Response to Clare Reimers e-mail of September 3, 2010
Regarding the R/V Knorr Long Core System

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1. Safety/Reliability. The system over-complexity compromises both safety and reliability. Simplification of certain aspects of load-handling and deployment would be beneficial. Specifically with respect to the grapple, computer control should be abandoned.

Indeed, as a result of electronic difficulties associated with a very sensitive [connectivity issues] CAN-BUS controller that 'manages' the programmable logic system for the Grapple, we have not executed a 'computer controlled' maneuver since sea-trials in 2007. The linear transducers and rotary encoders are still in place, as well as the network wiring and junction boxes, but during every launch and recovery operation in the field seasons of 2009, and 2010 all Grapple maneuvers have been executed manually at the joystick panel that controls both the Allied Systems A-frame and Grapple.

The programmable controller can offer some real safety and efficiency to the Grapple and A-Frame operations. In the future, with resolution and refinement of the CAN-BUS we still hope to utilize some of it's high resolution control capability.

The grapple basket needs to have a manually-actuated latch/lock mechanism added to secure the corer bomb.

Point well recognized, and during operations in 2010, we added a door lock system to back up the hydraulically operated door latch by securing the door with two special stainless steel 'aircraft straps' which can be safely installed and removed during launch and recovery operations. In the upcoming maintenance period we plan to design and install a permanent robust latch system to back-up the existing hydraulic arrangement.

The grapple control panel must have a functional emergency-stop, easily and immediately accessible to an operator.

The joystick panel that is used to control the Allied Grapple [and A-Frame] is factory equipped with a very easily reached [upper left corner of the on deck box] E-STOP which is constantly employed during operations. The E-STOP is depressed to disable all joystick controls at the termination of each operation, and accordingly opened at the onset of a new phase of maneuvers. It is of course available to immediately interrupt any operation in case of an emergency.

Behind the operator is an emergency stop for the hydraulic supply system [HPU]. We are evaluating the best way to wire this emergency stop to the grapple control panel so that one push button will immediately stop the grapple and the hydraulic power supply.

The encoders for the davits need to either be modified to make them more reliable or a manual or wireless control system designed.

The rotary encoders associated with the ODIM overboarding davits, as well as the CTCU winch, Storage Drum and Cable Counting occasionally began to fail during our 3rd year of operation [2010]. Until then the encoders had not caused any problems. They are marine grade electronic devices [O-ring sealed anodized aluminum housings] but after long exposure on deck to the elements some units began to leak and fail electronically. There are thirteen encoders on the ODIM system. We have on hand a deep inventory of spares, and swapping out an encoder takes a couple of hours. Preventive maintenance is possible by visually inspecting the devices, [checking the seals, corrosion detection] and this is now part of our routine as well. We are also looking into a secondary waterproofing technique that will involve a casting compound covering the vulnerable areas of the encoder.

Wireless communication is not an option as the mode of failure is internal to the encoders, and not one of a connective nature for the system.

The davits' multitude of electrical cables and hydraulic lines need to be better protected on deck.

We currently employ covered cable ways in the center of the fantail where possible, and secure, bundle and elevate the cables and hydraulic lines along and inside the starboard core barrel track. We have experienced two ruptures of a single hydraulic line [later found to be a result of a weakened, corroded jacket], though we have yet to incur a down-time incident due to any damage of the many power, communication, or network cables that connect the davits to the control nodes.

The release mechanism that drops the corer into the sediments needs to be simplified. Recently, a standard Benthos acoustic release has been shown to work reliably.

The original, solenoid-fired lever system that allowed instantaneous release of the core when signaled from the surface has been removed and the factory standard S-100 modem motor driven release mechanism is now routinely employed. As noted, this has improved the reliability of core release.

The acoustic release system has been simplified in several other ways over the course of our long core cruises. It used to include a pump-driven telescoping pole with a 200 kHz altimeter for sensing gear height off bottom, and a winch system with a drop weight to confirm this data. Both these devices have been abandoned. We still employ an acoustic modem supplied by Benthos, and now use a fixed mounted 12 kHz pinger to determine height above the bottom. The pinger can be switched off and on via the modem. This feature [turning off the pinger] insures good communication with the modem when the release command is sent.

The man basket needs to have a vertical motion capability. People should not need to stand on top of the basket rails during core extrusion.

Vertical motion capability of the man basket is not needed if the Grapple height is properly adjusted. When the height of the Grapple is adjusted to be proximate to the man basket structure it is not necessary for personnel to "stand on top" of the basket rails during the extrusion process. The hydraulic controls and the extruder can easily be reached from the interior of the man basket when the Grapple is positioned sufficiently low. After discussions with the Master and Chief Mate of the Knorr, we will be adding additional non-skid walkways, inside the basket on port and starboard sides to provide more footing for the operators.

2. <u>Load handling</u>. The long coring system needs to be subject to UNOLS winch and wire standards. A calibrated tension and wire payout readout that is clearly visible on deck is needed.

The long core over-boarding system is subject to the UNOLS winch and wire standards (RVSS, Appendix A and Appendix B) as much as any other winch in the fleet. The long core system was built to ABS standards and, as an inspected vessel, was evaluated and approved by the U.S. Coast Guard.

During long core operations we employ multiple readouts of the line out and tension. There are two in the Main lab where the operations are managed, one in the winch control tower where the ODIM operator is located and a final repeater on the Bridge so the watch can review the operations. We will work with the SSSG techs to see if a weather-proof version of a fifth repeater screen can be deployed on the fantail. Note here, though, during the lowering, release, pullout and return of the long core to the ship, all operational decisions are made in the main lab and winch control tower. The wire out and tension information on the fantail would be available largely for individuals not involved in the coring operation.

3. <u>Maintenance/Storage</u>. Storage of system components outdoors at WHOI or in ports is not advised. This causes excessive corrosion of the winch system and non-marine grade cable connections.

Where and when possible, the critical components of long core system are already stored inside when at WHOI. WHOI is in the process of acquiring 2 large 'Weather Port' structures for additional protected storage. One 40' x 50' protective structure will have a drive through electrically operated door, and a special free standing rigid tent and framework will be hoisted over the Plasma storage winch for longer term storage.

For the record, all cable connections associated with the long core deck equipment are specified and maintained as marine grade. As time and budgets allow, and to improve the system, we have been replacing the existing NEMA 4X marine grade connectors with sub-sea types, comparable to those used on full-ocean depth instruments.

Because of ship scheduling, at times the long core system has been stored in distant ports for several months at a time. On these occasions the system has been exposed to the elements in ways that may have caused maintenance problems. We believe that these situations should be avoided to the extent possible because of the exposure issues and also because storing at distant locations far from WHOI makes it nearly impossible to perform routine maintenance.

WHOI/NSF should consider hiring a full-time manager to oversee winch and load-handling system maintenance. 2-3 days of sea time lost due to maintenance issues could equate to this person's salary.

Matt Hawkins September 15 email outlines the steps NSF has taken and will take to provide proper maintenance for the long core system.

4. <u>Personnel management</u>. Personnel should stand regular 12 hr watches, not be "on call" at all hours. After sufficient training, 5-6 experienced coring technicians are needed for deck ops per each 12 hour watch. There has been a history of recruiting anyone available for these cruises. It would be better if personnel had some degree of involvement with the equipment or science.

It is wrong to characterize the coring teams as having a "history of recruiting anyone available for these cruises". While we (and NSF) do not have the resources to maintain a fulltime crew of coring technicians in support of the long core, we have gone to great lengths to cultivate a group of knowledgeable and experienced support personnel for the system.

A census of the coring personnel involved with the seven long coring cruises (six operational plus the sea trials) shows that a total 24 individuals have sailed in support of long coring operations out of a total of 63 potential slots. Of these, three have sailed on all seven cruises and one has sailed on six of them. These four sailed on the first four cruises, developing the expertise needed to operate the system. The core group includes Jim Broda (WHOI), Paul Walczak (OSU) and Chris Moser (OSU), who are the most experienced coring techs in the UNOLS fleet and Jeff Hood (WHOI) a machinist and mechanic who has proven invaluable for at sea repairs. We have built coring teams around this experienced core group. Of the remaining members of the coring teams, two have sailed on four cruises, three have sailed on three cruises, seven have sailed on two cruises, and seven have sailed on one cruise. This represents a significant growth of experienced long core personnel.

The people we have selected to be on the coring teams fall into several categories. Several of the members were involved with the development of the long core subsystems and serve in roles as both coring techs and as system troubleshooters. Others have come from different sea-going groups and operations and, although they were not necessarily experienced with the long core, they did have significant sea going and deck handling experience. Of course some people have had little prior experience before working with the coring team, but we know it is necessary to include new people in order to grow the pool of people available for future cruises.

With proper Chief Scientist planning, it is quite feasible to have the long core team on call, rather than standing 12 hour watches. Some demands on the team have been unreasonable and have been resisted. We do not think that there should be a rigid rule about staffing numbers since the needs of each cruise will be different (the amount of station time versus transit time for instance). We agree that an adequate number of individuals is needed in order to assure that the coring team is well rested during operations.

5. <u>Deck safety</u>. Personnel should be familiar with and use UNOLS standard hand signals while operating over-the-side gear. Safety shoes should be worn while working on deck with heavy equipment. During rough weather and high sea states, tag lines should be used routinely for positioning equipment such as the "dog dish" (the acoustic release and pinger platform).

All of the above are followed and part of daily practices.

Personnel who work over the side for extended periods (e.g. on the grapple, man-basket, attaching recovery clamps) and who are vulnerable to falling in the ocean should be restrained.

In agreement with the ships officers, harnesses and other restraining aids are employed when necessary.

6. <u>Science goals/Core curation</u>. The long corer should not be used as an exploratory system. Seismic records are needed to inform coring locations.

3.5kHz echo sounding provides the perfect combination of resolution and sediment penetration for choosing long core locations. Lower frequency seismics - like those on the RV Langseth - are not needed and not useful because they do not image the upper 50 m of the sediments very well.

Frequencies higher than 3.5 kHz might be useful because of better imaging of the upper sedimentary section, but these systems are usually not found on the UNOLS ships.

The idea that the long core should not be used as an "exploratory system" is also incorrect. The long core system has the same usefulness for exploratory coring as the standard jumbo piston core on UNOLS vessels, but with about double the recovery length. The cruises this spring and summer showed this to be true. KNR197-3 (Oppo/Curry, Chief Scientists), KNR197-4 (Baker, Chief Scientist), KNR197-10 (Keigwin, Chief Scientist), and KNR198-1 (Keigwin, Chief Scientist) all used the system quite successfully in exploratory mode without advanced seismic information beyond archived 3.5kHhz records from LDEO and the on-board 3.5kHz echo sounder on Knorr. No low frequency seismic surveys were needed - the length and penetration of the long core do not require it. Low frequency seismic records do not provide added value in site selection for the sediments in the upper 50 m.

Sites for long coring are selected based on the penetration of the 3.5kHz echo sounding signal and prior coring results. The preliminary coring results can come for existing archive cores within the study area (this is often necessary in order to obtain NSF funding for any coring cruise). Even if no cores have been taken in the study area, we always deploy a gravity core to assess the sediment characteristics prior to a long core deployment. The combination of a successful gravity core with good penetration, an echo sounding record that shows deep penetration of the sound pulse, and a stratified sedimentary section are all signs that the sediments are soft and that it is safe to deploy the long core.

Separately from this document, we will develop a document with our requirements for siting a long core operation which will be available to future Chief Scientists.

Core tops are unfortunately compromised by removing the piston during recovery. Developing a means of leaving the piston in place would be beneficial (break-away piston?).

In our new, improved, method of recovery, the piston is briefly [~ 1 minute] removed from the core liner, and then re-inserted. To date, we have no record of any loss of sediment as a result of this procedure.

It is unclear what the “unfortunately compromised” evaluation from the reviewer refers to, as there are several ways that core top samples can be lost. There is always some loss of core top because the long core system has a very high energy entry into the sediments. That is why we couple the long core with a gravity core and multicore core at our coring stations. Even though core tops are not guaranteed to be preserved in a massive corer like the Long Core, many records from our onboard GEOTEK MST logger show them to be remarkably good and comparable to that of the corresponding Giant Gravity Core we take at each Long Core site.

In general when significant portions of the core top are missing, the reason is because of over penetration of the coring system and delayed movement of the piston up the core barrel. This can be caused by inaccurate metering of the height of the core off the bottom, or by wave action and release of the core in a wave trough rather than a wave peak. Of course the reason we employ the parallel gravity cores and multicores is to ensure recovery of the core top sediment.

No Chief Scientist should expect a high quality core top from a piston core, either the long core system or the standard piston core on other UNOLS vessels.

Break-away pistons are notoriously unreliable and are not routinely employed in any modern coring operations, scientific or commercial. We don't see them as a viable alternative

At times, upper sections of liner implode around section #14. A means to rectify this (thicker schedule liner, better sealed joints between liner sections, better sealed coupler…) should be investigated.

This is an interesting comment especially specifying section 14. As far as we know, there is no evidence for a consistent implosion specifically at section 14, although there have been occasional core liner collapses with the system and when they occur they tend to be relatively high up the core. (Note: section 14 is about two thirds of the way up a 30 m long core, but only about half way up a 40 m core.)

A core liner collapse, when it occurs, is the result of a strongly sealed piston [which is necessary for good core recovery and performance] and incomplete penetration of the core due to encountering tough physical properties in the sediment. We experience this on some deployments but not others. During the early phase of pullout of the corer from the seabed, the piston must make it to the top of the core and contact the piston stop for extraction of the corer from the seabed to begin. Our experience with the long core has shown that when less than 100% penetration has occurred, the core cutter is generally plugged with very stiff sediment that refuses to budge or flow when pullout begins. Something has to give and this is when one of the threaded joints may collapse and let in water to relieve the tremendous [negative] pressure inside the liner. We believe that the threaded joints are a weak spot in the liner and we are evaluating ways to strengthen the joints using unthreaded, overlapping, glued liner sections, which may eliminate some of the weaknesses caused by the threading.

When a liner collapses, no sediment sample is lost. The core liner opening may produce a section of water between stratified parts of a normal core; this water section is removed during the core extrusion process. The addition of water through the core liner makes this section and the sediments near it unreliable for certain types of studies (pore water studies, for instance).

All piston cores fail in this manner if they do not fully penetrate. Thicker walled liner may help minimize the problem but it is unlikely to eliminate it. Of course the thicker walled liner will also mean less sediment recovery and even shorter cores because of lower penetration into the sediment. For paleoceanography and sedimentology studies, this would be a significant loss of capability. We would be willing to investigate using thicker walled liners for some cruises if requested by NSF and Chief Scientists. But we will also maintain the current capabilities, which we believe are nearly ideal for paleoceanography and marine sedimentology studies.

Establishing and adhering to community-wide curation standards will make long cores more useful to the entire MG&G community. Cores should be refrigerated. There should be a uniform labeling scheme.

The WHOI core lab has a long tradition of handling all recovered samples of sediment in a routine and standard way. Many other labs have adopted these procedures established and practiced since the early 1970s. For all cores archived at WHOI, labeling practices have been strictly enforced onboard, all long cores [so far] have been [GEOTEK] logged at sea, and all samples are subsequently carefully curated, described and published online once onshore. After a proprietary period where use of the samples is reserved for the collecting PI, the long cores, like all samples collected by WHOI, become available to the community at large.

Since sea trials, a refrigerated 20’ container [sometimes two] has been onboard the Knorr for each long core cruise. The recovered long cores are kept at 6-7 degrees C at sea, while in transit to the US from foreign ports, and continuously in the archives at the Mclean Lab on the Quissett campus at WHOI.

However, it should be noted that the rate of acquisition of new core easily outstrips our capability to provide long term refrigerated curation for every core. We can only assure that refrigeration is maintained at sea during the cruise, during transport to WHOI, and for a set period of time after splitting. The duration of refrigeration can be flexible – some cores for longer periods of time than others – but since every PI wants cores refrigerated, our space limitations mean that we cannot provide permanent refrigeration for all cores for every PI.

7. <u>Future operations</u>. The community needs a clear statement from NSF about future plans for the Long Corer System.

Matt Hawkins September 15 email addresses NSF’s intentions for the long core system.

Any new ship that carries it should have seismic (better than 3.5 kHz) capability and be able to perform seismic survey and long-coring on the same cruise.

No, this is not necessary. There is no scientific reason why the coring system needs to be coupled with a seismic system.