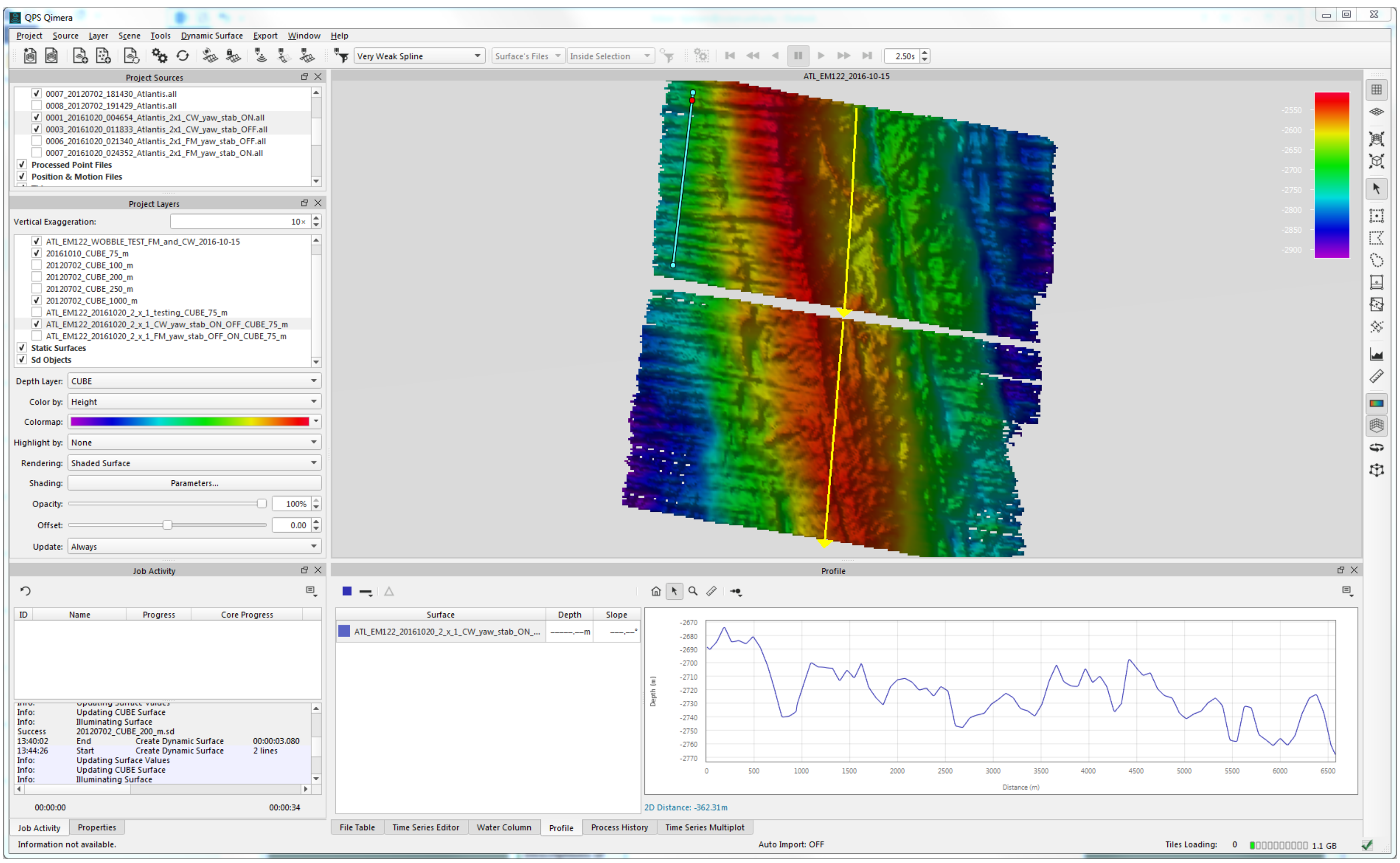
Updated 2016-10-26

Symptom

A periodic alternating deep/shallow bias extending across the swath. The surface shown below is illuminated to show the corresponding dark shadows extending across the track while the ship drives approximately south. The amplitude of the bias scales with the angle from nadir, approaching 1% of water depth on the outer beams (depth profile drawn across upper left of surface is shown in lower right window). It appears that the starboard side is generally biased shallower when the port side is deeper, and vice versa.

This artifact appears to exist in data examples going back to 2012. Its amplitude might technically be within spec for this system; however, it is a periodic, non-random bias that complicates processing and visualization. The example below exaggerates the effect visually due to shading.

This is similar to what we might see with an error in the vessel roll data, but the depth artifact does not appear to scale with roll period or amplitude. The artifact comes and goes over the course of many pings and many roll cycles (more discussion below).



Background

Tests and conclusions so far

The EM122 has two bad TX boards which will be replaced in late October. Data were collected for troubleshooting in a variety of modes including: 1 degree and 2 degree TX mode, with the two known bad TX boards removed, with FM enabled and disabled, and yaw stabilization on and off.

1. TX boards

No improvement was seen when operating in 2 degree TX mode. An improvement in sounding spacing on the seafloor in both 1 and 2 degree TX modes using yaw stabilization, suggests that the transmit sectors are being steered correctly to accomplish this, despite two bad TX boards.

2. Yaw stabilization artifact

The depth artifact exists with and without yaw stabilization enabled, meaning this is not related to the known issue of depth biases in turns with yaw stabilization enabled.

3. FM transmission

FM and CW transmit modes appeared to make no difference in the depth artifact, which is different in nature and period from the 'FM wobble' seen in the outer beams with some EM installations.

4. Sound speed mismatches

We have seen similar artifacts when there is a serious refraction problem due to bad sound speed data at the surface or in the profile, or a strong gradient in the upper few meters of the water column being submerged or deformed by the hull. This would certainly compound the depth artifact we are seeing, but it is not the root cause because the artifact we're chasing persists even with up-to-date XBT profiles that agree (independently) with the surface sensor to within 1 m/s in the upper mixed layer.

5. Motion system geometry

In some examples, the artifact resembles coupling of roll into the long-period yawing of the ship, suggesting a possible installation angle error. The PHINS MRU is mounted on a plate surveyed by IMTEC in 2011. The survey report has been reviewed independently by multiple individuals concluding that the MRU plate is mounted with a roll offset of 0.4122 deg port edge UP and 0.1424 deg bow edge UP relative to the vessel's horizontal plane. The report had described the pitch as 0.1424 deg bow edge DOWN.

To complicate the matter, the 2011 PHINS manual had conflicting definitions for MRU angle measurements (e.g., measuring angles about the X1 and X2 axes versus X1' and X2' axes). These appear to have been resolved in later versions of the manual.

The MRU is assumed to have the same pitch and roll as the mounting plate. The current PHINS configuration reflects the survey report with port edge UP and bow edge DOWN. These angles are translated as -0.4122 deg roll and -0.1424 deg pitch relative to the vessel horizontal plane. If the true MRU pitch is bow edge up relative to the horizontal vessel plane, then the MRU pitch configuration should be +0.1424 deg. *This should be changed only after final confirmation of the MRU pitch and when time allows for a new patch test.*

6. EM122 position and attitude feed locations

The SIS Installation Parameters (screenshot from AT26-21 report below is within mm of current config):

1) All transducer linear offsets are in the IMTEC reference frame.
2) Position feed (Pos, COM1) is configured to the C-NAV antenna position in the IMTEC reference frame.
3) Attitude feed (Attitude1, COM2) is configured to the PHINS reference point in the IMTEC reference frame.
4) Most EM configurations on other ships have the same reference point for position and attitude feeds to EM.
5) The ship has confirmed that position feed to the EM122 is directly from C-NAV.
    i. Is the C-NAV feed valid at the antenna location, or some other C-NAV reference?
6) iXBlue has confirmed that attitude feed is valid at the MRU reference point unless a manual lever arm is set.

Location offset (m)

	Forward (X)	Starboard (Y)	Downward (Z)
Pos, COM1:	-37.410	-2.956	-30.323
Pos, COM3:	0.00	0.00	0.00
Pos, COM4/UDP2:	0.00	0.00	0.00
TX Transducer:	-30.18129	-0.39007	0.42354
RX Transducer:	-25.71581	-0.01110	0.50488
Attitude 1, COM2:	-27.26953	0.45374	-2.85523
Attitude 2, COM3:	0.00	0.00	0.00
Waterline:			-5.270

Figure 6. Sensor linear offsets from Kongsberg SIS.

Next areas of focus

1. PHINS firmware

iXBlue has repeatedly recommended upgrading the firmware and configuring an estimated center of gravity to improve heave calculations. These seem like worthwhile steps in order to (at the very least) provide more context for troubleshooting. *We strongly encourage upgrading the firmware as soon as possible.*

2. Motion system timing issues

Testing in Qimera shows no improvement when simulating/correcting for motion latency or lever arm offsets in the transducer arrangement. This testing is limited strictly to latency in the arrival of the motion data to the EM122, and lever arms of the motion sensor in the EM122 reference frame. No testing has been done for lever arms of the position feed, and this does not shed any light on possible timing or lever arm issues in the PHINS motion system itself.

In the examples we've examined, the ping interval and period of the vessel motion have typically been within a few seconds of each other. The similar periods of the ping interval and vessel motion could lead to a longer-period modulation of the depth artifact, such as we see in the examples here, if there is an appreciable latency WITHIN the motion system (e.g., during attitude processing, before sending to the EM122, even with negligible latency in the communication to the EM122). This was recently seen on another (non-UNOLS, non-PHINS) vessel which had a nontrivial latency in the MRU processor, 'upstream' from the feed to the EM122. The result of this was a depth artifact with two components:

i. The first (high-frequency) component is like any other motion error, with a period and amplitude corresponding to the attitude amplitude and latency. This would appear similar to a latency in the 'downstream' communication between the motion sensor and EM122. Note: this is also the same kind of communication latency that can be simulated/corrected in Qimera, and has not addressed the depth artifact coming and going over many ping cycles.

ii. The second (low-frequency) component is due to the small difference between the ping interval and attitude period. The difference between the true attitude and applied attitude changes slightly with each ping, leading to a modulation of the depth artifact over the course of many ping cycles (e.g., 60-90 seconds). This is more in line with the kind of artifact we see, which has not been addressed by simulating/correcting motion communication latency in Qimera.

3. Heading offsets

Examining data from 2012-2016 in Qimera, it is clear there was historically a 0.6 degree heading offset configured in SIS installation parameters. This is now zero in the SIS config for Motion 1 and Heading 1, as well as PHINS config for the MRU. *Clarification is needed on how and when the MRU heading offset was zeroed.*