

Support for Sea Trials of Active Heave Compensation on the GLAD800 Drilling Rig

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LONG-TERM GOALS

The Strata Formation on Margins (STRATAFORM) program of the Office of Naval Research seeks to better understand continental margin stratigraphic evolution. In particular, the program is investigating the mode of stratigraphic development on the shelf and slope portions of the continental margins using field sites offshore northern California and New Jersey. Many of the advances in marine sciences over the past 30 years are based on core samples collected by the Ocean Drilling Program (ODP) and its predecessor the Deep Sea Drilling Program. However, the ODP's principal vessel, the *JOIDES Resolution*, will not drill in waters shallower than 75 m and has restrictions in waters shallower than 300 m. Recently, DOSECC, Inc., a consortium of universities and other research organizations, designed and fabricated a drilling system (the GLAD800) for the collection of core from modern lakes. This system can support a drill string of 800 m (water + sediment) from an anchored barge. An Active Heave Compensated drilling system was designed around the GLAD800 rig and designated the AHC800. The rig can accommodate a maximum of 8 feet of heave with a period of 8 seconds. Our concept is that the AHC800 will be used on a variety of platforms. Modular components of the rig can be efficiently deployed to utilize available deck space. The AHC800 is shipped in standard shipping containers that reduce the potential for loss and damage while keeping shipping costs at a minimum. The long-term goal for this system is for its extensive use in characterization of the continental shelves.

OBJECTIVES

The objective of this work was to perform sea trials on the active heave compensation system to verify its operational capability.

APPROACH

A short cruise was scheduled to set up the rig on the *Knorr* and place the active heave compensation system in operation. The system had been tested on land, but not under realistic operating conditions. The science crew was prepared for the collection of core samples.

The goals of these trials were to determine the following:

1. Can the AHC800 function effectively through the *Knorr's* moonpool?
2. Can the *Knorr* hold position within the tolerances required by drilling?
3. Can the AHC dampen vertical ship motion sufficiently to allow drilling to proceed?

4. Can this equipment recover sandy marine sediment?

WORK COMPLETED

Sea trials were conducted from November 5-9, 2001 aboard the R/V Knorr.



Figure 1. The AHC800 derrick positioned over the moonpool of the Knorr and the rod rack in position for the drilling operation.

RESULTS

1. The moonpool of the *Knorr* is located toward the stern and on the starboard side of the vessel. Although this location undoubtedly experiences greater heave than if the moonpool were located amidships, the location did not present insurmountable difficulties. In particular, the location off the centerline of the vessel did not cause side-to-side rolling motion that would have made pipe handling difficult and dangerous. This minimum rolling resulted from positioning the ship nearly into the wind and prevailing seas. In addition, the useable deck space on the *Knorr* was more than adequate to support the AHC800 and associated support equipment, and inboard laboratory space for processing core is excellent.

2. The *Knorr* appears to have the ability hold position within the tolerances required by drilling. The two stern and one bow thrusters were adequate for holding position within a 8-10 meter circle in winds up to 25 knots. However, the DGPS system did experience some difficulties. The Roberston DP system, if provided with stable DGPS data, can keep the vessel within 5 m of it's assigned position in winds as high as 25 knots. However, we experienced 5-15 m 'jumps' in apparent position that caused the DP control to drive the ship off site in a futile effort to occupy that erroneous position. Second, the

ship's 'pivot point' was not corrected to the moon pool / drill pipe, which meant that efforts to change the ship's heading while on station resulted in a displacement relative to the drill site. Third, careful thought should be given to the problems posed by spinning the ship's position while both a taut-line wire and drill pipe are in the water. Winds can and do shift, and to maintain position the ship's bow should be 2 points off the wind. Doing this while on station and in the bottom, however, raises obvious problems of entanglement.

3. The goal of the AHC is to provide a platform that maintains distance from the ocean floor to within one inch in wave conditions up to 8-foot amplitude with 8-second periods. Tests of the system were performed in conditions up to and beyond the specifications. The results indicate that the system should be able to meet specifications once it's fully tuned.

To measure the performance of the AHC, a comparison is made between ship motions, as measured by a line running to the sea floor, and motions of the AHC. For a perfectly performing AHC, the motions are equal and opposite so their sum is zero. In Figure 2A, we see sample ship motions and the sum of ship and AHC motion (on a 10 times larger scale). Observe that the deviation is largest following rapid accelerations. This is expected on two counts. First, the control algorithm is currently omitting any consideration of the extra voltage required for acceleration. It is straightforward to include an acceleration correction, but this was not done for simplicity during initial tests. Second, the control loop approximates future velocities as constant, so the larger the acceleration, the larger the controller error. To reduce this error, the control loop time must be shortened. During these tests, the control loop time was left at its initial value of 100ms.

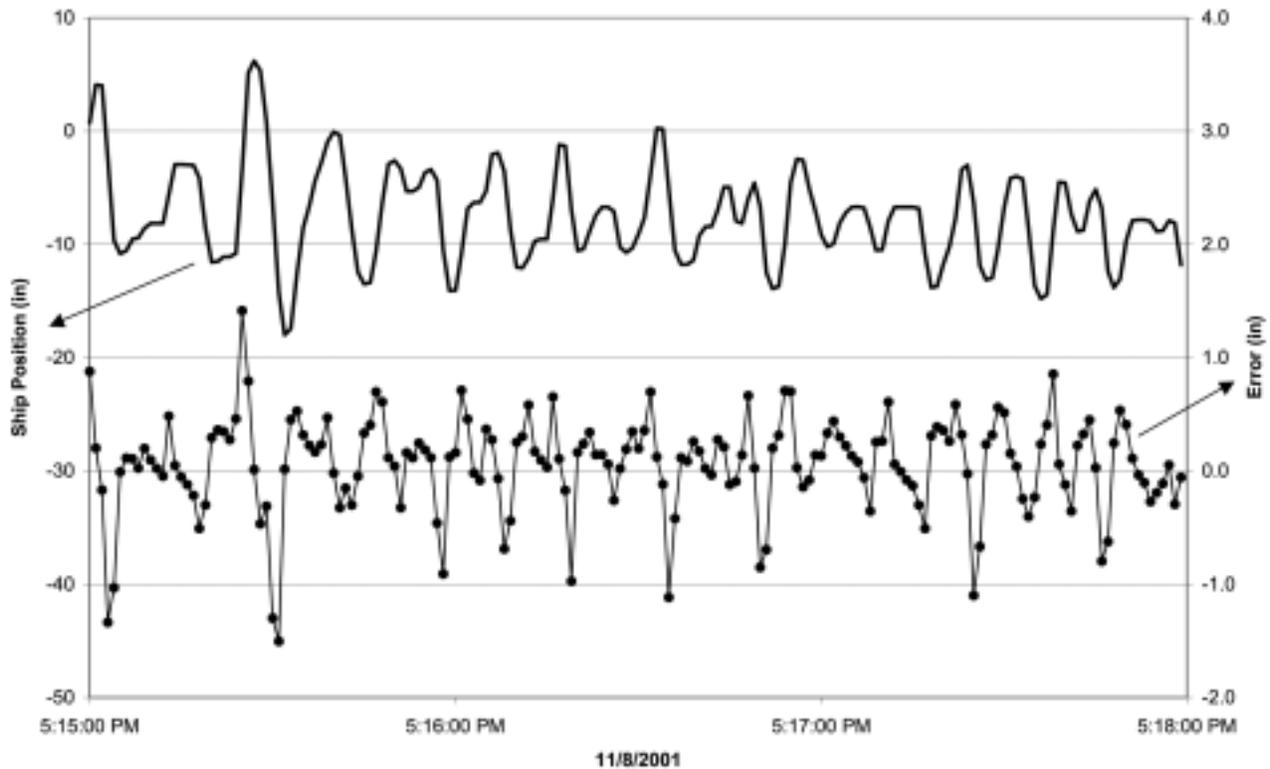


Figure 2A. Vertical ship position and error of the active heave compensation system in correcting for the vertical motion.

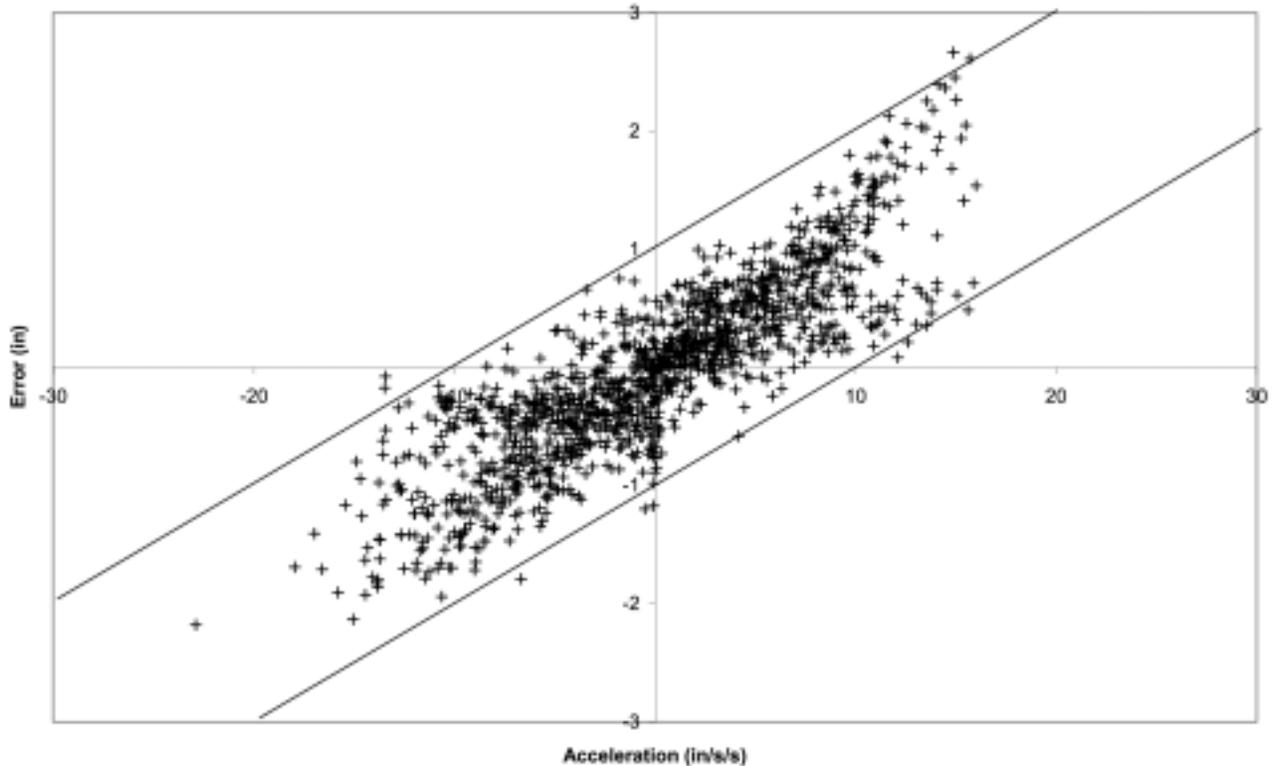


Figure 2B. Scatter plot of heave compensator error vs. ship's acceleration, which shows the error of the heave compensator as a function of ship's acceleration.

There are three main things to note about the data depicted in Figure 2B:

- Diagonal lines have been drawn at ± 1 inch, showing that if the error correlating to acceleration were cancelled (rotate the diagonal to make it horizontal), the untuned system already achieves ± 1 inch.
- Extrapolating from the data shown out to the maximum specified accelerations of ± 30 in/sec/sec, the system without acceleration correction has errors of only about ± 4 inches.
- The spread in the data does not appear to increase for large accelerations.

There are a number of AHC parameters that have not yet been optimized. With the number of adjustments that remain to be made and the performance of the system already demonstrated, it should be straightforward to achieve ± 1 inch and possible to achieve ± 0.5 inches or better.

4. In terms of recovering fine-grained silts and clays, however, our one successful attempt at 'Mud Patch 2' showed the HPC system is almost certain to work well. The problem we had in recovering that core was in erroneous depth to the seafloor, not in the coring technique.

IMPACT/APPLICATIONS

The AHC800 has the potential for making a significant contribution to scientific knowledge along the continental shelves. The system should provide a relatively low cost, but reliable coring system that can be deployed on a variety of platforms.

TRANSITIONS

A number of other projects have shown interest in the utilization of the AHC800. These include the SHALDRIL program sponsored by the Office of Polar Programs of NSF. In addition, there is the potential for using the AHC800 for the drilling of large lakes in support of paleoclimate investigations sponsored by NSF.

RELATED PROJECTS

The GeoClutter Project is the most closely related and has the most immediate need for the application of the AHC800 coring rig.

PUBLICATIONS

Nielson, D., G. Mountain, M. Pardey, J. Austin, C. Alexander, 2001, Heave Compensated GLAD800 Coring from the *R/V Knorr*: a Progress Report: poster PP21B-0479, American Geophysical Union.