Marcus G. Langseth

Long Core Stability Modifications

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References

1. *Long Core Repositioning Study - Installation Feasibility*, Glosten Report 11003.01, 25 February 2011.
2. *R/V Marcus G. Langseth Trim & Stability Booklet,* C.R. Cushing & Co., August 2007.
3. *R/V Marcus G. Langseth General Arrangement with Sponsons,* The Glosten Associates, July 2012.
4. *R/V Marcus G. Langseth Cost Estimate*, *Option 3,* The Glosten Associates, July 2012.
5. *R/V Marcus G. Langseth Cost Estimate*, *Option 4*, The Glosten Associates, July 2012.
6. *R/V Marcus G. Langseth Temporary Stability Letter*, *Piston Coring*, The Glosten Associates, March 2012.

Summary

In February of 2011, a study was performed to identify a replacement platform for the Long Core system upon the retirement of the *R/V Knorr* (Reference 1). One of the vessels studied was the *R/V Langseth*, which was found to be suitable from an arrangement standpoint and would permit the maximum length of core. The study identified stability as the limiting technical issue for the *R/V Langseth* and recommended further study.

Two potential solutions to the stability problem have been found:

1. Remove OBS Deck, Mammal Tower, and exchange Long Core equipment and seismic gear as needed per cruise.
2. Install sponsons.

Of the two possible solutions, the addition of sponsons provides a better technical and operational solution, but it requires a higher capital cost.

Approach

Prior to developing solutions, it was necessary to fully understand the effects on stability of the installation of the long core system. Initially, the existing Trim and Stability Book (Reference 2) was studied to assess existing limitations and to determine how the limitations might impact future modifications. Once the existing stability limits were understood, the long core installation's impact on stability was evaluated. The arrangements and weights for the long core gear generated in Reference 1 were used. After the evaluation was completed, possible modifications were identified and checked against stability requirements.

Imposed Limitations on Modifications

Limitations were placed on the proposed modification as follows:

1. The proposed modifications were to have minimal or no impact on the existing capabilities of the vessel. This included impacts on the functionality of the equipment, as well as on the vessel operations.
2. The proposed but not yet fully installed winch modification should be accounted for. This included the new pivoting fairleads installed for piston coring, a Markey DESH-5 CTD winch to replace the current CTD winch, and a Dynacon Traction winch, both permanently installed on the Paravane Deck. Figure 1 shows the proposed new winch arrangement.
3. No reduction in fuel capacity.
4. No further tank restrictions (See "Initial Stability Findings" section).
5. The preference for long core system implementation without a seismic gear demobilization requirement.

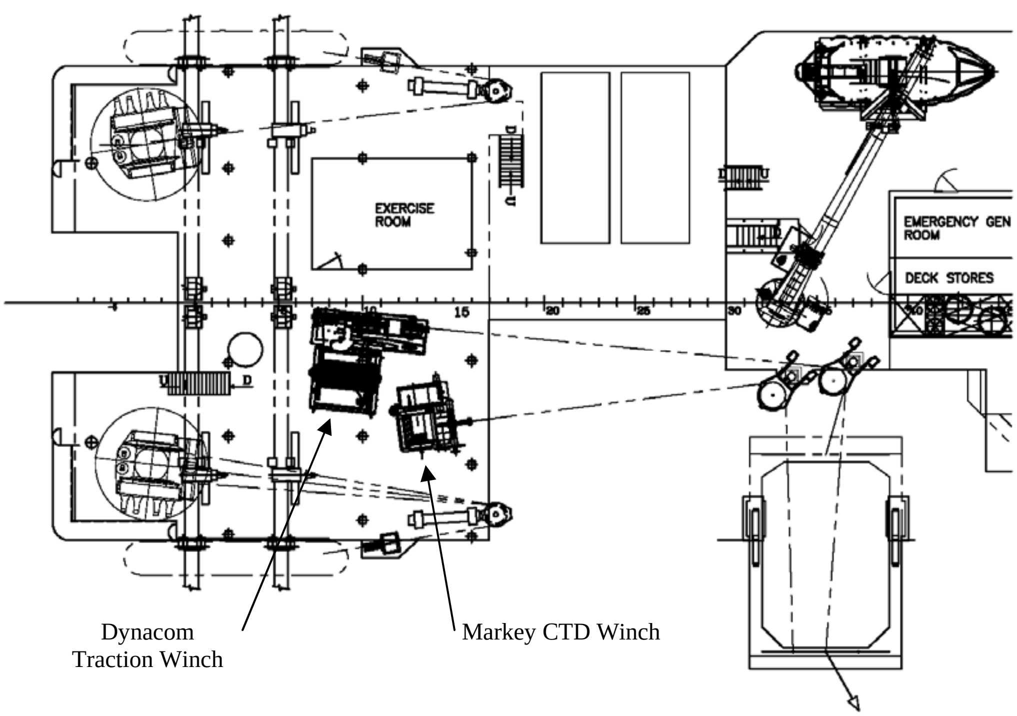

Figure 1 Paravane deck winch arrangement

Initial Stability Findings

The vessel is very sensitive to aft trim. Although up to 2 m of aft trim is allowed by Reference 2, in reality, loading conditions with trim in excess of 1.5 m do not meet the required damage stability criteria. The vessel does not have sufficient ballast capacity forward to reduce trim in arrival conditions, nor does it have sufficient port and starboard ballast locations to reduce the vessel's list. Therefore, fuel must be burned carefully as these tanks are used to reduce vessel list.

The vessel is severely limited by the load line due to fixed ballast and locked-in freshwater ballast. The vessel has fixed ballast in No. 02 and 04 starboard fuel oil deep tanks and the fore peak ballast tank to reduce the trim and compensate for list. The vessel also has locked-in freshwater ballast in the No. 07 port and starboard tanks.

Additionally, the following specific tank restrictions apply per Reference 6:

1. No. 2 WT FO tank (starboard) **must remain empty** at all times while at sea.
2. No. 7 WT FO tank (port) **must remain empty** at all times while at sea.
3. No. 8 WT FO tank (port) **must remain empty** at all times while at sea.
4. No. 10 Deep tanks (P/S) **must remain empty** at all times while at sea.
5. No. 4 FO tanks (P/S) **must remain full** at all times while at sea.
6. Aft Peak Ballast tank (starboard) **must remain empty** at all times while at sea.
7. The FO Settling and Service tanks (starboard) shall remain near 80% full.
8. The FO Settling and Service tanks (port) **shall not carry fuel**.
9. Condensate from the seismic compressor may be stored in the FO Service tank (port) only.
10. The FO Settling tank (port) **must remain empty** at all time while at sea.
11. The Clean Cable Oil and Dirty Cable Oil tanks **must remain empty** at all times while at sea.

With the tank loading restrictions, the vessel meets the stability criteria with little margin. As the vessel is at its loadline limits, no additional weight can be carried, either in the form of ballast or payload.

Long Core Impact on Trim and Stability

The additional long core weights are summarized in Table 1. The total weight is sizable; e.g., 122 MT, 11.58 meters above the BL, and 3.48 meters aft of the AP. The long core foundations account for 21.3 LT of structural modifications, which cannot be removed on a temporary basis.

With the additional long core equipment, the aft trim will increase by an additional 2 m depending on the exact load condition.

Table 1 Long core equipment and foundations

	Total Weight (lbs)	Long'l Center (ft aft AP)	Vertical Center (ft above BL)
A-Frame Fnd	4,547	9.57	34.00
Streamer Deck	21,811	-20.15	36.25
Stern Enclosure	15,099	11.30	33.75
Core Handling Equipment	5,533	17.00	21.80
Core Handling Davit	32,500	19.50	26.75
Modified A-Frame	46,000	11.30	49.25
60" Dia Deck Sheave	3,000	11.30	34.00
Traction Winch	52,829	-15.00	36.50
Line Stowage Spool w/ 2" Plasma	44,300	-42.50	36.50
Frequency Van	17,400	-42.50	29.50
New Crane (Effer 80000 or similar)	17,000	-5.25	63.33
New Fairlead	1,000	-24.75	36.50
Core Storage Davits	8,015	-75.00	29.25
Total	**269,034**	**-11.42**	**37.98**
	122.0 MT	**3.48 m AFT**	**11.58 m**

Proposed Solutions

There are two basic strategies to allow for the long core equipment: existing high weight may be removed, or new buoyancy and water plane may be added. Weight to be removed must be located high and aft. Buoyancy to be added must be aft. The four possible solutions are described below and Table 2 summarizes the overall weight impacts for each of the solutions.

Table 2 Weight changes for proposed solutions

Solutions	Δ Weight (MT)	LCG (m aft AP)	TCG (m stbd CL)	VCG (m ABL)
Option 1a – Remove Seismic Gear	-172.6	-6.56	0.45	11.316
Option 1b – Seismic w/Long Core Fdns	21.3	-0.85	0.59	10.219
Option 2 – Remove Mammal Tower & OBS Dk	-55.3	-7.69	0.41	15.952
Option 3 – Combine Options 1b & 2	-34.0	-10.70	-1.57	13.437
Option 4 – Add sponsons	79.58	-17.38	0.00	5.422

1. Remove enough seismic gear to compensate for the additional long core gear. While technically feasible, this would require extensive crane facilities and storage at the port where the change occurs. It would also be time consuming and would require returning to the port of departure to reconfigure the vessel. This results in two conditions to examine; 1a, Long Core operations without the Seismic gear, and 1b, Seismic operation without the Long Core gear but with the Long Core foundations. The total seismic gear shown in Reference 2 is 172.6 MT, which is more weight than the long core equipment, at about the same height, and 10 m forward. Removing the seismic gear would compensate for the additional weight of the long core equipment; however, when doing seismic surveys, the long core gear could be removed but not the foundations and deck modifications. This would add 21.3 MT to all the current seismic operating conditions, which cannot be accommodated without further fuel restrictions.

2. Remove the majority of the OBS Deck and the Mammal Observation Tower. Part of the OBS Deck is retained to support the paravane booms and the sat com antenna. Mammal observation would be performed from the pilot house top. Lamont Doherty indicated that the removal of the OBS Deck would not be considered; however, it was identified in Reference 1 and retained as an option for comparison purposes. Compared to the long core weights, these modifications are much less weight, higher, and 12 m forward.

3. Since neither of the above proposed solutions fully compensate for the increased long core weights, a combination of these approaches may be employed, which is to remove the mammal tower and the OBS Deck while also removing the majority of the seismic gear. The analysis for Option 3 consisted of the combination of the first two options. The actual proportions of each can be adjusted if this option is chosen. Option 3 has all the disadvantages of removing the seismic gear, with the added inconvenience of losing the use of the OBS Deck.

4. Add sponsons. A set of 4 ft sponsons were designed spanning from Frame 70 aft to the transom. The sponsons add buoyancy aft where it is most needed, while also providing additional water plane for increased GM. The sponsons also make the arrangement of the long core equipment easier without affecting any seismic functions. The A-frame on the starboard side and the rescue boats on the port side

would have to be moved outboard. Figure 2 shows the arrangement of the Main Deck with the sponsons. Reference 3 shows the entire proposed general arrangement.

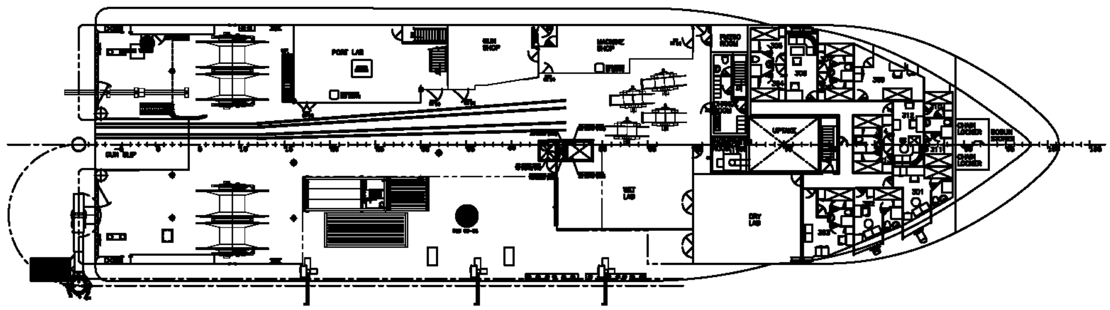

Figure 2 Main deck arrangement with sponsons

Stability Analysis of Proposed Solutions

The hydrostatic model, criteria, and load conditions used in the piston coring analysis (Reference 6) were used in this analysis. These were developed from the original Trim and Stability Book (Reference 2). The fuel burning sequence and ballast has been modified to accommodate the large changes in weights and locations.

No hydrostatic changes to the model were required for Options 1 through 3. For Option 4, sponsons were added to the original model. The same operating conditions were used for all four solutions.

Table 3 presents the summary of hydrostatics of the four proposed solutions at the load line departure condition and also the piston core load line condition for baseline comparison.

Table 3 Proposed solutions – hydrostatic summary at departure (load line)

Solutions	Draft at LCF (m)	Trim (m)	Heel (m)	Fuel (MT)
Baseline – Piston Core	5.88	0.25	-0.02	865
Option 1a – Remove Seismic Gear	5.87	-0.10	0.01	925
Option 1b – Seismic w/Long Core Fndns	5.87	0.70	0.00	891
Option 2 – Remove Mammal Tower & OBS Dk	5.89	0.32	0.01	869
Option 3 – Combine Options 1 & 2	5.89	-0.05	0.00	924
Option 4 – Add Sponsons	5.88	-0.05	0.00	964

Per Reference 2 the following criteria were applied to each of the proposed solutions:

- 46 CFR 170.170 – *Intact Weather Criterion*
- 46 CFR 170.173(c) – *Intact Criteria for Unusual Proportion and Form*
- 46 CFR 171.080(f) – *Damage Criteria for New Vessels*
- 46 CFR 173.005 – *Lifting Criterion*

The same assumptions from Reference 2 apply:

1. The propulsion room is exempt from flooding, even though the wing tank inboard bulkheads are within the required extent of damage.
2. Liquid runoff is permitted in damaged tanks.
3. No open downflooding locations are within 15 degrees of heel.

Table 4 presents a portion of the results of the intact and damage stability analysis for the four proposed solutions in the Arrival Condition, which has approximately 20% remaining fuel. This is generally the most limiting loading condition as the vessel is at its greatest aft trim.

Options 1 and 2 do not meet the stability criteria for the entire operating range. Options 1a was not included in the table because Option 1b is more limiting, and Option 1b does not meet the required stability criteria. Option 2 was not included in the damage stability analysis, since it does not meet intact stability criteria righting energy requirements for a third of the intact conditions. Neither of the options compensate for the additional weight of the long core equipment or foundations.

Table 4 Proposed solutions – hydrostatic summary at departure (load line)

Solutions	Intact Stability		Damage Stability			
	GM (0.15 Req'd) (m)	Area 30-40 (0.03 Req'd) (m-deg)	Damage Case	RA (0.05 Req'd) (m)	Damage Case	Distance to Margin Line (m)
Option 1b	1.553	0.0345	D1 (fail)	0.034 (fail)	E1 (fail)	-0.025(fail)
Option 2	1.562	0.0192 (fail)	-	-	-	-
Option 3	1.664	0.0668	All pass	> 0.05	All pass	> 0
Option 4	3.975	0.0912	All pass	> 0.05	All pass	> 0

Option 3 meets the stability criteria for the full range of operating conditions.

Option 4 also meets the stability criteria for the full range of operating conditions. In addition, the vessel may depart with 40 MT of additional fuel, compared to Option 3.

With Options 3 and 4, the vessel has increased stability and more available deadweight. Therefore, a combination of the following previous tank restrictions 1 through 6 could be removed resulting in more net fuel capacity.

Costs

The total cost for Option 3 is $4.2M, and the total for Option 4 is $6.1M. While there are fewer removals in Option 4, the cost difference is dominated by the extra cost of the sponsons. Details are shown in Table 5and Table 6.

Table 5 Option 3 costs

Item	***Marcus G. Langseth*** **Option 3 - Removals**	**Labor (Hours)**	**Materials ($)**	**Total ($)**	**Percent**
1	Design	0	143,500	143,500	4.0%
2	Detailed Design (Shipyard)	5,332	0	453,200	12.6%
3	Removals	8,646	91,500	826,400	22.9%
4	Relocations	320	0	27,200	0.8%
5	Fabrication	8,550	65,400	792,200	22.0%
6	Installation	256	110,000	131,800	3.7%
7	Long Core Gear	0	633,000	633,000	17.5%
8	Test	0	40,000	40,000	1.1%
9	Shipyard Management	2,666	0	226,600	6.3%
10	Owner Engineering/Management	1	334,600	334,700	9.3%
	Sub-Total	25,771	$1,418,000	$3,608,600	
	Labor Rate	$85	PER HOUR		
	Material Markup	15%		212,700	
	Estimate Contingency	10%		360,860	
	Total Estimated Cost			**$4,182,160**	

Table 6 Option 4 costs

Item	***Marcus G. Langseth*** **Option 4 - Sponsons**	**Labor (Hours)**	**Materials ($)**	**Total ($)**	**Percent**
1	Design	0	186,700	$186,700	3.5%
2	Detailed Design (Shipyard)	8,952	0	$760,900	14.3%
3	Removals	560	0	$47,600	0.9%
4	Relocations	2,880	0	$244,800	4.6%
5	Fabrication	26,144	197,300	$2,419,500	45.5%
6	Installation	256	110,000	$131,800	2.5%
7	Long Core Gear	0	633,000	$633,000	11.9%
8	Test	0	40,000	$40,000	0.8%
9	Shipyard Management	4,476	0	$380,500	7.2%
10	Owner Engineering/Management	1	476,000	$476,100	8.9%
	Sub-Total	43,269	$1,643,000	$5,320,900	
	Labor Rate	$85	PER HOUR		
	Material Markup	15%		$246,450	
	Estimate Contingency	10%		$532,090	
	Total Estimated Cost			**$6,099,440**	

Discussion

Option 3

Option 3 includes the removal of the Mammal Tower, OBS Deck, and most of the seismic gear. It has big operational impacts, as ports will have to be chosen for storage facilities and crane support, and a significant amount of time and effort will be required to convert between seismic and long core missions. The two missions cannot take place on the same voyage, and the vessel would have to return to its port of departure to collect the removed gear. The OBS Deck will be unavailable for any of its current uses. With the reduced deadweight onboard, some of the previous tank restrictions can be removed. Option 3 has the lowest capital costs.

Option 4

Option 4 includes the installation of 4 ft sponsons. This option has many benefits such as no operational restrictions and reduced tank restrictions. Additionally, the vessel can carry seismic gear and long core equipment on the same voyage and use simultaneously if desired. More fuel can be carried at departure, especially if the long core equipment is not onboard. The extra fuel may lead to longer endurance; however, due to the increased drag of the sponsons, the vessel's fuel efficiency will decrease if the speed is not reduced. This impact has not been investigated. Stability margins will increase, and the increased freeboard should result in a dryer main deck. The long core equipment will fit better on the sponson than the previously proposed cut away aft superstructure. There will be more main deck area available for general science work. Option 4 will, however, have the higher capital costs and some reduction in top speed.

Conclusions and Recommendations

A study was performed to propose and evaluate solutions for installing the long core equipment aboard the *R/V Langseth*, particularly related to maintaining stability margins. There are two potential solutions that result in adequate stability of the vessel. One removes equipment and structure weight at great cost to operational flexibility. The other adds 4 ft sponsons, which results in greater fuel range and many other advantages at a higher cost and reduced maximum speed.

Option 4 has the least operational impact and addresses current stability based operational limits, as well as the stability impacts of adding the long core system. Given these benefits, we believe that Option 4 provides the best technical solution if the initial capital cost can be supported.