

RV Investigator Marine National Facility Rod Palmer B.Comp | Senior Technical Officer



RV Investigator - Background

- RV Investigator is a blue-water research vessel, owned and operated by CSIRO Australia and managed by the Marine National Facility and ASP Shipping
- Main areas of Science: Oceanographic, Geosciences, Ecosystems and Atmospheric research
- Built by Sembawang shipyard Singapore – Keel laid 9 May 2012
- 93.9m purpose built research vessel
- Cruise speed 12 knots
- 60 days / 10,800 M Range
- 60 Berths (20 Crew, 40 Science)
- Delivery date Sept 2014



RV Investigator - Oceanographic Capability



- CTD deployment system
- Comprising of 2 winches Rapp-Hydema
- Cable handling and deployment Crane (Triplex)
- Water sampling carousels 24 & 36 bottle, with SBE9+CTD
- Multiple auxiliary instruments
- Integrated data streams

RV Investigator - Winch Specification

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- Two 58KW electric drum motor drive winches controlled by Rapp-Hydema software
- Cable capacity, 7400m of 8.03mm Rochester cable in 25 layers, SWL 1.5t
- Electric driven and synchronised spooling
- Load cell and encoders are mounted in spooling sheave for alternative measurements
- Precise control Auto payout/in to set points of between 1-100m/min, and centimetre-level control using joystick
- Both winches provide Active Heave Compensation



• SWL 5t



- After 4 years of operation
 - Many challenges have been presented in the pursuit of the highest quality of performance
 - Re-configuration of the CTD door
 - Additional weights for carousel deployments
 - CTD wire kinking during deployments
 - CTD rotation during deployments
 - CTD cold weather deployment -17°C, (1.4°F)
 - CTD Earthing issue
 - CTD Active Heave Compensation lag

RV Investigator - Orientation of CTD Door

- During Sea trials in 2014:
 - CTD door kept striking the side of the ship
 - Hydraulic rams Undersized
- Challenge:
 - Change the orientation of the CTD door
- Result:
 - Class approval sort
 - Ship's hydraulics and electrics re-routed
 - Ship's drawings updated
 - Vertically opening of CTD door



RV Investigator - Orientation of CTD Door



CTD Door – Horizontal Opening



CTD Door – Vertically Opening

RV Investigator - Additional Weights

- During deployment of the CTD, we found the descend rate was not correct, we couldn't deploy at 60 m/min as the frame and bottles were to light in the water
- Challenge:
 - Add weights to the 24 & 36 bottle carousels
 - Without affecting the depth rating or 1.5t SWL
- Result:
 - CTD weight in water was calculated
 - Weight of the cable was calculated
 - Weights added to achieve 60m/min



RV Investigator - CTD Wire Kinking

- During a 2016 voyage Active Heave Compensation was not available
 - Winch software required an upgrade
- During deep casts, on retrieval, we found the cable was kinking
 - Affecting the electrical integrity of the cable
 - Causing the deck box to alarm
 - We suspected Carousel rotating
- Challenge:
 - Re-terminate the CTD cable within 3 hours of next station for 30 days
- Result:
 - CTD cable was re-terminated
 - Software upgraded for leg 2
 - Rotation issue put on hold until leg 2



RV Investigator - CTD Rotation

- Suspect the 36-bottle carousel was rotating
 - May be contributing to the wire kinking
- Challenge:
 - Investigate rotation issue
 - Develop an Inertial Motion Unit (IMU)
 - Utilised the serial data uplink of the SBE9+
 - Other institutions experienced a similar issue Fin recommended
- Result:
 - Live data showing CTD rotations
 - Installation of a fin, stopped the CTD rotating

RV Investigator - CTD Rotation

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No fin - Showing rotations





Fin - No rotations

RV Investigator - Cold Weather Deployment -17°C

- Prior to deployment, advice was sort from Seabird
 - keep sensors above -2°C
 - blow dry air through instruments
 - Deploy and retrieve the carousel quickly
- Challenge:
 - Stop the seawater freezing
- Result:
 - Unable to keep instruments above -2°C
 - Blew dry air through instruments
 - Water froze in instruments and tubing
 - Warm water used



RV Investigator - CTD Earthing

- During the Nov 2016 dry dock
 - CTD winches removed Axle alignment
 - Two 65 Amp heaters installed
 - On initial 2017 voyages, spiking on CTD graphs
- Challenge:
 - Investigate spiking issue
- Results:
 - Winch and slip rings checked
 - Induced interference on SBE11 control cable
 - New electromagnetic shielded conduit installed
 - Earthed "CTD wire" sheath Removed spikes
 - SBE11 deck box modified Removed earth loop







- AHC on both winches
 - Controls variations of ship's roll
- AHC is achieved by a dedicated Motion Reference Unit (MRU5+)
 - Instantaneous vertical height, velocity and acceleration
- RV Investigator does not have a dedicated MRU5+ for AHC
- Challenge:
 - To overcome the variations of ship's roll during CTD deployments
 - Not paying out while the CTD is actually moving up



RV Investigator - Active Heave Compensation



- Result:
 - CSIRO implemented a software solution Kalman Filter
 - Utilises the Seapath's Navigational MRU5+
 - Calculates linear vertical height, velocity and acceleration of the boom head
- Performance:
 - Winch follows the command signal faithfully
 - Lagging by up to 0.9 sec
 - Winch motion out of phase with vessel motion
 - Significant error



RV Investigator - Active Heave Compensation



- Work around:
 - Incorporating a "predictor" calculation
 - Using the instantaneous values, height, speed and acceleration of the boom the Kalman filter "predicts" a best estimate of the dynamics of the CTD boom head
 - Predicting up to 0.6 sec -Most accurate
 - Winch trace closely matches the CTD boom head location
 - Residual CTD motion around nominal (0.2/3m)
 - Still consulting with manufacturer



For further information visit <u>http://mnf.csiro.au/</u>

Questions

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