EM Technical Note

The advantages of yaw stabilization in multibeam surveying

KONGSBERG

Fact: it is crucial in deep waters as well as shallow waters surveys

The what, the why, the how of yaw stabilization

The actual footprint position on the bottom from a multibeam echo sounder will be determined by the vessel attitude when pinging. It is very desirable that the sounding density is uniform both along and acrosstrack for the purpose of maintaining the highest possible resolution in the charts to be made from a survey. Irregular sounding density resulting from non-compensated yaw and pitch of the vessel could lead to unmapped features or loss of resolution.

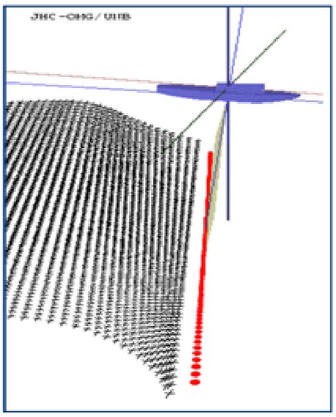
One of the basic requirements so as to achieve a good survey quality is to get a near 100% coverage of the surveye area and to have a regular spreading of the soundings, as well as a continuous pattern of the sonar image pixels. This criteria has always been a leading one for hydrographic services and it seems to be adequate for the other customers as well. [1] H.Tonchia, F.Parthiot

The concept of "complete" swath coverage is often simplified. The assumption that everything within the bounds of the edge of the swath is covered might seem intuitive. When regional coverage with just a certain accuracy level was the main requirement, this was enough. Increasingly, however, reliable small-target resolution is as important a criteria in survey standards as accuracy. To reliably meet that resolution, the seafloor must be evenly sampled at a density significantly finer than the dimension of the target to be resolved. To maintain an even sampling density, all the dynamic rotations of the platform must be compensated for. This involves all three axes, not just two.

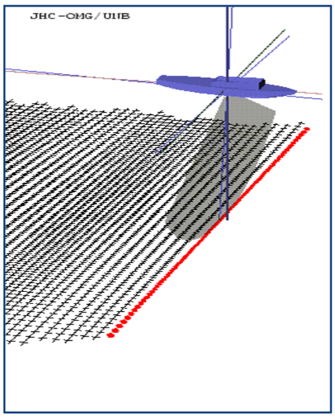
Roll and pitch stabilization are now offered with almost every product on the market as it is relatively simple to do, involving only one transmit sector. This certainly helps stabilize the swath, but rotations about the third axis can actually have the most profound effect on sampling density. To stabilize on this axis it is required an additional non-trivial step which, to date, only one supplier has provided: Kongsberg Maritime. That essential step is to break up the swath into multiple sectors using multiple near-simultaneously separately-steered transmissions.

How important this third step is, depends on the amount of yaw rotation that takes place between pings. Thus the importance of this generally increases with depth as the yaw rate of a vessel does not scale with depth (the slower the ping rate, the more inter-ping yaw will take place). Strictly if the inter-ping yaw is more than the transmit beam width you will have a gap. This criteria is commonly exceeded even in low seastates with deep water (off continental shelf) systems and thus yaw stabilization is essential to meet simple 100% coverage criteria for those depths.

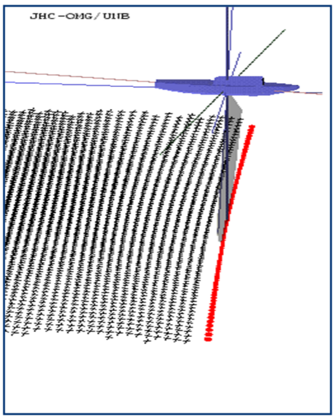
Yaw stabilization is implemented in Kongsberg Maritime deep water multibeam systems **EM 302** and **EM 122.** It is also a feature present in the median to deep waters **EM 710,** and in our latest development for shallow waters: the **EM 2040** multibeam echosounder.



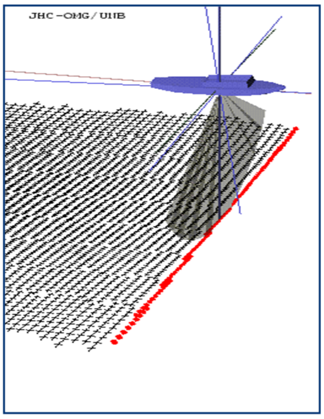
No Stabilization



Roll Stabilization



Roll and Pitch Stabilization



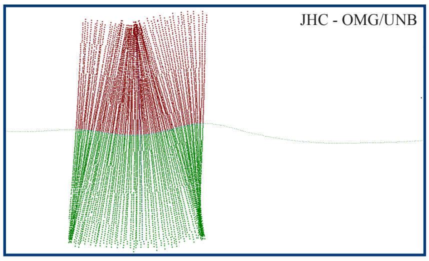
Roll, Pitch and Yaw Stabilization

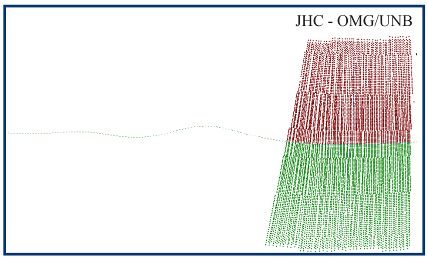
But the criteria can be even tighter than this in shallow water. Already most swath systems are forced to slow down in shallow water to meet the common requirement of 3 swaths along-track on the target. This translates to a required along track spacing that is considerably finer than the along track dimension of most projected transmit beam widths. Thus the minimum inter-ping yaw change is even more constricting. So yaw stabilization can still be essential even in shallow water, where small target detection is a requirement. This is generally the case wherever small boats are operating in open water as small boats have significantly higher yaw rates than larger vessels. Our EM 2040 multibeam system is the only true wide band shallow water system in the market that supports yaw stabilization; a great achievement for Kongsber Maritime and a goal for any competitor out there.

The advantages of yaw stabilization in multibeam surveying

Interestingly, while yaw stabilization is the main reason that multi-sector systems were introduced, there is the added benefit that pitch stabilization is more exact using multi-sectors. Simultaneous multi-sector yaw and pitch stabilization are best run together. And as an extension of the multi-sector approach, once the technology has been developed to do multiple near-simultaneous transmissions, there is the added benefit of also being able to have multiple simultaneous swaths. This extra step, greatly improves the along track swath spacing allowing small target detection at higher (potentially double) the survey speed previously required.

Data collected in 900m of water with yaw stabilization disabled





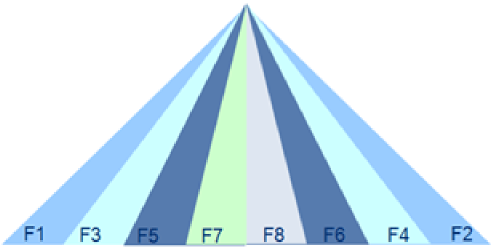
Data collected in 900m of water with yaw stabilization enabled

Multi-sector transmission means that the system transmit several independent frequency coded sectors, all are transmitted simultaneosly and individually controlled.

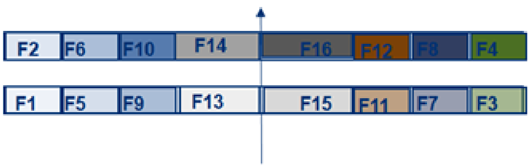
The benefits are:

- Very effective pitch and yaw stabilization.
- Very strong damping of multi-bounce interference
- Individual TX focus in each sector which gives a smaller TX footprint

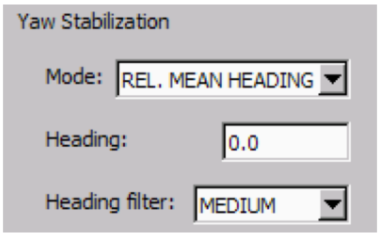
Dual Swath implies that two fans are transmitted, one in front of the other. The intention is to obtain a better coverage of the seafloor, for example when the highest ping rate is already used and without decreasing vessel speed



8 sectors for EM 122 and EM 302
3 sectors for EM 710 and EM 2040



In dual swath mode up to 16 sectors are individually controlled



Yaw stabilization functionality in SIS

How it is done during multibeam data acquisition with SIS (Seafloor Information System)?

The yaw stabilization function in SIS creates even alongship sounding spacings when the vessel's course is variable. The parameter is implemented with variable tilt angles on the individual transmitter beams. The echo sounder operates most efficiently when the transmission angle is as close to 0 degrees as possible relative to the vessel's heading.

Three stabilization modes are available.

• *Off*: No heading stabilization takes place. The transmitter sector follows the current heading of the vessel. Unless the vessel's heading is 100% straight you may experience blind zones on the survey coverage when you operate in deeper waters (exceeding 300 to 500 meters).

• *Manual*: The transmit fan is placed perpendicular to a manually selected course. This course is selected with the Yaw Compensation parameter described above. The setting should only be used on long and straight survey lines, but it is also useful if you need to compensate for a crab angle caused by current or wind.

• *Relative mean heading*: This setting places the transmitter sector perpendicular to a filtered course corresponding to the vessel's current mean heading. The course input is then taken from the gyro, and filtered with a Heading Filter parameter. Relative mean heading is the recommended yaw stabilization mode. With this setting the average yaw steering will be close to zero, avoiding an offset caused by e.g. a crab angle. (Also the operator does not have to remember to set the course line)

References

[1] H.Tonchia, F.Parthiot: "Wide Swath Bathymetry and Imagery Systems Some users observations and thoughts", Oceans'94, pp III219-224.

[2] John Hughes Clarke. Ocean Mapping Group. University of New Brunswick: http://www.omg.unb.ca/~jhc/yaw_stab/

[3] Seafloor Information System (SIS) - Operator Manual.

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