Expedition 390 South Atlantic Transect I Engineering Report

Cape Town, South Africa to Cape Town, South Africa

09 April 2022 to 09 June 2022

Matthew Allen, Development Engineer

IODP Coring Tools

I spent the majority of JR operating time on sites observing rig floor and coring tool operations. Expedition 390 had a very high amount of hard rock coring planned and a relatively small amount of sediment coring.

RCB Coring

The RCB drilling BHA consists of a 9-7/8" coring bit (C7), either a bit sub or a mechanical bit release, a controlled length drill collar, top sub, then a head sub. The controlled length drill collar is important because when the RCB barrel lands, it must be spaced out correctly to engage the latch in the head sub.

The coring systems are run in pairs or barrels, one deployed inside the drill pipe, with the second either being redressed or waiting on the rig floor. The top section, the latch and wireline GS receptacle, are switched from one barrel to the other on the rig floor using lifting clamps and winch lines. This allows the rig crew to drop RCB barrels, then remove the core from the barrel that just got to surface, saving some time. The barrels are pumped down when the next drill connection is made up. An RCB barrel landing on bottom is confirmed by an increase in pressure.

Due to the time required to advance coring a full-length core, ~9.5m, the decision to advance by half cores, ~4.5m, was made due to the hard and consistent formations encountered. The thought process is that the longer the barrel stays on bottom, the more likely it is that the core has jammed and is no longer entering the core liner. If it has jammed, then the latch is being forced upward and can potentially break, as was experienced on EXP 391. Half cores were a decision made to prevent that from occurring and force a drill pipe trip.

RCB Observations

- This expedition had a very high core recovery percentage for hard rock coring.
- High heave can force the drilling BHA to bounce on the bottom of the hole and damage the bearings, reducing bit life. It will also set the core catchers prematurely and can jam the core in the core liner.

RCB Improvements

1. Core Techs requested a 5" long liner support sleeve for the RCB barrels. During coring, the core liner would regularly be pressed beyond the 3" length sleeves. Create a 5" long sleeve, based off OP3410, using same non-mag material. Correct sleeve drawings to fix manufacturing issues. Sleeves were shipped to the JR without proper machining.
2. Remove the holes from OL1008 and remove the window from OL1007. These features are not needed and are no longer used.

APC Coring

The APC drilling BHA consists of 11-7/16" coring bit, bit sub, seal bore drill collar, latch sub (for XCB), top sub (for APC to land), head sub, and a non-mag drill collar (for APC orientation). The seal bore drill collar allows the APC to be "shot" into sediment formations using pressure. Seals will seat in the ID of the seal bore drill collar. The latch sub allows the XCB to be utilized with the same drilling BHA as the APC, ultimately saving a drill pipe round trip.

The APC barrels are also run in pairs. However, instead of being dropped, the APC barrels are run in hole on the coreline. The APC barrels cannot be dropped because the shear pins and other more delicate parts for orientation would be damaged, especially the orientation and temperature devices. One top shear sub assembly is run and swapped between two sets of core barrels. At the rig floor, the top sub is removed from the lower barrel, and then the rods are "restroked" into the closed position. At the end of the restroke, the shear pins are replaced. After this, the barrel is laid down and the core is removed. The plastic core liners have a hole pre-drilled in them, between specific lines, to prevent their rotation and allow for orientation.

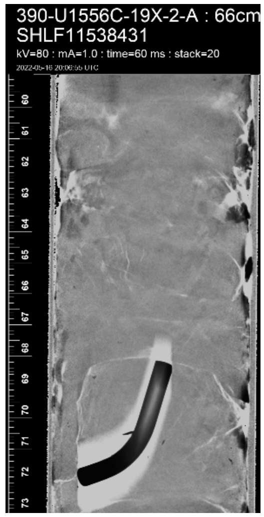
Shooting a water to sediment interface (mudline core) was found to be a critical operation. Often times the "estimated" water depth can be affected by JR draft, tidal forces, and heave. A mudline core shoot depth used from a previous expedition will often times result in a different recovered core length due to these factors, also including a different drill pipe tally. Scientists want a core that shows this interface, so the first full core of a hole that has no interface is often repeated. On this expedition, full cores occurred twice on the first shot for holes. This required a new hole to be created immediately, the DP operators to offset the JR, and the next core to be a repeat mudline core, shot from a modified depth.

APC Observations

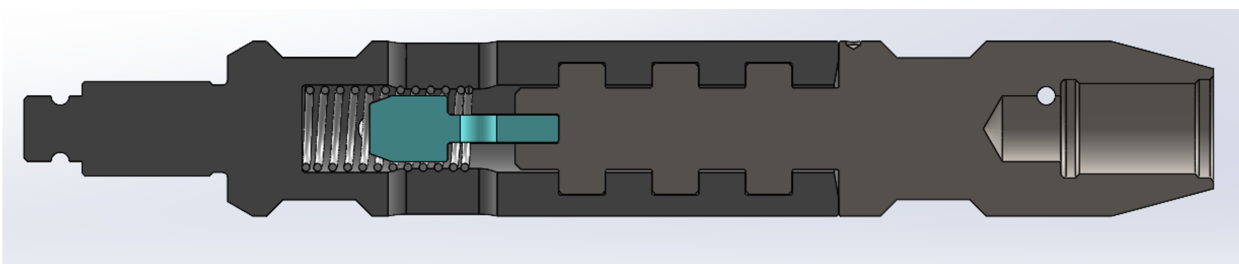
- Orientation issues. The wireline assembly is all non-mag. The Ice-Field tools are no longer supported. Project to replace the capability with a gyro could also eliminate the need for the non-mag drill collar.
- APCT3 issues, mostly related to several of the APCT3 packages not working. One shorted to the cutting shoe. Another was egg shaped, and got stuck inside a shoe. Another was dead entirely.
- Shear pin pieces are able to fall free after shooting the APC. Both the small and large pieces have been observed in the drill pipe. The drill pipe connections become magnetized, so the pieces will stick to the inside of the connections and remain there.
- Seal redressing and quick connect to easily remove the lower piston head.
- In deep water, and in higher heave conditions, the APC tends to preshear.

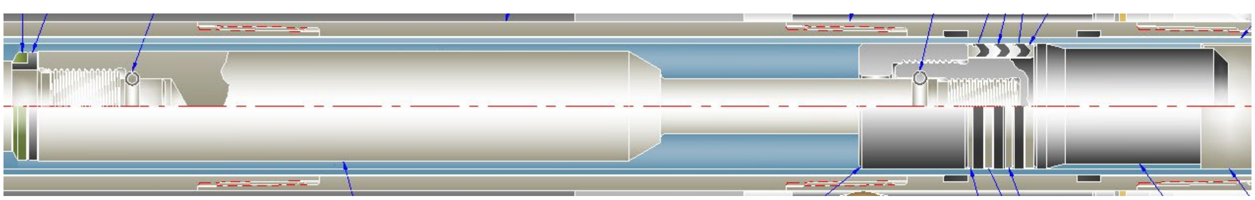
APC Improvements

1. Modifications to prevent shear pins pieces falling free. Below is an image of the large piece of an APC shear pin that was returned inside a core.



2. Shear value verification testing. 15 pins from on board inventory to shear test to verify values in College Station. This is a check to be sure they are working as intended.
3. Quick connect addition to quickly remove the lower piston and prevent the whole assembly being laid down.





4. Contingencies for APC system when experiencing preshearing during operations
   a. Slow the run in hole rate
   b. Pump down as the coreline in run in hole as well
   c. Run the spring seat in the drilling BHA
   d. Remove the Spang Jar from the wireline/sinker bar assembly
   e. Remove the orientation assembly from the assembly
5. Design a stabbing guide for the GS Cup and Spear when they reconnect them to run another APC.

XCB Coring

The XCB system was used after APC coring to capture the sediment to basement interface in holes. The XCB uses the same BHA that the APC uses. It uses a double latch design that is different than the latch used with the RCB system. It is unique in that the core is cut by a smaller cutting shoe that is attached to the bottom of the barrels. There are two different types of cutting shoes. The original legacy shoe design using carbide inserts, and a newer PDC design. The PDC shoes were used to cut all basement interfaces, since they are better and more durable when cutting hard materials. The older shoes were used at times when the material was known to be softer and not near basement depth. The system was designed with a spring and hex shaft setup to keep the smaller shoe in advance (ahead or below) of the outer coring bit, to capture more core in softer materials. The spring and hex shaft allow the bit to retract into the larger bit when harder formations are encountered. In theory, this movement allows the shoe to stay cooler by surrounding it with the full flow from the much larger flow areas of the coring bit.

XCB barrels are also run in pairs. They are dropped, similarly to the RCB system. One notable difference in operations with the XCB and RCB systems are the coreline BHA will be run in drill pipe while the XCB is cutting core. The RCB system will be off bottom and not cutting core when the coreline is deployed to retrieve the barrel. One top section of the XCB is used and is switched between two sets of barrels. Orientation cannot be used, since the system is rotating the core material.

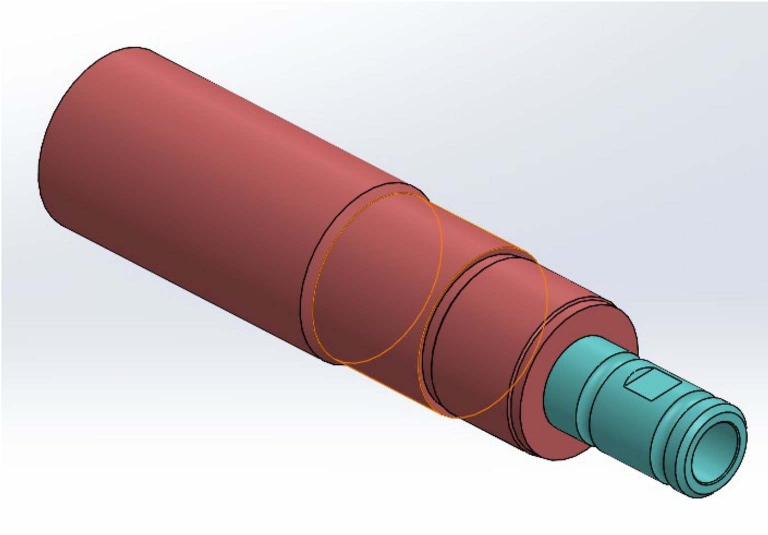
Coring parameters are important for good core recovery percentages. This system is used at that point where the material is too hard APC core, but still too soft to core with the RCB. Light weight on bit is used. The flow rates were varied in order to recover more core. More flow rate was used as the formation got harder, and the wireline BHA was removed from the drill pipe ID while coring to allow full flow rate to reach the bit and shoe.

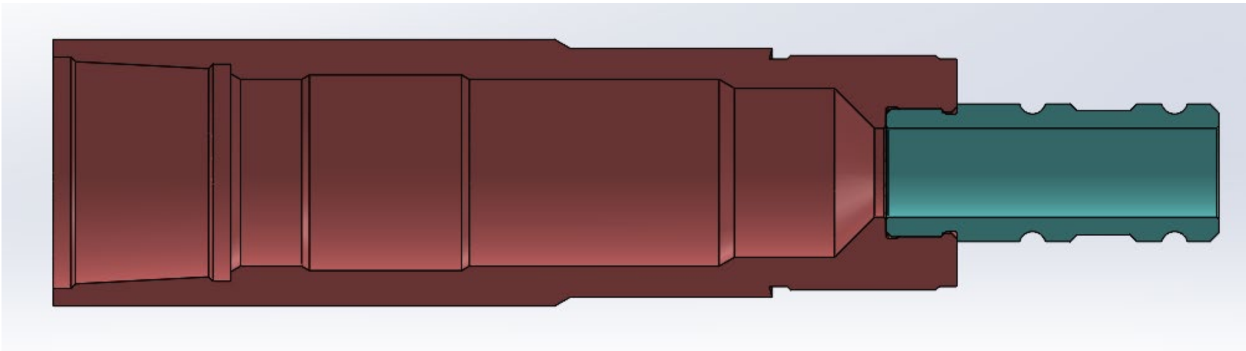
XCB Observations

- PDC cutting shoes are good, old shoes are...not as good.
- Hex shaft does not easily retract. This causes the cuttings shoes and the subs directly above to get very hot due to a lack of flow. When they eventually are pulled back up into cooler fluid, the water is effectively quenching the heated material (steel). The subs oval, or the cutting shoes simply break while trying to break the connections on the rig floor.
- The liner hanger vent sub liner hanger (swivel) rust up. This does not allow the core liner to rotate freely, causing bad recovery.
- PDC coring bit is 9-7/8” OD, hole is smaller for logging. This is not frequently used (if ever).

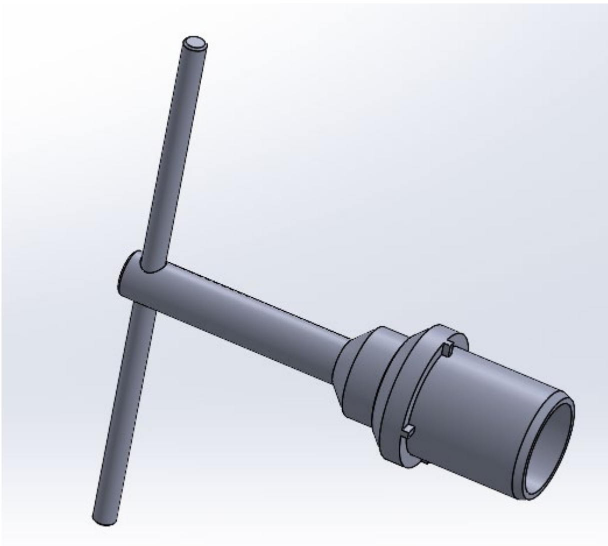
XCB Improvements

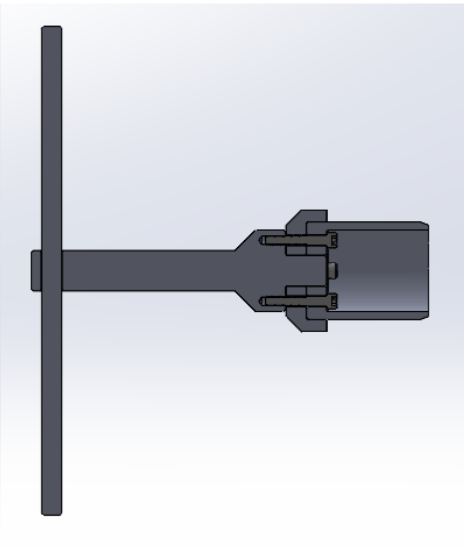
1. Non-mag core liner swivel. Two parts now, wrench flats for removal, normally Baker locked.





2. XCB cutting shoe removal tool for drill crew





3. Hex shaft redesign – Concepts. Ultimate goal is to develop a shaft that can slide under load and still survive in the drilling environment.

ES FOR SOFT BROACHED HOLES IN FITTINGS

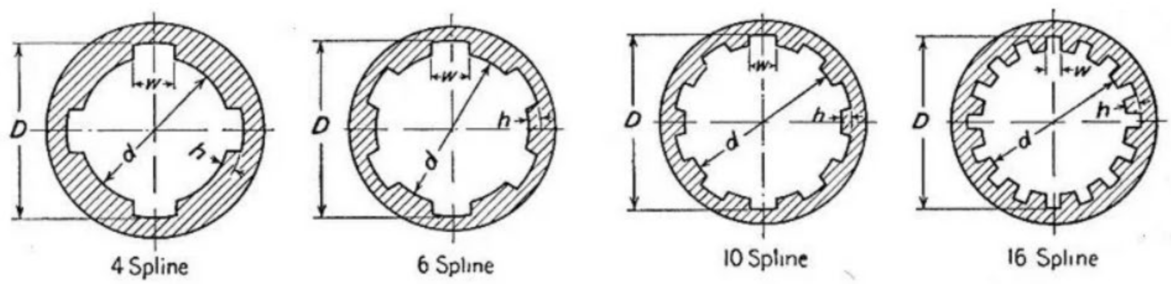
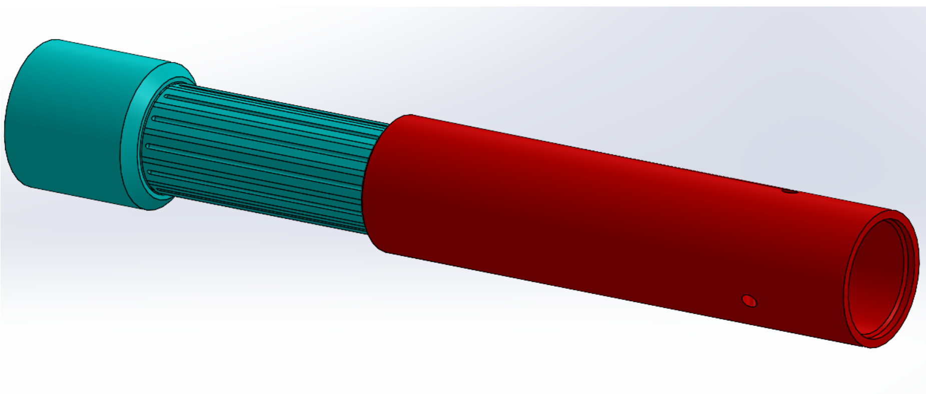
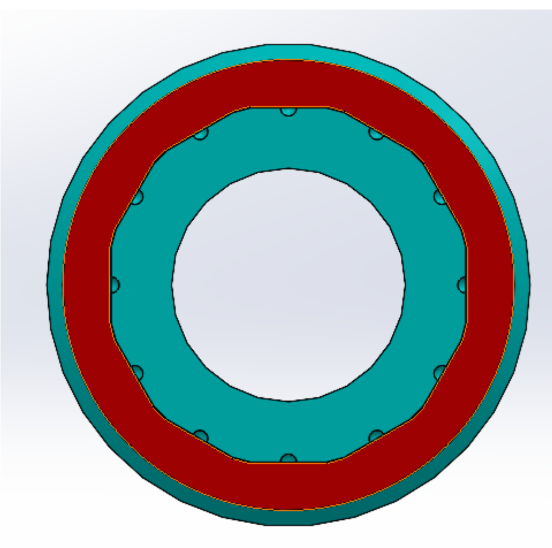


FIG. 1—DIMENSIONS FOR 4, 6, 10, AND 16 SPLINE FITTINGS (SEE TABLE 1)





MSS Testing

Testing Summary

MSS testing and troubleshooting was completed during the expedition. The MSS repair report from engineering was used a guideline for all testing performed. The relay board dip switch testing was performed as described. The relay board and other components were assembled and tested before running a full sequence to completion. Full data sets of EC3 and DR3 for all possible dip switch combinations were captured by test 8 (DLIS#011). EC4 and DR4 were found to be unresponsive, or not providing the same range of values as EC3 and DR3. Subsequent troubleshooting and repair efforts were not successful in restoring expected functionality.

	Test #	Date	EC#	DR#	Observations	Test Type	Test Information
1	DLIS#002	27-Apr-22	3	4	Minimal response	Ring Test	SLB 12" caliper calibration ring. 3 passes around sonde. 3 more passes beside sonde.
2	DLIS#003	27-Apr-22	3	3	Good response	Ring Test	SLB 12" caliper calibration ring. 3 passes around sonde. 3 more passes beside sonde.
3	DLIS#004	27-Apr-22	4	4	Minimal response, major positive shift	Ring Test	SLB 12" caliper calibration ring. 3 passes around sonde. 3 more passes beside sonde.
4	DLIS#005	27-Apr-22	4	3	Good response, major positive shift	Ring Test	SLB 12" caliper calibration ring. 3 passes around sonde. 3 more passes beside sonde.
5	DLIS#005	1-Jun-22	3	3	Good repsonse. Characterized DR3, ideal ring location between 50 and 60cm. Test procedure spelled out in the MSS Test Report. See real time processing observation notes.	Ring Test	IODP test donut. Passes done in 10cm increments. First pass, switch in the 10ohm position. Second pass repeated with the switch in the off position.
6	DLIS#008	1-Jun-22	4	3	Minimal response observed. Dip switches do not seem to change the conductivity much, if at all.	Dip Switch Test	IODP test donut. Placed between 50 and 60cm position. Switch in the 10ohm conductivity position. Used IODP dip switch test setup. Test stepped in 20s intervals.
7	DLIS#009	1-Jun-22	4	3	No response. Unresponsive to the ring in different orientations.	Ring Test	IODP test donut. Passes done in 10cm increments. First pass, switch in the 10ohm position. Second pass repeated with the switch in the off position.
8	DLIS#011	1-Jun-22	3	3	Much better range observed, with expected trend of conductivity going down while susceptibilty goes up.	Dip Switch Test	IODP test donut. Placed between 50 and 60cm position. Switch in the 10ohm conductivity position. Used IODP dip switch test setup. Test stepped in 20s intervals.
9	DLIS#016	3-Jun-22	3	4	Response is extremely attenuated and baseline is vastly different from DR3. DR4 does not provide expected response.	Ring Test	IODP test donut. Passes done in 10cm increments. First pass, switch in the 10ohm position. Second pass repeated with the switch in the off position. Additionally completed a second ring test, SLB 12" ring, spin test to confirm signal repsonse from all phase angles. Then passed the ring along the entire length of sonde.
10	DLIS#017	3-Jun-22	4	3	Unresponsive. Test completed again to verify that EC4 does not work after, once again.	Ring Test	IODP test donut. Passes done in 10cm increments. First pass, switch in the 10ohm position. Second pass repeated with the switch in the off position. Additionally completed a second ring test, SLB 12" ring, spin test to confirm signal repsonse from all phase angles. Then passed the ring along the entire length of sonde.

First Testing Completed April 27th on Site U1556

The first test objective was to test DR4 with the known good EC3. DR4 was known to have been used in expeditions before leaving the JR for testing, so we wanted to test it and compare it to the other sonde, DR3. To test the MSS logging tools, the following logging components were made up in order, from top to bottom:

- DTC-H – Telemetry Cartridge
- Adapter Head – Bulkhead
- ELIC – Communications from MSS EC to SLB
- EC – MSS Electronics Cartridge
- DR – MSS Measurement Sonde

The Schlumberger (SLB) logging software and equipment was used to complete all testing. Initially, the MSS IODP calibration ring did not fit around DR4. We had a limited amount of time during coring operations to test at site U1556, so the decision was made to utilize a SLB 12" caliper calibration ring, made of stainless steel to determine tool functionality. The same test procedure was used for the four tests completed on April 27th. The ring was passed around the sonde (conductivity) for three passes. Then the ring was then passed beside the sonde for three passes.

EC3 and EC4 were found to provide high response with DR3. Little to no response was observed from EC3 or EC4 with DR4. EC4 and EC3 were also found to provide different signal magnitudes. Not knowing what the output is "supposed" to be, we chose to assume that EC3 remains functional since it stayed on board the JR. Thus, EC4 significantly shifted the output data in the positive direction from EC3 output. Important to note: EC4 did provide the data recorded in tests 3 and 4.

After completing the first four tests, it was observed that DR3 and DR4 have different outer diameters. The calibration ring was designed to fit on the smaller of the sondes. The inner diameter of the ring was modified to fit onto the larger diameter sonde as well.

Before logging Hole U1556B, a zoom meeting to discuss the MSS tools was completed. Further testing and methods were discussed. Planned logging combinations for further holes was also discussed. The decision was made by scientists to run the combination of EC3 and DR4 to log Hole U1556B. We were informed that this was the combination that was run on expedition 392. We were also informed this combination was used on expedition 396.

Second Testing Completed on June 3rd in Port

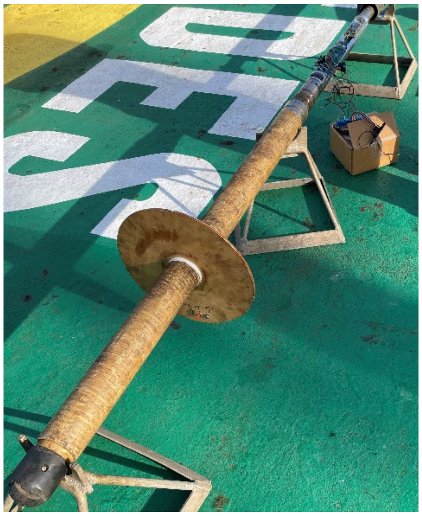
Additional testing of the MSS tools was completed upon return to port in Cape Town. Power supply while in transit is not acceptable for calibrating wireline logging tools, per Clay from SLB. Coring operations and weather conditions also did not allow for further testing ahead of time.

After logging Hole U1556B, the decision was made by the science party to use the combination of EC3 and DR3 to log the next planned hole, U1557D. The returned logging data did not produce useless results from EC3 and DR4 for Hole U1556B.

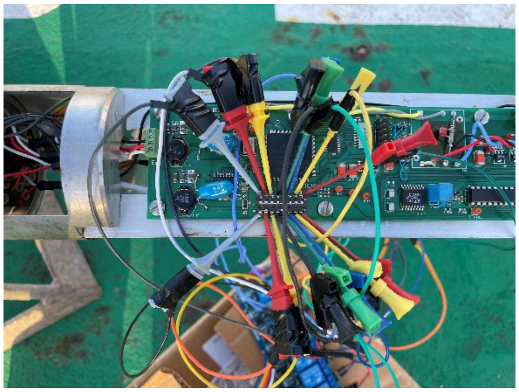
Six tests were completed, once again, with the main objective of trouble shooting the MSS tool components. EC3 and DR3 were tested first to confirm a working set up, and to refine the ring test procedure and steps.

The testing procedure for the Calibration Donut from engineering is as follows:

- Startup WAFE and get MSS up and running
- Start recording data
- Wait 1 minute (to establish baseline)
- Put the conductivity coil 20cm from the bottom of the sonde
- Wait 1 minute
- Move the coil 10cm further up from the bottom
- Wait 1 minute
- Repeat previous two steps until the coil is a total of 70cm up from the bottom
- Wait 1 minute
- Remove coil from the sonde (to get a return to baseline) and wait 1 more minute before terminating data recording



The optimal sensor location on the sondes was found to be from 50 to 60cm as measured from the lower (downhole) end. After confirming the setup was working, EC4 was then tested with DR3 (working sonde). However, after producing noticeable signal response during the first testing, during the second round of testing, EC4 had minimal noticeable signal response.



A dip switch test was performed on EC4 with DR3 first to get a complete data set of all possible options. The data is represented by Ascii files for test 6 (DLIS#008). The procedure for dip switch testing is as follows:

- Turn on the WAFE and start recording data
- Install the calibration ring on the sonde at the ideal location and allow the relay board to complete a full cycle through all the DIP switch settings

After observing minimal response from EC4 with DR3, we immediately ring tested them to confirm they were producing minimal response. After confirmation, EC3 was tested with DR3, to confirm the setup was still working. They were confirmed working as expected, then dip switch tested. A complete data set is represented by files for test 8 (DLIS#011).

Two final tests were done to confirm that both DR4 and EC4 were not producing expected signals. DR4 was testing with the working EC3. The small board repaired in College Station was found to have no effect on signal output, either connected or disconnected. The decision was made to leave it connected. EC4 was again tested with the working DR3. In addition, each electronics cartridge was pulled and inspected. No obvious flaws were observed. A guide pin on EC4 was found to be out of place and repaired, but it had no effect on signal output.

Both EC4 and DR4 have been red tagged “RONG” and marked as inoperative.

Schlumberger (Clay) End of Expedition 390 Notes on MSS Tools

The primary MSS tool and EC is located on the main pallet. The backup is located on the backup pallet. MSS has been having ongoing issues since April 2019 with the #4 set only being repaired and returned to the rig in the last few months. The DR4 sonde ran on Exp392 after coming back from repair and reportedly gave good data, but upon testing it at the beginning of this expedition, I found it virtually non-responsive. It powers up just fine and gives a signal, but that signal does not seem to change significantly in response to external conditions (I.e. dead curves). Likewise, the EC4 cartridge worked for a basic op-check at the start of the cruise, sat on the pallet for over a month, and then was found non-functional during tests performed after the ship returned to port at the end of May / early June. Currently, both the DR4 sonde and EC4 cartridge are red-tagged – neither of them seems to be reliable (or functional at all, really – they power up, but the MSS curves don’t change if either or both of those assets are in the string). Use DR3/EC3 for all logging jobs on Exp393 and we can make any further attempts at troubleshooting / testing on the bad set after that, when it is not going to disrupt service delivery.

VIT Light Mount Testing

The assembled clamp, with 3D printed light mount and simulated light, was made up to the VIT frame. The VIT was run down to ~5,000m water depth on three different occasions. No visible issues observed. The simulated light was held completely, with no indications of the 3D printed material being affected by hydrostatic pressure under water. The components and light mount were disassembled and shipped back to College Station at the end of the expedition.

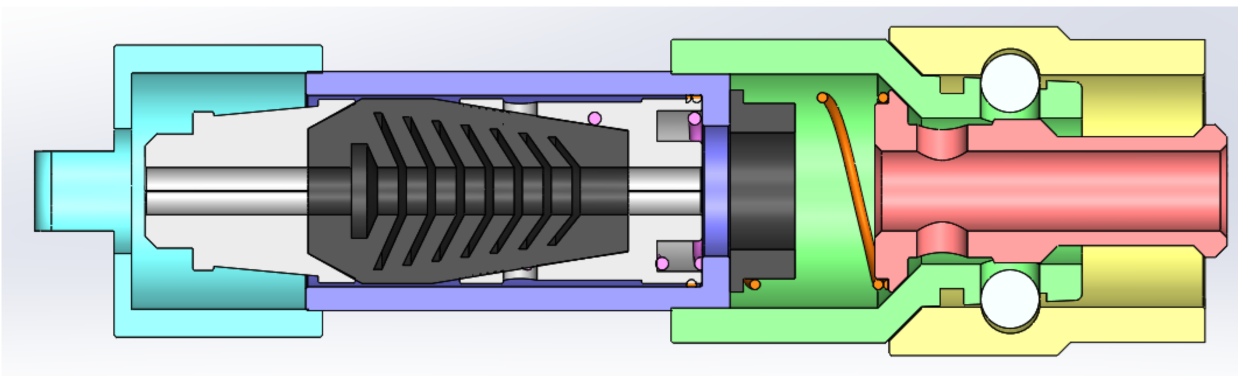
RigWatch User Manual

The RigWatch IODP user guide was updated. Incorporated as much of the new IRIS changes as I could, or as I could understand at that time. There were many changes to the system between the last guide updates to current RIS system. A new paper copy of the guide was printed out and added to the binder on the JR.

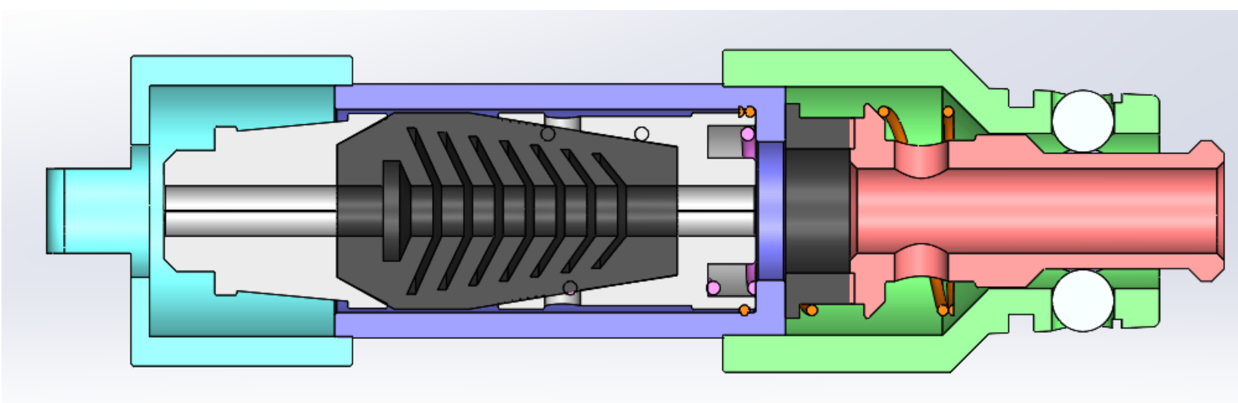
Schlumberger Oil Saver Reverse Engineering

Worked with Clay from SLB to reverse engineering the old wireline oil savers. They are in poor condition and are not supported anymore. The components were broken apart with the help of Clay and the rig crew. After measuring each component, a 3D assembly was created in SolidWorks. I was made aware that this may have been a project started in the past.

Engaged

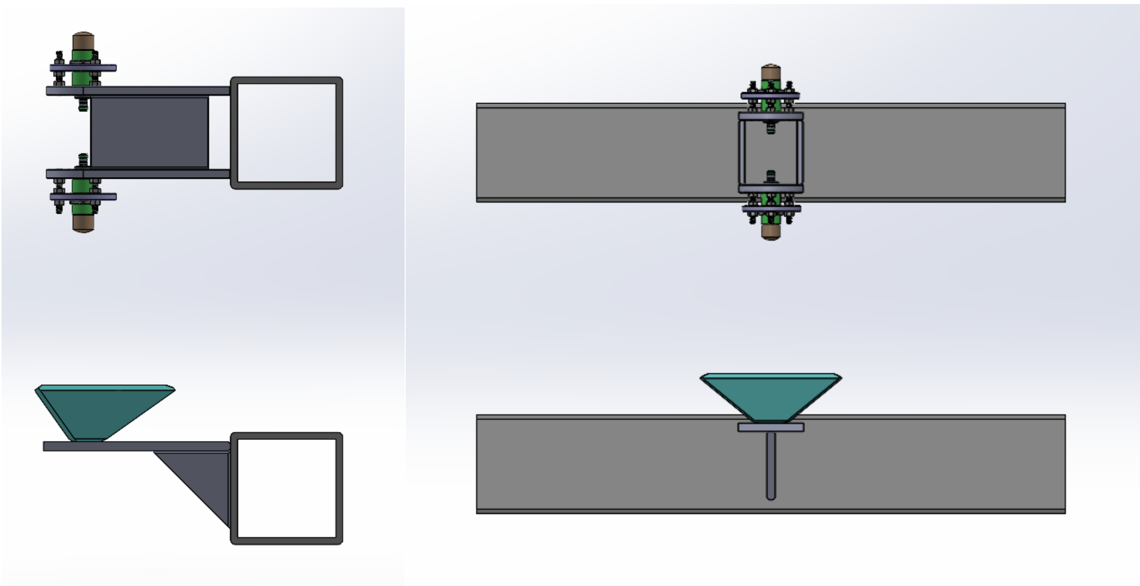


Disengaged



Radar Distance Sensor Design

I took what Bill Mills sent and modified the design.



Still a work in progress. Plan is to mount them to the back of the block and compensator trolley.

APCT3 Issues

One of the APCT3 metal frames was found to not fit inside the cutting shoe. It was measured and found to be out of round, as well as having some "high spots" due to machining. The spots were ground down, but in the process of test fitting it inside a shoe, the temperature probe was broken off inside a hole in the cutting shoe. After many attempts, I was able to successfully fish the probe out of the hole, saving the cutting shoe.

Additionally, one of the APCT3 boards was shorting out to the cutting shoe. It was measured, inspected, and found to need silicone and insulation. It was repaired and has been working.

Operations

Daily Report Template

Worked on a daily report template. The template has examples of all of the possible reporting sections in it. Also completed a daily report during transit on the way back into Cape Town at the end of the expedition.

OpsPlanner

Followed along with EXP 390 and learned how to use the program. Got a run through of the program from Steve Midgley (SM). Also went step by step through the process of creating a plan, then modifying one during the expedition, to keeping the current operations up to date. Learned a lot about how to modify existing plans to keep a very accurate timing of when the expedition should end. Also learned how to prioritize the science objectives when dealing with changes to the original plans.

Weekly and Site Reports

Reviewed the weekly and site reports from SM. I also followed along and collated the information for the upcoming sites. Reentry systems in place, reports from previous expeditions, planned operations.

Reviewed ODL and TAMRF Contract

Read through the contract between Over Seas Drilling (Siem) and Texas A&M Research Foundation. Discussed with SM.

RigWatch

Learned how to operate RigWatch from SM. Operations deliverables from RigWatch for the expedition. How the system works, and how to create and start new job files. Creating Ascii files for scientists, backing the job files on data1, and finally burning the files to a disc.

Operations Inventory

Toured the JR with SM. Physically inspected and counted the operations inventory. Updated the current AMS inventory totals with the Core Techs to correct all inventory totals. Also updated APCT3 inventories.

Other Activities

- Returned 2 APCT3s for calibrations/repair
    - 31 & 41
- Assisted ETs with APCT3 issues
    - Saved a cutting shoe by fishing a broken temperature probe from an internal hole
    - Found one metal frame to be out of round
    - Solved one other issue with the board grounding to the cutting shoe
- Supported operations superintendent as needed
- Supported core techs as needed
- 3D printed an electrical cabinet component for Nico (Siem electrician)
- Received assembly layouts of all coring tools and other assemblies from Core Techs:
    - APC, XCB, RCB, MBR, LFV, etc.
- Assembled mechanical bit release assembly with the Core Techs
- Inspected and assembled other various items with the Core Techs
- Toured the JR with SM multiple times inspecting a lot of IODP equipment
- Learned how to use Sample Master
    - Trained by SM in Hole and Site nomenclature
    - Discussed the correct way to input drill ahead sections, like reentry systems
    - Discussed how to handle reentry systems and holes started by previous expeditions
- Witnessed the Elmagco brake removal and installation
- Created a new design with Clay for a version 2 of the core liner cutter
    - Created some 3D prints to iterate the design and to show ideas to the Tech Staff
- Went through and cleaned out the engineering work station desk
    - Still a lot of items left, but removed a lot of the obvious trash