Ship-in-channel intelligence using rapid-deploy inertial devices

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Summary
The ability to accurately measure a vessel's motion in waves can greatly aid in managing the safety, efficiency, and comfort of vessel and port operations. These measurements can be used to inform ship models used in under-keel clearance management (UKCM) systems and aid in operability forecasts related to the magnitude of these motions and the effect of the resulting accelerations on cargo, crew, and passengers. OMC International developed the iHeave® device for this purpose and has recently developed iHeave® v2, which has the same level of ship motion measurement accuracy in a much more ergonomic device.

Keywords: Vessel motions, UKC, iHeave

Introduction

The usefulness of the models used to safely predict passage through depth-limited waterways are best verified against vessel motion measurements. Validation can be achieved by comparing the measurements with the forecast range of vertical motions to ensure the models are safe and appropriate for purpose.

The collection of this validation data can be challenging since vessels under pilotage are often high-stress environments with little leeway for the set up and care of extra instrumentation, especially during the weather conditions of particular interest for vessel motion modelling (see Figure 1). Under these conditions, the setup and tear-down of measurement equipment is an extra burden that must be kept to a minimum for the safety of all.

Figure 1 Hazardous conditions at the Columbia River Bar (image courtesy of Columbia River Bar Pilots)

These restrictions typically limit the opportunities for in-field measurements of vessel motions through port and other UKC-restricted waterways, despite the volumes of traffic that routinely take place. Where pilots use carry-on devices such as PPU units, the availability and provenance of the data and metadata can be problematic.

An alternate approach was developed [1] to provide a means of acquiring dynamic vessel motion measurements without the need for a bow-mounted device. An inertial motion unit (IMU) approach was adopted so that roll, pitch, and heave motions could be collected at a single point from the safety of the vessel's bridge. GNSS position and timestamp data are also recorded.

A handful of these "iHeave®" vessel motion recording devices were made in the early 2010s and used at ports around the world [2]. However, owing to their weight and bulk, their usage was limited. This has been improved upon with iHeave v2 by providing a much smaller, lighter and user-friendly version of the vessel motion measurement device.

iHeave v2

The older *iHeave®* device relied on USB sticks for data transfer, and LED indicator lights for device status reporting. The new device features a touch-enabled live status display to allow users to check that the device is operating and recording motions at a glance (Figure 2). It is also capable of sending this data via mobile networks, allowing for the data to be used in near real-time.

Figure 2 iHeave® v2 touch display and control buttons

The *iHeave® v2* can be used to display the actual dynamic roll motions on its live display. Feedback from pilots and previous investigations by OMC have demonstrated that the indicated roll angles displayed by a typical ship-mounted heel indicators can greatly exaggerate or otherwise misreport the actual roll experienced by a ship in dynamic conditions, as shown in Figure 3. This is due to the lateral accelerations of the ship as it rolls and sways.

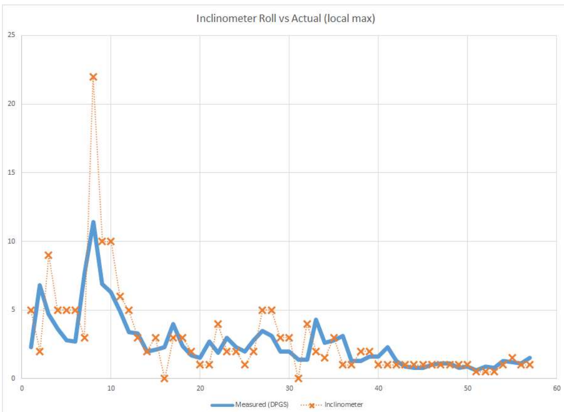

Figure 3 Inclinometer roll versus reference (degrees)

This can lead to misunderstandings of the vessel's range of motion, particularly in large swells and storm events, and means that it is not a reliable way to compare the motions of two different vessels. The sensors used in the *iHeave®* devices do not suffer from this affect.

Ship & port intelligence

The logistical hassles of measuring ship motions with the DGNSS and original *iHeave®* are barriers to the collecting ship motion data, with concerted effort required to collect data for specific analysis campaigns. The new device enables bulk data collection as business-as-usual for port operations, which opens up the opportunity to derive deeper port and ship intelligence. These informational assets build over time to produce detailed operational insights, which can be used to directly enhance under-keel clearance management through bespoke ship-in-waterway modelling (Figure 4). Vessel-specific characteristics are collected to build profiles that inform the modelling for movement planning for short- and long-range planning horizons.

To meet the needs of UKC model validation, the vertical components of motion need to be resolved to decimetre accuracy. Both the original and the newer *iHeave®* devices are accurate to 0.03° for dynamic pitch and roll motion and 5cm for heave, based on direct comparison to the baseline DGNSS measurements.

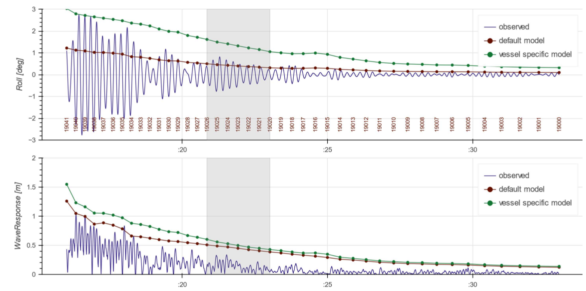

Figure 4 Observed roll characteristics provide the modelling with specific vessel parameters with respect to the waterway and loading condition

Conclusions & Future Directions

The *iHeave® v2* enables ports to measure ship motions as part of business as usual through much enhanced ease of use and portability over the original device. This has been achieved with no reduction in measurement accuracy and the incorporation of cellular communications to automate data upload for analysis.

OMC's research team is actively pursuing ways in which this timely and potentially high volumes of vessel motion data can be used to enhance UKC and port management beyond those already identified. Further ideas include the development of a companion App to make vessel particulars easier to collect, and an upgraded *iHeave®* capability using wirelessly tethered DGNSS units in addition to the IMU for enhanced measurement capabilities in all six degrees of freedom.

Acknowledgements

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