Tote, Inc.'s Response to the National Cargo Bureau, Inc.'s "Report on Review of Cargo Securing Manual and Cargo Stowage and Securing" dated August 4, 2016

I. OVERVIEW

On August 9, 2016, the National Transportation Safety Board ("NTSB") posted on Accellion a report produced by the National Cargo Bureau, Inc. ("NCB"), dated August 4, 2016, and entitled "Report on Review of Cargo Securing Manual and Cargo Stowage and Securing" ("NCB Report").

By letter to the NTSB dated August 12, 2016, Tote, Inc. ("Tote"), through its Party Coordinator, conveyed various concerns about the assumptions, analysis, and conclusions contained in NCB Report, and advised it would provide a more detailed response upon further analysis of the Report. As a party to the investigation into the sinking of the SS EL FARO, Tote provides this further response to the NCB Report, based on consultations with relevant operational and technical personnel.

As set forth in detail below, the NCB Report appears to be based on erroneous information and assumptions it was provided, the source of which is unclear. *See, e.g.*, NCB Report at 8. In many cases, NCB uses assumptions that are contrary to, or inconsistent with, the factual record already developed, disregards existing Tote policies and procedures that testimony indicates were followed for the accident voyage, and reaches conclusions unsupported by a precise analysis of the factual record -without any factual basis or other explanation for doing so.

The NCB Report makes a series of erroneous assumptions, which result in faulty and unsupported conclusions in its Report. The most significant erroneous assumptions are:

- the NCB fails to apply (or even mention) the simplified lashing procedures in use on board the EL FARO (as reflected in the EL Class Minimum Lashing Requirements document), and, as a result, erroneously assumes that certain interior stacks of LO-LO containers were not lashed;
- the NCB erroneously assumes, without factual basis, that 60% of the RO-RO trailer cargo on the second deck was stowed with a Roloc box off the button;
- the NCB incorrectly assumes a vessel speed of 24 knots (when the correct service speed is approximately 19.5 knots);
- the NCB assumes an incorrect lashing angle of 60 degrees for the RO-RO cargo (when the Cargo Securing Manual specifies a lashing angle of 45 degrees.); and
- in performing its calculations under Annex 13 of Cargo Securing Code ("CSS Code"), the NCB oversimplifies its calculations and erroneously: (a) assumes 1/2 of the RO-RO trailer weight rests on the Roloc box (which conflicts with the Cargo Securing Manual), and (b) fails to calculate actual restraining forces due to lashings and higher coefficient of friction associated with the RO-RO trailer wheels.

As discussed in more detail below, when just a few of these erroneous assumptions are corrected, the calculations demonstrate that the cargo securing procedures employed on board the EL FARO were sound, adequate (and, in fact, demonstrate a substantial safety margin), and complied with the Cargo

Securing Manual and other applicable guidelines. When all of the erroneous assumptions are corrected, the calculations demonstrate an even greater margin of compliance.

The conclusions in the NCB Report are unsupported, particularly when viewed in light of the erroneous assumptions upon which the report is based and the evidence that is currently in the record. Consequently, the report has the potential to significantly mislead the public and surviving family members about the factual record developed by the NTSB and Coast Guard over the course of the investigation. But in even simpler terms, this report fails to meet the exacting standards of the NTSB or to paint a fair and objective picture of the cargo securing and lashing on the El FARO on the accident voyage. We respectfully request the NTSB correct the errors in the NCB Report before publishing the report, or not publish it at all.

II. PRELIMINARY ISSUES

As an initial matter, the NCB Report does not explain the nature and context of the standards it is applying. It cites various circulars issued by the International Maritime Organization ("IMO") pertaining to cargo securing, including the Guidelines for the Preparation of the Cargo Securing Manual, Maritime Safety Committee Circular 745, dated June 13, 1996. These guidelines, which are also referenced in the Cargo Securing Code, were adopted as a result of amendments to Chapters VI and VII the International Convention for the Safety of Life at Sea ("SOLAS"). These guidelines were first introduced in the United States pursuant to U.S. Coast Guard Navigation and Vessel Inspection Circular 10-97, Guidelines for Cargo Securing Manual Approval ("NVIC 10-97").

At the time of the loss of the EL FARO, these guidelines were, as a legal matter, voluntary standards under U.S. law.[1] The tenor of the NCB Report suggests that the standards and calculations are precise legal requirements. They are not. Notwithstanding the voluntary nature of these guidelines, however, Tote complied with these standards,[2] as set forth in more detail below.

Additionally, the NCB appears to have used the load case file "full.dep.lc" for at least a portion of its analysis and refers to this as the vessel's "departure condition." *See* NCB Report at p. 7. Our records indicate that this CargoMax ".lc" file is a notional full load condition of the EL FARO that was developed in 2007, during the time frame that CargoMax was approved by ABS. It is not, however, a load case reflecting the EL FARO's last voyage on September 29, 2015. It is unclear from the NCB Report what

---

[1] On May 9, 2016, compliance with the SOLAS cargo securing manual standards became mandatory for self-propelled vessels over 500 gross tons on international voyages that are subject to SOLAS. *See* 81 Fed. Reg. 27992, dated May 9, 2016, at 27994. ("The SOLAS CSM requirements are included as an annex to a Coast Guard guidance document issued in 1997 [NVIC 10-97] but a vessel owner or operator's compliance with that guidance is only voluntary. This interim rule makes compliance with the SOLAS standards mandatory for self-propelled vessels over 500 gross tons on international voyages that are subject to SOLAS.") Thus, as to the EL FARO, these guidelines cited in the NCB report were voluntary, advisory standards.

[2] We note that the NCB Report suggests that the Cargo Securing Manual contained minor errors regarding portable cargo securing devices, that the layout of the information pertaining to fixed securing devices could be improved, and that certain procedures to determine the adequacy of container securing on deck was lacking. *See* NCB Report conclusions 1, 2, and 3, at page 12. While Tote takes issues with those criticisms, Tote is not going to address those issues herein because, even if the NCB's criticisms were correct, the NCB Report acknowledges that none of these issues contributed to the cause of the incident. *Id.*

the NCB relied on in making this assumption. We are unable to determine from the limited supporting calculations contained in the NCB Report how this impacts the NCB's analysis, but we note for the record that this load case should not have been used in performing any type of analysis, as it does not reflect the vessel's loading when it departed Jacksonville.

III. CONTAINER CARGO (LO-LO)

A. Deck Strength Margin

1. <u>The alleged exceedances, even if they existed, were few and not significant.</u>

NCB alleges there were deck "strength margin" exceedances. Specifically, out of a total of 148 container stacks on the EL FARO,[3] NCB alleges 8 instances of "overweight stacks" (that is, where the strength margin reflected in Cargo Max was less than 0). These alleged exceedances are listed in Table 1.[4] The maximum stack weight for these stacks is 53.6 LT per stack. As shown in Table 1, the exceedances range from 0 (that is, Bay 15 Stack 05 is not even an exceedance, yet NCB listed it as one) to 0.7 LT. In the case of the 0.7 LT exceedance (the largest one identified), that constitutes an exceedance in that particular stack by 1.3% of the total permitted weight (53.6 LT). The other "exceedances" are all less than that amount for each given stack. When compared to the total weight in a given bay, these "exceedances" becomes even less significant as they account for not more than 0.19% of the total bay weight.[5] Furthermore, as discussed in more detail in section V.B below, taking into account the various safety factors built into the calculations for the strength of the decks, these minor exceedances cannot be a basis to predict a failure of any kind.

---

[3] On the EL FARO's final voyage, there were 148 stacks of containers. *See* Final Stow Plan, MBI Exhibit 69, at pages 1-15.

[4] The NCB Report states that the CargoMax load case shows a stack weight for Bay 19 Stack 02 that is 8 long tons less than that shown on the final stowage plan. We agree with this minor weight discrepancy and have accounted for that in our analysis, as NCB has apparently also done.

[5] Container weights are not precise and therefore the alleged exceedances may not even exist, or are within an acceptable margin of error. The new SOLAS Convention Reg VI/2 does not have a stated accepted margin of error for container weight Verified Gross Mass. However, some countries have developed an acceptable margin of error. *See e.g.* U.K. Marine Guidance Note 534, Sec. 13.1 (setting 5% as an acceptable margin of error for enforcement of SOLAS container weighing requirements). The alleged exceedances are all well below that margin of error.

Table 1
Stack Weight Exceedances - Relative Significance

Stack	Alleged Exceedance (LT)	Total Stack Weight Calculated by NCB (LT)	Total Bay Weight Calculated by NCB (LT)	% Overweight (by stack weight)	% Overweight (by bay weight)
Bay 03A -Stack 7	0.4	54	371.4	0.74%	0.11%
Bay 03A - Stack 8	0.7	54.3	371.4	1.29%	0.19%
Bay 10 - Stack 06	0.4	54	625.7	0.74%	0.06%
Bay 12A - Stack 05	0.6	54.2	334.1	1.11%	0.18%
Bay 13 - Stack 10	0.6	54.2	582	1.11%	0.10%
Bay 15 - Stack 05	0*	53.6	595.8	0.00%	0.00%
Bay 16B - Stack 02	0.2	53.8	254.2	0.37%	0.08%
Bay 17 - Stack 06	0.1	53.7	606	0.19%	0.02%

* This is not an exceedance; the NCB Report was incorrect by listing this as one.

2. <u>**When deck beam structure is considered, there are NO exceedances.**</u>

NCB ignores a crucial fact regarding deck stowed containers. A system of deck beams is present and designed to distribute the container stack weights throughout the deck support structure. Therefore, a given stack's weight, combined with the weights of the other stacks that share the same support beams, is distributed throughout the support structure by the beams that group of stacks share. It is inappropriate to consider a single stack in isolation. Instead, pairs or groups of stacks (or indeed all stacks that share a common beam) must be considered to determine if a true exceedance exists. Here, in every case of an alleged exceedance, an adjacent stack is sufficiently below the 53.6 LT stack weight limit to make up for any alleged exceedance in one stack. In other words, the average of the adjacent stacks (whether averaging pairs of stacks, three adjacent stacks if both adjacent stacks are considered, or all stacks sharing common beams) shows that no exceedance exists. This is reflected in Table 2, which shows the available strength margin in the adjacent stack to the port and starboard of the stack that weighed over 53.6 LT. This confirms that when adjacent stacks sharing common beams are considered, there are no exceedances.

Table 2
Stack Weight Exceedances - Effect of Adjacent Stacks

Stack	Stack Margin on Adjacent Stack to Port (LT)	Alleged Stack Margin Exceedance in Subject Stack (LT)*	Stack Margin on Adjacent Stack to Starboard (LT)
Bay 03A -Stack 7	0.4	-0.4	no stack
Bay 03A - Stack 8	no stack	-0.7	1.8
Bay 10 - Stack 06	0.4	-0.4	0.7
Bay 12A - Stack 05	13.3	-0.6	18.1
Bay 13 - Stack 10	5.3	-0.6	4.3
Bay 15 - Stack 05	0.1	0	4.3
Bay 16B - Stack 02	0.2	-0.2	no stack
Bay 17 - Stack 06	1.3	-0.1	8.6

* In all cases, there is available stack weight margin in a single adjacent stack (and even more when both adjacent stacks are considered) to make up for the "exceedance" in the subject stack.

It does not appear from the NCB Report that the NCB considered the vessel's deck scantlings and underlying methodology employed to develop the maximum stack weights, set forth in Appendix 9 of the Cargo Securing Manual. In this regard, the above approach of averaging stack weights is entirely consistent with the finite element analysis and approach employed by Herbert Engineering in assessing the maximum stack weights. *See* Exhibit A, Deck Structure Analysis, Herbert Engineering Corporation (MBI Exhibit 144), at Page 6, paragraph 1.

3. <u>NCB's conclusions regarding stack weights are unsupported and amount to pure speculation.</u>

There is no basis to conclude, or even suggest (as NCB does), that the alleged exceedances "would increase the potential for stack collapse," that this "may have contributed towards the incident as any loss of containers would be likely to increase the vessel's GM," or that any "lashing failure" occurred, and certainly not "progressive lashing failure with potentially catastrophic shift of cargo." *See* NCB Report, at 12. NCB points to no evidence of an actual collapse or failure and no evidence that the stack weights they allege are too heavy, in fact, caused any problems. As discussed above, NCB was wrong in alleging that any exceedance actually existed, in the first instance, because it failed to average the stack weights and account for the contributing strength of the adjacent deck structure in the vicinity of the alleged overweight stacks. Moreover, the evidence available to date, specifically verbal reports from the master to shore-side personnel and the videos of the EL FARO in its resting place, do not reveal any evidence of stack collapse or deck beam distortion or failure. Simply stated, it is pure, unsupported speculation for NCB to suggest that a stack weighing up to 54.3 LT was improper, contradicted the Cargo Securing Manual, or might result in "stack collapse." *See also* Section IV below (discussion regarding safety factors and breaking points).

B. Lashing Margin[6]

The NCB Report concludes that the lashing strength requirements were exceeded for 8 of the 148 stacks. *See* NCB Report at 8. However, the NCB incorrectly assumes that only twist locks (and no lashings) are applied to all interior container stacks. *See* NCB Report at 8. The basis for this assumption appears to be "[i]nformation provided to [NCB, which] indicated that these stacks were secured using twist locks only (no lash) and single lash system was not used." *Id*. It is not clear what "information" was actually provided to NCB and whether that information was in the form of a document or other evidence, or testimony that has been developed during the investigation. Whatever the source of the "information," that assumption in the NCB Report is incorrect.

The NCB Report does not mention or refer to the simplified lashing guidance used on board the EL FARO (also referred to as the "EL Class Minimum Lashing Requirements," attached as Exhibit B.). We presume that these guidelines were not provided to the NCB, as they materially contradict the incorrect assumption used in the Report. In accordance with the EL Class Minimum Lashing Requirements,

[6] The lashing margin "represents the amount of weight which may be added to the stack without violating the lashing strength requirements. If the weight margin is red (negative) then some weight must be removed from the stack or a stronger lash system applied." *See* MBI Exhibit 136 at 44.

internal abutting stacks that are of different container lengths are also treated as "outer" stacks and therefore receive lashings, in addition to twist locks. *See* Exhibit B at 1.

Specifically, this guidance provides that "[a]ll bays will have the outer two high container stacks lashed regardless of where the outside box is located" and "[i]f there are two high 48' / 53' containers next to a stack of 40' / 45' containers in the interior of a bay - a gap is created. Both the 2 high 48' / 53' stacks and 40' / 45' stacks of the bay they will be treated as outer stacks and lashed." *See* Exhibit B at page 1.[7] There is no evidence that the crew of the EL FARO and stevedores deviated from these simplified lashing guidelines and, therefore, the NCB Report is based on incorrect information.

The following table (Table 3) shows the alleged lashing margin exceedances set forth in the NCB Report (which are based on the incorrectly assumed lashing profile) and the corrected/actual lashing margins when the EL Class Minimum Lashing guidelines are applied.

Table 3
Lashing Margin Exceedances - Corrected

Stack with alleged lashing margin exceedance	Lashing Margin Exceedance alleged in NCB Report (with twist lock and no lash) (LT)*	Lashing Margin (following simplified lashing guidelines with twist lock and single lash) (LT)*
Bay 12A - Stack 02	-3.9	11.0
Bay 14B - Stack 00	-1.3	6.5
Bay 14A - Stack 03	(missing)[#]	12.5
Bay 16A - Stack 01	-2.3	9.3
Bay 16B - Stack 02	-3.2	5.1
Bay 17 - Stack 08	-0.9	-0.9
Bay 19A - Stack 01	-3.6	9.6
Bay 19B - Stack 02	-6.0	9.2

* A negative number reflects a lashing margin exceedance exists. A positive number reflects the lashing margin is adequate.

[#] The NCB Report contains CargoMax lashing margin calculations for the alleged exceedances, but these were not include in the Report for Bay 14A.

As noted in Table 3, after applying these simplified lashing guidelines, CargoMax indicates that 7 of the 8 alleged exceedances do not, in fact, exist. Instead, for these stacks, the lashing strength requirements are fully satisfied, by a significant margin. *See* Table 3 and Exhibit C - CargoMax Load Out Supporting Calculations.

Thus, the only remaining exceedance noted in the NCB report is in Bay 17, Stack 08, which the NCB calculated to be an exceedance of 0.9 LT. Putting this single "exceedance" into perspective, if the total weight of this particular stack were reduced by 0.9 LT (which amounts to 1.7 % of the stack weight) then this exceedance would not exist. The magnitude of this exceedance, alone, suggests that even if the NCB's calculations are accurate, this exceedance is within weight margins of error and is insignificant.

---

[7] Note that the references to "two high" in this guidance are referring to the fact that lashings will be secured to the bottom of the second tier. Those references do not mean that the guidance only applies if the stack is a total of two containers high. To the contrary, the guidance indicates the same rules apply when the stacks are "Two High or Higher." *See* Exhibit B at page 1.

This single exceedance of this magnitude cannot provide any basis to conclude that a container or lashing would fail, much less to conclude that "progressive lashing failure with potentially catastrophic shift of cargo could be expected." *See* NCB Report at 12. As discussed below, *see* Section V.A, the NCB Report makes it clear that they "were not able to determine precise points at which lashings would break or fail" and that there are safety factors involved, making failure as a result of an insignificant exceedance highly unlikely.

IV. RO-RO LASHING

The NCB Report contains an analysis regarding the adequacy of the lashing of the RO-RO trailers stowed on the second deck of the EL FARO during the accident voyage. That analysis addressed the adequacy of lashing for: (a) RO-RO trailers stowed on a Roloc button, and (b) RO-RO trailers assumed to have been stowed off of a Roloc button.

A. All RO-RO trailers stowed on a Roloc button on the 2nd Deck were adequately secured in accordance with the CSS Code.

In performing its analysis, the NCB found, and we agree, that in all instances where a RO-RO trailer was stowed on a Roloc button on the second deck, the cargo was "adequately secured" and satisfied the standards contained in Annex 13 of the CSS Code. *See* NCB Report at pages 9, 29, 31, and 33.

B. The NCB's analysis of RO-RO trailers assumed to have been stowed off of a Roloc button is flawed as it is based on incorrect information and assumptions.

The NCB Report then examines trailer cargo that may have been stowed off the button. *See* NCB Report at 9 and 10. In conducting its analysis, the NCB assumes that 60% of the RO-RO trailers stowed on the second deck were stowed off the Roloc button. There is no support for this 60% figure in the factual record developed by the investigation for the El Faro's last voyage. In fact, evidence is available that directly contradicts this assumption. The NCB Report also contains additional incorrect assumptions regarding vessel speed and lashing angles, and uses an incorrect methodology that ignores the actual restraining forces in effect on the wheeled end of a trailer. Based on these erroneous assumptions and incorrect methodology, the NCB Report concludes that the RO-RO "[l]ashings [on the second deck] would be expected to fail in the event of significant vessel movement (rolling and pitching) and this is more likely than not to have contributed towards the incident…" *See* NCB Report at 12.

1. NCB's assumption that 60% of the RO-RO trailers on the second deck were stowed off the button is unsupported and incorrect.

The NCB Report states that "it was reported" that 60% of the RO-RO trailer cargo was stowed off the button, and they therefore assumed this to be fact for the subject voyage. *See* NCB Report at 10. There is no other substantiation or basis for this assertion in the NCB Report. The only reference to this figure in the investigation that we are currently aware of was a response to a question posed to Mr. Kidd, of PORTUS, who was asked by the NTSB what percentage of RO-RO cargo on the second deck was stowed off the button. Mr. Kidd estimated that 60% of the RO-RO cargo was off button on the second deck. *See* Exhibit D. His testimony is susceptible to many interpretations, in part because on the day of the EL FARO's last voyage, roughly 30% of the cargo on the second deck was non-trailer cargo, which is not designed to be secured on a button in any event.

In addition, Mr. Kidd qualified his testimony as follows: "I have no recollection of the exact number [of cargo stowed off button], because, I mean, the boats -- both boats we got in a week were so similar, they just -- you know, a week later, you couldn't remember which boat it was that you did so-and-so." *See* Exhibit D at 20.

Additionally, the NCB Report apparently did not take into account other testimony from Tote Witnesses that the EL FARO had significantly more lashing points on the second deck than the EL YUNQUE, and typically 90% of the cargo below decks was stowed on the button. *See* Exhibit E, Capt Hearn NTSB Transcript at 19-20. Captain Hearn, a former Captain of the EL FARO, estimated, "most of the stows below decks were on a button, unless it was a vehicle that didn't - wasn't configured to go on a button. So I would say over 90 percent would always be on a button. If it was a case where it was not on a button, there was extra lashes[sic] put on the roloc box." *Id.* at 19. Captain Hearn further testified that Tote had "added a lot of D-rings on the second deck, which gave that ship a lot more flexibility to secure cargo. So she was, of the class, the best on that deck with extra lashing points … ." *See* Exhibit E at 20. Other testimony suggests the EL FARO was fully capable of stowing all of its cargo on the second deck on the button.[8] Other witnesses' accounts suggest that the amount of off button trailers on the second deck during its final voyage is far below 60%. In light of the totality of evidence, it is possible Mr. Kidd's 60% estimate was a generalization that did not apply in any way to the subject voyage.

The above discussion is not meant to definitively resolve the percent of RO-RO trailers stowed off button on the second deck -- the investigation may never be able to determine this with any level of precision. However, even without that precision, this demonstrates that NCB's 60% assumption, in light of the actual evidence, is another example of the source of NCB's assumptions not being clear, and the assumptions themselves being suspect, as they assume a worst case without a sufficient factual basis for doing so.

As we discuss further below, our comprehensive review of the calculations in the NCB Report reveals that the percentage of RO-RO trailers stowed off button is irrelevant. Our calculations indicate that even if one assumes that <u>all</u> the RO-RO trailer cargo on the second deck were stowed off button, the vessel's lashings on the second deck still satisfy the strength requirements in Annex 13 of the CSS Code.

2. NCB's CSS Code Annex 13 Calculations Use Incorrect Assumptions.

The NCB's calculations include a series of incorrect assumptions, which have a cumulative effect of creating the existence of a lashing deficiency when, in fact, no such deficiency existed. As demonstrated by the supporting calculations submitted with this response, in many cases, correcting just one or two of the many erroneous assumptions made by NCB demonstrates that the RO-RO lashing is adequate under the standards contained in the vessel's Cargo Securing Manual and Annex 13 of the CSS Code. Correcting all such errors has a dramatic impact and results in a significant margin of compliance.

i. The NCB's assumption that RO-RO trailers stowed off the button would be lashed with a minimum of six (6) chains is correct.

The NCB assumed that if a RO-RO trailer was attached to a Roloc box and was stowed off the button, there would be a minimum of two (2) chain lashings at the rear of the trailer and four (4) chain lashings at the Roloc Box used to secure the cargo. *See* NCB Report at 9. This assumption is supported by Exhibit

[8] Captain Hearn testified that, the EL FARO's second deck "had about the right flexibility for stows with the roloc box and the pin that went and held those trailers … . And because that ship had the extra [D] rings, even if it was a different size, it wasn't a standard size trailer, there was usually cargo lashings in position for it normally … ." Exhibit E at 21.

B and testimony of various witnesses, and therefore we agree this is a valid assumption regarding the minimum lashing applied to RO-RO trailers stowed off the button.[9] *See* Exhibit B at pp 4-5.

ii. The NCB over-simplifies its calculations and, in the process, does not account for the restraining forces of the wheels of the trailer, and thereby significantly underestimates the restraining forces present.

In performing its RO-RO lashing strength calculations, the NCB incorrectly assumes "that half of the weight was over the ROLOC and half over the rear of the container." *See* NCB Report at 35, 37, and 39. The NCB then performs calculations using half the weight of the trailer on the Roloc, in isolation, to determine the adequacy of the lashings. *Id.* This assumption does simplify the calculations considerably. However, this assumption and methodology conflict with the Cargo Securing Manual. By making this assumption, the NCB ignores the effects of: (1) the rigidity of the trailer; (2) the uneven distribution of weight between the Roloc box and the tires; (3) the contributing restraining force provided by the trailer's wheels (which have a higher coefficient of friction than the Roloc box); and (4) the contributing restraining force of the chain lashings in the vicinity of the wheels.

The Cargo Securing Manual specifies that the weight of RO-RO trailers on a Roloc box is **not** evenly split, but instead more weight rests on the wheels than on the Roloc box. For example, for a 29.1 long ton RO-RO trailer, the Cargo Securing Manual specifies that 17.9 long tons rests on the wheels and 11.2 long tons rests on the Roloc.[10] *See* MBI Exhibit 40, Cargo Securing Manual, E-03-135-A9, page 3 of 3, Table 4. Because a greater proportion of the trailer weight rests on the wheels, and the wheels have a greater coefficient of friction than the Roloc box, the NCB's simplified approach of merely examining the lashings on the Roloc box significantly underestimates the restraining forces under the Annex 13 calculations.

To be accurate, the applied and restraining forces for the entire trailer and lashings, as a whole, need to be calculated to determine whether the Annex 13 strength requirements are satisfied. The NCB has not cited any authority or other basis for employing its simplified methodology of effectively cutting the trailer in half, and arbitrarily assuming one half of the trailer weight rests on the Roloc box. Its methodology in performing these calculations is not contained or ratified in Annex 13 to the CSS Code, nor is such a methodology used in the sample Annex 13 calculations contained in the Cargo Securing Manual. *See* MBI Exhibit 40, Cargo Securing Manual, at 144-145. Although the NCB's method and assumptions simplifies the advanced calculations and makes them easier to perform, this underestimates the restraining forces that are present, and, as a result, the NCB's calculations do not accurately assess compliance with the lashing requirements contained in Annex 13 of the CSS Code. Tote's supporting calculations and analysis is discussed further below.

---

[9] While we agree this assumption regarding the lashing profile of off-button RO-RO cargo is ultimately a correct one, the NCB's asserted basis and path for making this assumption is suspect and illustrative of its flawed methodology. The NCB Report states that this assumption regarding the lashing profile of the RO-RO trailers is based upon its "review of the actual departure stowage plan … the stowage plan for the RO-RO decks also indicated [that off the button trailers] were secured with six (6) lashing chains." *See* NCB Report at 9. We note that the final stowage plan does not, in any way, indicate how cargo was lashed on the vessel's departure. *See* EL FARO Final Stow Plan, MBI Exhibit 69. This is yet another example of the NCB's failure to link its assumptions with evidence and facts and further illustrates the flawed methodology employed in creating the NCB Report.

[10] These Strength Rating Loads specified in the Cargo Securing Manual correspond to 38.5% of the trailer load resting on the Roloc box, and 61.5% of the trailer load resting on the wheels of the chassis. See Table 4 of the Cargo Securing Manual.

iii. The NCB's used an incorrect service speed for the vessel.

Without explanation or support, the NCB assumes in its Annex 13 strength calculations that the vessel service speed during the EL FARO's voyage was 24 knots. *See* NCB Report at 28 - 38. NCB's source for, and basis for using, this incorrect information is not identified, but it is clearly incorrect. There is no evidence or factual basis supporting this speed. The evidence objectively bears out that the EL FARO, on southbound voyages, routinely sailed at approximately 19.5 knots. *See* Exhibit F, SS EL FARO Noon Report. This is consistent with the AIS reports of the vessel's final voyage. As set forth below, this error significantly impacts the strength calculations performed under Annex 13 of the CSS Code, showing that NCB's findings of deficiencies are unsupported and incorrect.

iv. The NCB's used an incorrect lashing angle of 60 degrees in its Annex 13 calculations.

In performing the calculations pursuant Annex 13 of the CSS Code and the vessel's Cargo Securing Manual, one of the variables is the assumed lashing angle between the lashing and the deck. *See* Cargo Securing Manual, MBI Exhibit 40 at 146. In its calculations and analysis for the lashing of RO-RO trailers off the button, the NCB assumes that the lashing angle (relative to the deck) is always 60 degrees. *See* NCB Report at page 10, 35, 37, and 39. The NCB refers to this as the "optimal lashing angle," without any further explanation or support for this assumption. *Id.* This is incorrect.

In its calculations, the NCB does not reconcile the fact that the procedures in the Cargo Securing Manual for the stowage of RO-RO trailers specify a lashing angle to be 45 degrees or less - not 60 degrees - between the lashing and the deck. *See* Cargo Securing Manual, MBI Exhibit 40 at 146. The evidence in the investigation demonstrates PORTUS employees and EL FARO crewmembers followed the lashing guidelines in the Cargo Securing Manual, and there is no factual basis to assume the contrary. In fact, the NCB Report acknowledges that, with respect to the RO-RO cargo on second deck, it has "no specific evidence that any excessive lashing angles or inadequate securing points were used in this case." NCB Report at 10.

3. When the erroneous assumptions in the NCB report are corrected, the lashing strength requirements contained in Annex 13 of the CSS Code are fully satisfied, even if one assumes <u>all</u> RO-RO trailers were stowed off the button.

In our analysis, for each of the holds on second deck, we calculated the restraining and applied forces for the entire trailer (not just 1/2 of the trailer as the NCB did), and corrected the speed of the vessel to 19.5 knots. Those corrections, alone, resulted in **<u>all</u>** of the holds on the second deck not being in exceedance. In other words, even leaving in place all of the other erroneous assumptions that were made in the NCB calculations (off-button, lash angle, etc.), and assuming 100% of the RO-RO trailer cargo on the second deck was stowed off the button on the EL FARO's final voyage, the lashing strength requirements contained in Annex 13 of the CSS Code were fully satisfied.

i. Assessment and Analysis of NCB Calculations

First, we analyzed the three sets of calculations contained in Annex III of the NCB Report (at pp. 35-39), which suggested exceedances with respect to the RO-RO lashings on the second deck. These calculations examined application of Annex 13 of the CSS Code for the lashing applied to RO-RO trailer cargos stored in Holds 2A/2F, 2B/2E, and 2C/2D, respectively.

In its Report, the NCB calculates what it considers to be the "maximum weight" that a RO-RO trailer can weigh and still satisfy the lashing strength requirements contained in Annex 13 of the CSS Code. *See*

NCB Report at 10 and Appendix 3. These "maximum weights" calculated by NCB, are depicted in Table 4 below. *See also* NCB Report at page 10. When the NCB calculates this "maximum weight," it does so following all of the erroneous assumptions and methodologies discussed above. In our analysis, we corrected just two of the incorrect assumptions (vessel speed and calculating the restraining forces for the entire trailer/lashings instead of just one half of the trailer/lashings). The results depicted below (Table 4) demonstrate that the lashing profile (using 6 chains when off button) for the RO-RO trailers on the second deck is more than adequate under Annex 13 of the CSS Code.

Table 4
(NCB and Tote Calculations of Maximum Allowable Trailer Weight under CSS Code Annex 13)

Holds	Worst Case/Maximum Trailer Weight (lbs) - EL FARO 185S	NCB Calculated Maximum Allowable Weight (24 knots - 1/2 of lashing/trailer weight analyzed)	Tote Calculated Maximum Allowable Weight (19.5 knots - 100% lashing/trailer weight analyzed
2A/2F	79,000	35,400	81,700*
2B/2E	78,000	40,300	112,000*
2C/2D	76,000	42,300	118,500*

* These maximum allowable weights, under the Annex 13 calculations, far exceed the maximum gross weight (MGW) allowed for any container on a chassis that would be loaded on the second deck (noted as 81,560 lbs in the NCB Report). This confirms that the use of six chains to lash RO-RO trailers that are stowed off button is proper and adequate.

The supporting calculations for Table 4 are enclosed as Exhibit G.

ii. Tote's analysis of the RO-RO lashing calculations validates compliance with Annex 13 of the CSS Code

To further validate our analysis of the NCB Report, for each hold we identified those trailers on the second deck that are subject to the worst-case loads under Annex 13 of the CSS Code, based on the trailer location and weight. The trailers identified as being the most critical in this regard are listed in the following table (Table 5):

Table 5
Most Critical RO-RO Trailers

Hold	Trailer Number	Weight (lbs)
2A	910270-7	79,000
2B	921711-0	78,000
2C	921734-1	76,000
2D	910114-6	80,000
2E	943893-9	75,000
2F	581885-6	75,000

The calculated applied loads and respective restraining loads,[11] under Annex 13 of the CSS Code, for each of these trailers, are calculated as follows (Table 6):

Table 6
CSS Code, Annex 13 Calculations
(Trailer Off Button, Speed = 19.5 kts, lashing angle = 60 degrees*)

Hold	Trailer Number	Weight (lbs)	CSS Code Total Applied Load (Kn)	CSS Code Total Restraining Load (Kn)	CSS Code Applied Load < Restraining Load/Margin of Compliance
2A	910270-7	79,000	154	155	Yes/+0.5%
2B	921711-0	78,000	137	153	Yes/+10%
2C	921734-1	76,000	129	151	Yes/+15%
2D	910114-6	80,000	138	156	Yes/+12%
2E	943893-9	75,000	139	149	Yes/+7%
2F	581885-6	75,000	139	149	Yes/+7%

* For this set of calculations, we used the 60 degree lashing angle assumed (incorrectly) by NCB.

We have attached supporting calculations for further details. *See* Exhibit H, Supporting Calculations for Table 6.

When the proper lashing angle is also corrected to 45 degrees, that additional correction to the calculations provides an even greater margin of compliance with Annex 13 of the CSS Code, beyond what is demonstrated in Table 6 above. A summary of these applied loads and respective restraining loads,[12] under Annex 13 of the CSS Code, is contained in the following table (Table 7):

[11] Application of Annex 13 of the CSS Code typically include an assessment of the longitudinal, transverse, and vertical forces and restraints. *See* CSS Code Annex 13, 7.1. The NCB Report concludes, and we agree, the most critical forces governing compliance with Annex 13 of CSS Code, for the RO-RO cargo on the second deck, are the applied and restraining loads in the transverse direction. Calculations for the longitudinal and vertical directions are therefore not included in the tables contained in this response.

[12] See footnote 11.

Table 7
CSS Code, Annex 13 Calculations
(Trailer Off Button, Speed = 19.5 kts, lashing angle = 45 degrees)

Hold	Trailer Number	Weight (lbs)	CSS Code Total Applied Load (Kn)	CSS Code Total Restraining Load (Kn)	CSS Code Applied Load < Restraining Load/Margin of Compliance
2A	910270-7	79,000	154	169	Yes/+9%
2B	921711-0	78,000	137	167	Yes/+18%
2C	921734-1	76,000	129	165	Yes/+17%
2D	910114-6	80,000	138	170	Yes/+19%
2E	943893-9	75,000	139	164	Yes/+15%
2F	581885-6	75,000	139	164	Yes/+15%

The supporting calculations for Table 7, using the proper lashing angle of 45 degrees, are provided in Exhibit I.

The above calculations demonstrate that the lashing of the cargo on the second deck of the EL FARO was in compliance with the CSS Code, even assuming all of the RO-RO cargo on the second deck was off button (which it clearly was not). Accordingly, there is no basis to suggest inadequate lashing or lashing failures for the RO-RO cargo contributed to the casualty.

V. NO EVIDENCE OF LASHING FAILURE

We have noted above our concern with the flawed assumptions and conclusions, and the resulting suggestions that the alleged lashing "deficiencies" or "exceedances" could result in a lashing failure, etc. However, in addition to those observations, there are additional factors that call into question any conclusion that a lashing failure occurred. First, we believe NCB made it very clear in its Report that it did not conclude that any lashing failure in fact occurred. *See* NCB Report, at §9.0 p. 12 (Conclusion #7 which reads: "Lashing failure points could not be determined.") In addition, the presence of safety factors suggests that any minor exceedances would be unlikely to result in any failure. Finally, other available evidence lends no support to the suggestion that any lashing failures occurred.

A. The NCB Report concedes it has no evidence of an actual lashing failure.

The NCB acknowledged that it was "not able to determine precise points at which lashings would break or fail as this is subject to numerous variables such as cargo position, cargo securing points, lashing angles, material strength, wave properties and ship motions that we could not predict." *See* NCB Report, at §8, p. 11. Similarly, with respect to the RO-RO Cargo on the second deck, NCB acknowledges it has "no specific evidence that any excessive lashing angles or inadequate securing points were used in this case." *Id.*, at §6.0, p. 10. The NCB Report continues by noting that lashings that are in accordance with the Cargo Securing Manual should provide satisfactory restraint for roll amplitudes up to 25 degrees coupled with pitch amplitudes up to 6 degrees, yet it provides no evidence that those conditions were experienced at a time during the subject voyage that resulted in a failure. *Id.*, at §8, p. 11. In that regard, the NCB also notes that there are safety factors involved (see below), and comments that those safety factors may not be sufficient if any of the lashing values were significantly exceeded or if they were exceeded by a small amount for a prolonged period of time. *Id.* Given the "small" exceedances that may have existed, the focus would be on a prolonged period of time, and there is no evidence of that here either.

B. The safety margins involved here were significantly greater than implied by NCB.

There are several safety factors and other margins of safety built into the calculations that go largely unmentioned in the NCB Report. These safety factors are important to consider, in order to put perspective on the NCB conclusions that "lashings could be expected to fail," that "progressive lashing failure" was possible, and that minor deck exceedances created the "potential for stack collapse." See NCB Report at 12.

With respect to the purported deck strength exceedances, these minor exceedances, even if correct, do not predict that the deck structure will fail. This is because the design limits used by Herbert Engineering in assessing the maximum LO-LO stack weights assumes an allowable stress of approximately 20 ksi (20,000 psi), yet the actual ultimate or breaking strength of the ship's structure is much greater. *See* Exhibit A at 7. The deck structure and the maximum stack weights are developed with a safety factor of at least 2.9.[13] Put differently, the deck structure would need to be subject to loads over 290% of the allowable stresses. The stack weight exceedances calculated in the NCB Report are all are in the range of 1.29% or less of the allowable stack weight, which further demonstrates the unlikelihood that deck strength or "deck collapse" played any role in the casualty.

Similarly, the RO-RO lashing strength requirements also have a significant safety factor built into the calculations. The safety factor built into those calculations is approximately 5.4.[14] Applying a safety factor of 5.4, one would expect the lashings to be subject to 540% of the allowable load, before the lashings exhibited signs of failure. Again, in light of this safety factor, the magnitude of this single minor exceedance of 0.9 LT further demonstrates the unlikelihood that LO-LO lashing failure played any role in the casualty.

C. Other available evidence does not support a finding of lashing failure.

There is no evidence that directly supports a conclusion that there was a lashing failure, whether isolated or in a cascading manner. Available evidence does not support any such conclusion, and instead supports a conclusion that no lashing failures occurred. The verbal reports from the master to shore-side personnel do not mention any lashing failure or other issue with the cargo. Moreover, the extensive and detailed videos and photographs of the EL FARO in its resting place do not reveal any evidence of stack collapse, deck beam distortion or failure, or below deck cargo shift. Without any such evidence, there is no support for any such conclusions. This is particularly the case when the suggestions of such failures are contained in a report that is based on incorrect and incomplete information and assumptions, as well as faulty methodology.

---

[13] The main deck structure of the EL FARO was constructed of Grade A steel. *See* ABS Rules Drawing 662-700-201, Midship Section ALT E, 10/19/1974. Such steel has an ultimate strength of at least 58 ksi (58,000 psi). *See* ABS Rules for Materials and Welding, Part 2, Chapter 1, Section 2. Given that the ultimate strength is 58 ksi and the allowable strength assumed by Herbert Engineering was no more than 20 ksi, the safety factor is at least 2.9.

[14] The minimum breaking strength of the trailer RO-RO lashings on the second deck is 33,000 lbs. *See* Cargo Securing Manual, MBI Exhibit 40 at 102. The maximum safe working load ("SWL") of the RO-RO lashing is 9200 lbs (41 kn). *Id.* Application of the CSS Code further reduces the cargo securing load ("CS") with an additional safety factor of 1.5. In the case of RO-RO trailers on the second deck, the NCB specifies CS to be 24 kns (6070 lbs). Comparing the minimum breaking strength (33,000 lbs) with the CS load of 6067 lbs results in factor of safety of 5.4.

VI. CONCLUSIONS

First, the alleged deck strength margin exceedances for the LO-LO container cargo, even if they existed, are insignificant, in light of their magnitude and the safety factors built into the calculations. More importantly, if the averages of the adjacent stacks are measured, which is consistent with the underlying finite element methodology upon which the maximum stack weights were assessed, no exceedance exists and, in fact, a significant margin is present. Finally, review of the underwater video does not suggest any type of stack collapse or deck failure. Accordingly, there is no basis to suggest container stack collapse or deck failure played any role in the casualty.

Second, the lashing margin calculations for the LO-LO lashing, contained in the NCB Report, were based upon the erroneous assumption that certain interior stacks were not lashed. After applying the simplified minimum lashing procedures in place on board the EL FARO, 7 of the 8 alleged lashing margin exceedances do not exist. The remaining exceedance of 0.9 long tons is insignificant. All of the remaining 148 stacks were within the requirements of the CSS Code and Cargo Securing Manual.

Finally, with respect to the lashing of the RO-RO trailers on the second deck, the NCB Report and its conclusions are fundamentally flawed because the NCB: (1) over simplifies its calculations by calculating the loads and restraining forces for one half of the trailer (rather than the whole trailer) and, in the process, significantly underestimates the restraining forces that existed; (2) assumes an incorrect speed of the vessel; and (3) assumes an incorrect lashing angle for the lashings, among other incorrect assumptions. By simply using the correct speed of the vessel, and calculating all of the restraining forces on the whole trailer (not just one half of the restraining forces as the NCB does), the corrected calculations demonstrate that the strength requirements of Annex 13 of the CSS Code are fully satisfied. NCB's assumption that 60% of the RO-RO Cargo was off button is baseless and incorrect, but, even if true, the corrected calculations demonstrate that the lashing of the RO-RO cargo on the second deck fully complied with the strength requirements contained in Annex 13 of the CSS Code (and this would be the case even if all trailers were stowed off button).

Given the erroneous and unsupportable conclusions in the NCB's Report, and its inherent unreliability discussed above, we respectfully submit that any public disclosure of the investigative report would hinder and detract from the investigative process. We respectfully request the NTSB correct the errors in the NCB report before publishing the report, or not publish it at all.

* * * * *

Exhibit A - Deck Structure Analysis, Herbert Engineering Corporation (MBI Exhibit 144)
Exhibit B - EL Class Minimum Lashing Requirements
Exhibit C - CargoMax Load Out Supporting Calculations
Exhibit D - Randy Kidd, MBI Transcript Excerpt
Exhibit E - Captain Hearn, NTSB Transcript Excerpt
Exhibit F - SS EL FARO Noon Report, September 30, 2015
Exhibit G - Tote Supporting Annex 13 Calculations, Table 4 (Maximum Weight)
Exhibit H - Tote Supporting Annex 13 Calculations,
Table 6 (Vessel Speed 19.5 knots, lashing angle 60 degrees)
Exhibit I - Tote Supporting Annex 13 Calculations,
Table 7 (Vessel Speed 19.5 knots, lashing angle 45 degrees)

Exhibit A

Deck Structure Analysis

of the

NORTHERN LIGHTS

Rev. 0
July 29, 2005

Prepared for:

Sea Star Line, LLC
8710 Longshore Way
Jacksonville, FL 32226

Prepared by:

HERBERT ENGINEERING CORP.
Naval Architects • Marine Engineers • Software Specialists

ALAMEDA OFFICE
2417 Mariner Square Loop, Suite 125, Alameda, CA 94501
Tel: +1 510 814 9700   Fax: +1 510 814 9763

ANNAPOLIS OFFICE
927 West Street, Suite 202, Annapolis, MD 21407
Tel: +1 410 268 8930   Fax: +1 410 268 8931

E-mail: info@herbert.com   Web: www.herbert.com

Table of Contents

Executive Summary
This analysis was performed on the deck structure of Bays 1 through 20 of the Seastar RoRo containership Northern Lights to confirm that the current structure has sufficient strength and to investigate possible stack weight increases in the studied area.

The initial analysis shows no excessive shear stresses, but some areas with high tensile and compressive stresses, as well as some pillars with stresses above the buckling limit. The longitudinal girders around Frame 144 and the centerline girder around Frame 220 are the most significant areas where the structure needs reinforcement. Proposed upgrades to the structure take care of these overstressed areas.

A study will be made to investigate whether it is possible to increase allowable stack weights in the studied area without additional reinforcement. The details of this study will be submitted in an amendment to this report.

Introduction
This report describes the first steps in the analysis of the deck structure of the Seastar RoRo containership Northern Lights. The purpose of the study is to identify any parts of the structure that do not have sufficient strength for the container loads, and confirm the strength of this structure with suggested repair details.

FE Modeling

Model
The model is comprised of beam elements representing main supporting members of the upper deck and side shell structure as well as container supports and stanchions supporting the upper deck. The beam elements represent the main sections with attached plating. The model extends longitudinally from Frame 20 to Frame 267, the full width of the ship transversely, and from the 2nd deck to the main deck vertically. The x-axis is axis is positive forward, the y-axis is positive up and the z axis is positive starboard.

The units of the model are as following:
- Length * inches
- Force * kips (1,000 Lbs)
- Stress * ksi (1,000 psi)

Gross scantlings are used throughout the model. Sheer of the forward and aft ends is modeled, while the deck camber is not modeled. All rider plates/doublers that are fitted on the support structure are currently modeled. The wireframe model is presented in Figures 1 through 3.

The scantlings used in the Model were taken from the following drawings:
1. HEC Drawing SSL-670-100-001, Alt 1, Container Support Structure (which shows main deck and pillar scantlings confirmed by ship check onboard in June 2005)
2. Sun SB Drawing 662-700-201, Alt E, Midship Section
3. Sun SB Drawign 673-700-301, Alt 0, Scantling Plan, Main Deck and Below
4. JJH Drawing 1252-702-602, Alt A1, Scantling Plan (showing addition of a new midbody and modification to existing scantlings from the 1993 conversion, stamped *Certified, As Built*)

If there was any discrepancy in scantlings between drawings, the scantlings shown on drawing SSL-670-100-001 were used as they are based on a ship check and measurements made onboard.

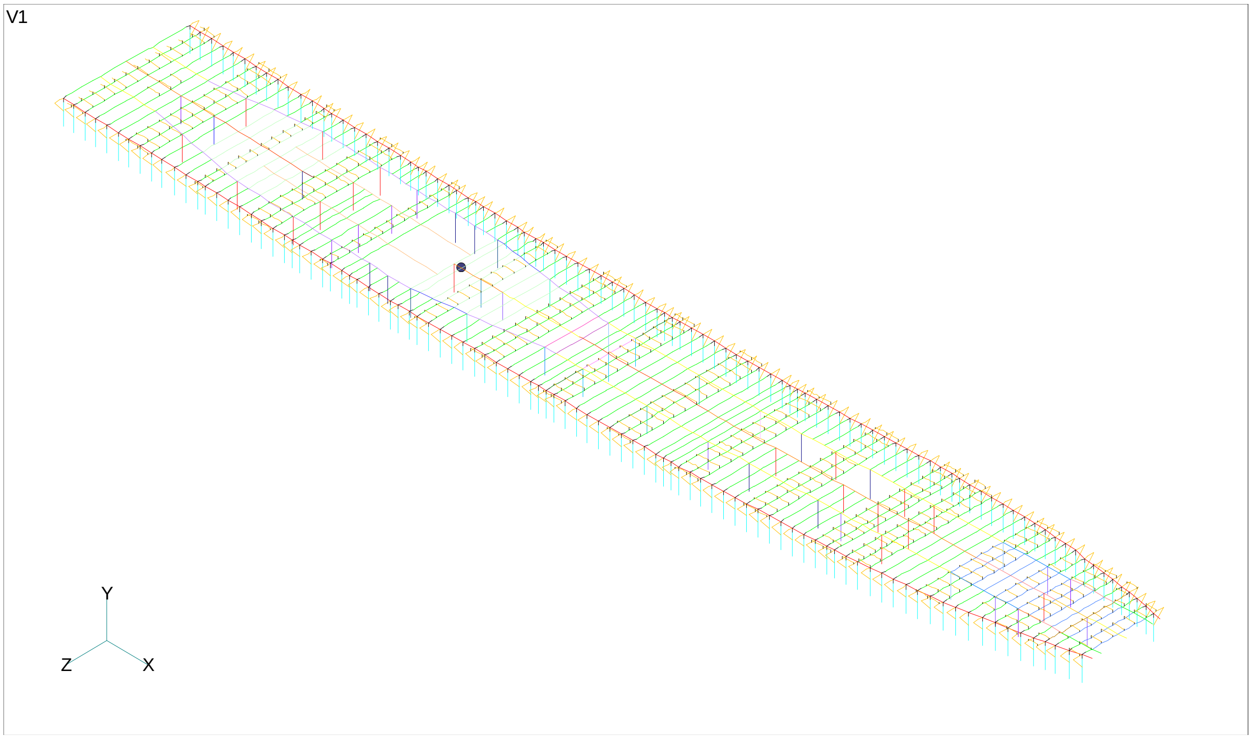


Figure 1 - Wireframe Model, isometric view

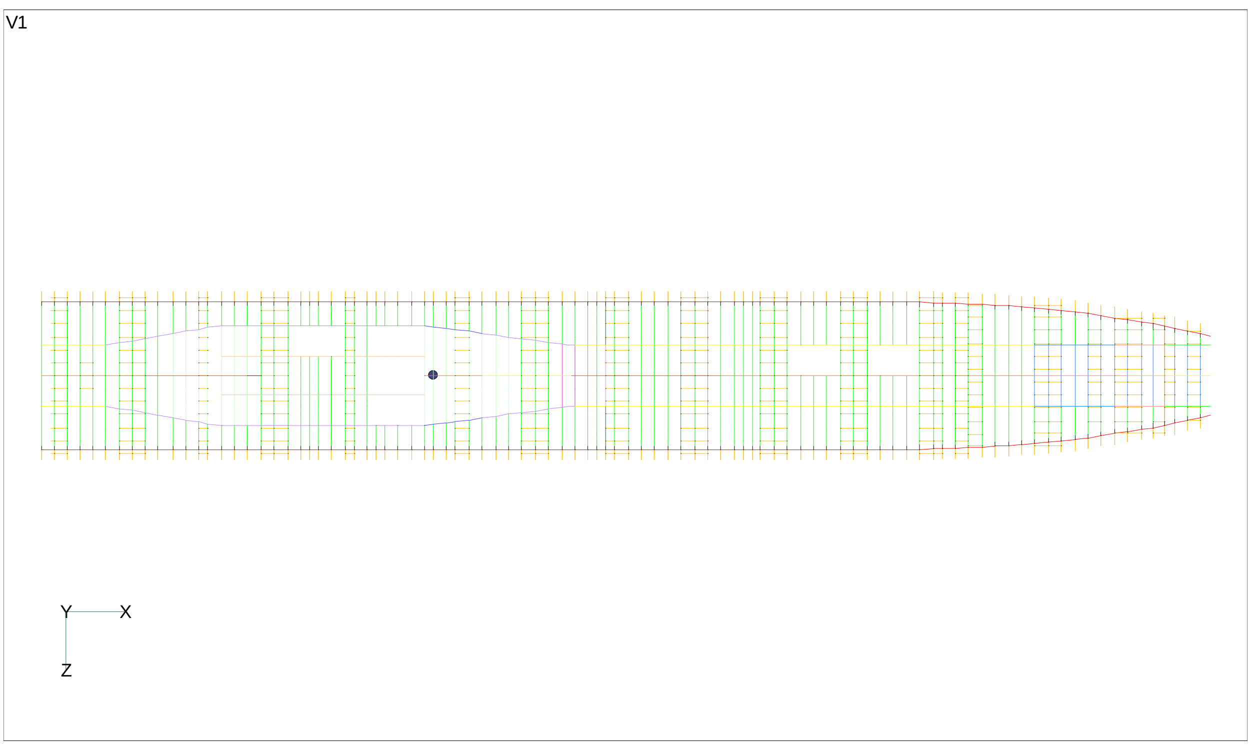


Figure 2 - Wireframe Model, plan view

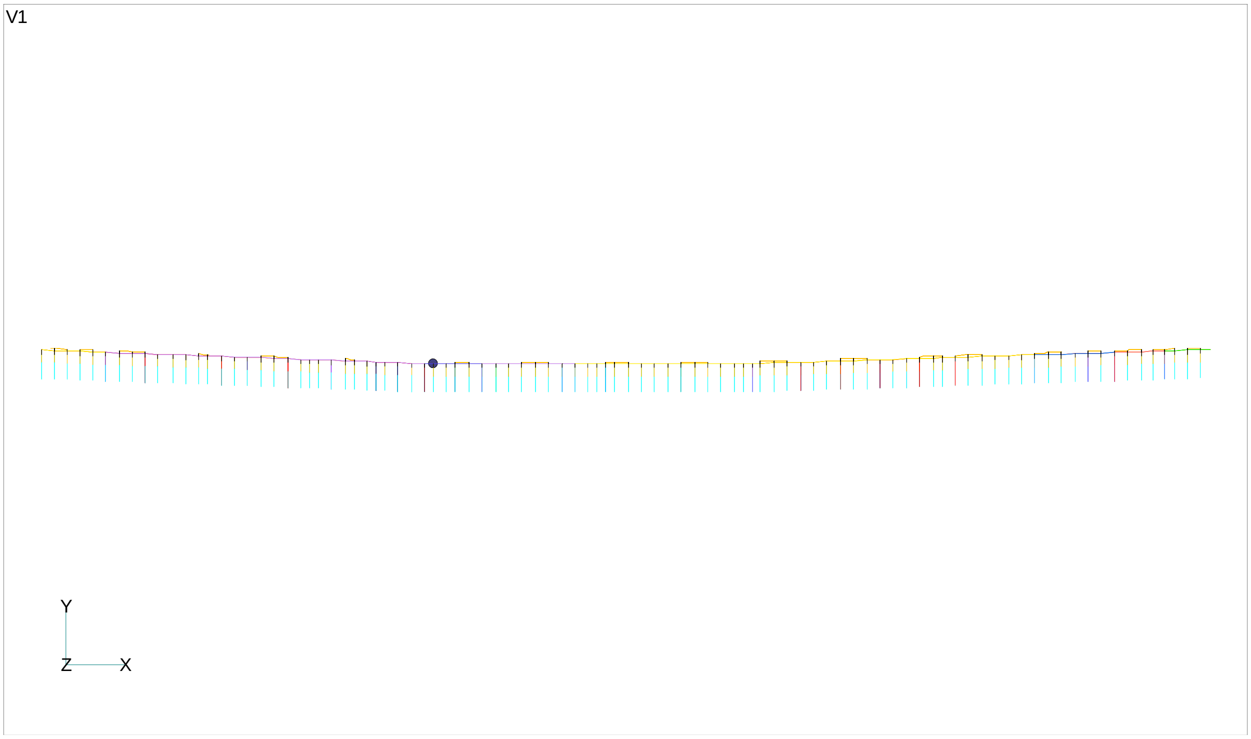


Figure 3 - Wireframe Model, profile view

Loads

The loads in the model are in accordance with ABS Rule 3-2-7/5.3 and are the static load of maximum allowable stack weights for different combinations of 20*, 40*, 45* 48* and 53* containers. The following specific load cases are studied:

1. Max 20* containers + remaining 40* containers
2. Max 40* containers + dedicated 20* containers
3. Max 45* containers + dedicated 40* and 20* containers
4. Max 48* containers + dedicated 40* and 20* containers
5. Max 48* containers + remaining 45* available spaces + dedicated 40* and 20* containers
6. Max 53* containers + dedicated 40 + 20
7. Alternating 40/45 on bays + dedicated 40 + 20.

The magnitude of the loads is directly related to the evaluation criteria described later in the report. The following maximum allowable weights are used for the different container sizes:

- 20** 90 kips
- 40** 120 kips
- 45** 120 kips
- 48** 120 kips
- 53** 120 kips

Transversely, the loads for two adjacent container corners are lumped into one point. Longitudinally, the distances between containers are large enough so the load for each individual container is modeled separately.

No sea loads are assumed for this analysis. Discussions with ABS indicated that weather loads need not be considered for the following reasons:

1. The deck in question is 18* above the freeboard deck.
2. There are 7* high vent cuts in the side shell 6* above the freeboard deck, and the container deck extends 6*6* outboard of the side shell. The outboard container stack lands on this sponson.
3. The containers are only about 2* maximum off the deck, though long containers are stored on cross beams which raise them another foot.
4. In previous similar analyses for these ships, no weather head was added.

Constraints

The main constraints of the model are placed at the forward and aft end, and at the 2nd deck level, and additional constraints are placed at the location of bulkheads between the main deck and the 2nd deck. The following constraints are applied:

- At the forward and aft end, symmetry boundary conditions are used at the top of the pillars and at the end of the longitudinal girders.
- At the 2nd deck level, all nodes are fixed.
- At locations where bulkheads are present below the main deck, the main deck nodes are fixed, with the exception of rotational fixity around the axis parallel to the direction of the bulkhead. For example, a longitudinal bulkhead would result in constraints in all directions except for rotation around the x-axis.
- At the location of the escape trunks at Frame 230, the main deck nodes are pinned.

The constraint points applied at the locations of the longitudinal bulkheads and the escape trunks at the main deck level are presented in Figure 4.

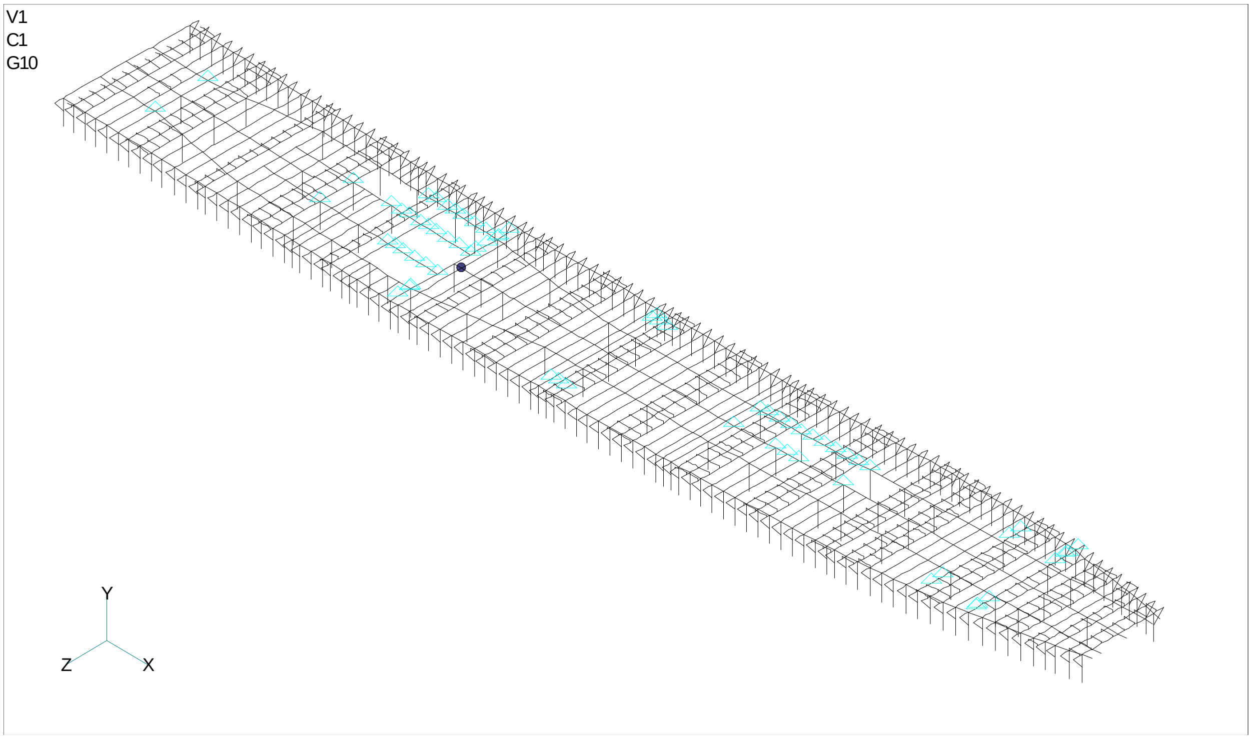


Figure 4 - Constraint points

Results

Evaluation Criteria

For the static loads assumed on the structure, the evaluation criteria for this analysis are taken from TABLE 2 of ABS Part 3 Chapter 2 Section 7. For all members, the following evaluation criteria are applied:

1. Combined Stress in Longitudinal Girders * 17.92 KSI (8 LTSI)
2. Combined Stress in Transverse Frames * 20.16 KSI (9 LTSI)
3. Combined Stress in Pillars * 20.16 KSI (9 LTSI)
4. Shear * 15.0 KSI (6.7 LTSI)

In addition to this, the pillars were evaluated for buckling with the following criteria:

5. Compressive stress from axial loads * k − n L / r, where k = 17.54 KSI (7.83 LT/in2) and n = .0644 KSI (.345/12=0.02875 LT/in2), L=Length, r = gyradius. (3-2-8/3.1)

Deflections

The deflection plot presented in Figure 5 shows that the points with the largest deflections are located at two locations:

- Around Frames 144
- Around Frame 220

At these locations the container supports are located between pillars, both at centerline and at the side girders, therefore allowing larger deflections than in most places where there are pillars either at or very close to the container supports. These areas also correspond to areas in need of reinforcement as is explained later.

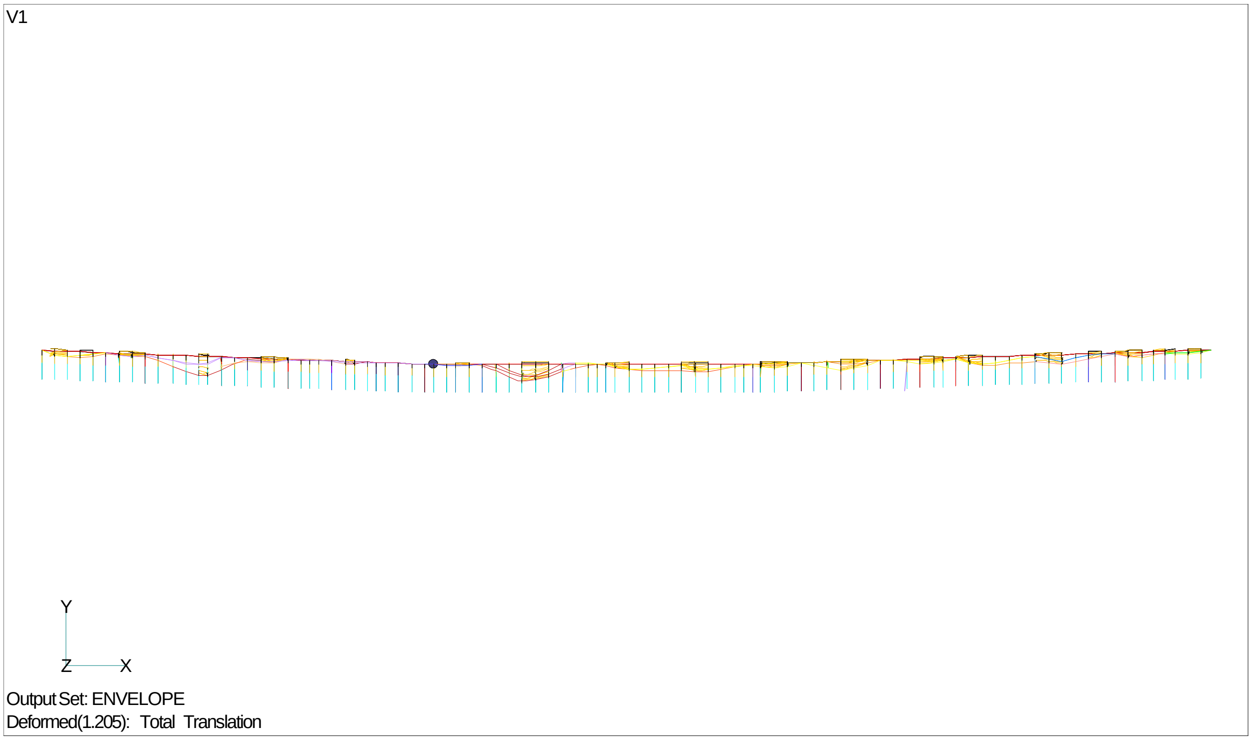


Figure 5 – Deflected model

Stresses

The maximum shear stress in the longitudinal and transverse support beams was 14.8 ksi, below the allowable shear stress of 15 ksi.. Tensile/compressive stresses are discussed below.

The stress plots show that several of the locations with the highest stresses are in the same locations as the areas of high deflections. Table 1 and Table 2 give the details of the overstressed areas.

Ref #	Member	Frames	Scantling	Reported Stress	Allowable Stress	% overstressed
1	Transverse girder at pillars	52	34x0.5+8x0.75	21.31	20.16	5.7%
2	Transverse girder at CL	108	34x0.5+8x0.75	22.42	20.16	11.2%
3	Stbd Long Girder	144-150	34x0.75+25x1	21.49	17.92	19.9%
4	Port Long Girder	144-153	34x0.75+25x1	19.77	17.92	10.3%
5	CL Long Girder	144-150	35x0.75+25x1.12	26.98	17.92	50.6%
5a	Stbd Transverse Girders	144 &147	34x0.5+8x0.75	25.13	20.16	24.7%
5b	Port Transverse Girders	144 &147	34x0.5+8x0.75	22.69	20.16	12.5%
6	CL Long Girder	156-159	35x0.56+25x1	18.01	17.92	0.5%
7	Stbd 12' Long Girder	185	34x7/16+6x1	20.33	17.92	13.5%
8	CL Long Girder	206-209	35x0.56+20x1	23.84	17.92	33.1%
9	CL long girder	215-218	35x1+30x1.375	22.07	17.92	23.1%
10	CL long girder	220-223	35x1+30x1.375	18.88	17.92	5.3%
11	Stbd Transverse girder	218	34x0.5+8x0.75	21.93	20.16	8.8%
12	Port Transverse girder	218	34x0.5+8x0.75	22.00	20.16	9.1%

Table 1 - Failed longitudinal and transverse members

Ref #	Frame Location	Scantling	Top FEM Stress	Bottom FEM Stress	Allowable Stress	% overstressed at top	% overstressed at bottom	Axial Stress	Allowable	% overstressed
13	34 CL	12x79#	18.70	18.06	20.16	-7.26%	-66.56%	17.19	13.03	31.94%
16	82 CL	14x84#	17.99	15.62	20.16	-10.78%	-71.07%	14.14	13.04	8.41%
18	138 S	12x85# with doubler	23.37	13.85	20.16	15.93%	-31.28%	5.55	14.24	-60.99%
22	215 P	14x127#	21.99	14.62	20.16	9.10%	-27.49%	10.79	13.92	-22.47%
23	215 S	14x127#	21.96	15.62	20.16	8.90%	-22.54%	10.73	13.92	-22.91%
24	234 CL	14x95#	19.16	16.87	20.16	-4.96%	-16.33%	15.00	13.87	8.12%

Table 2 - Failed pillars

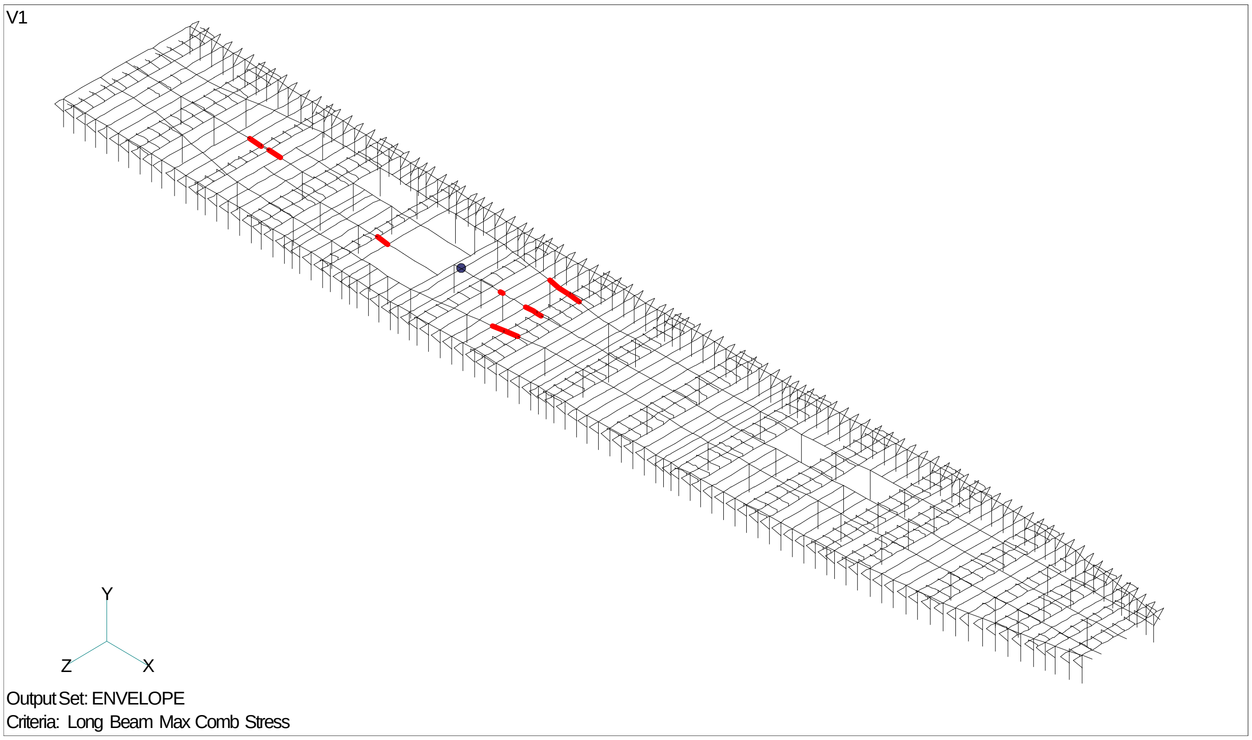


Figure 6 - Failed Longitudinal Members

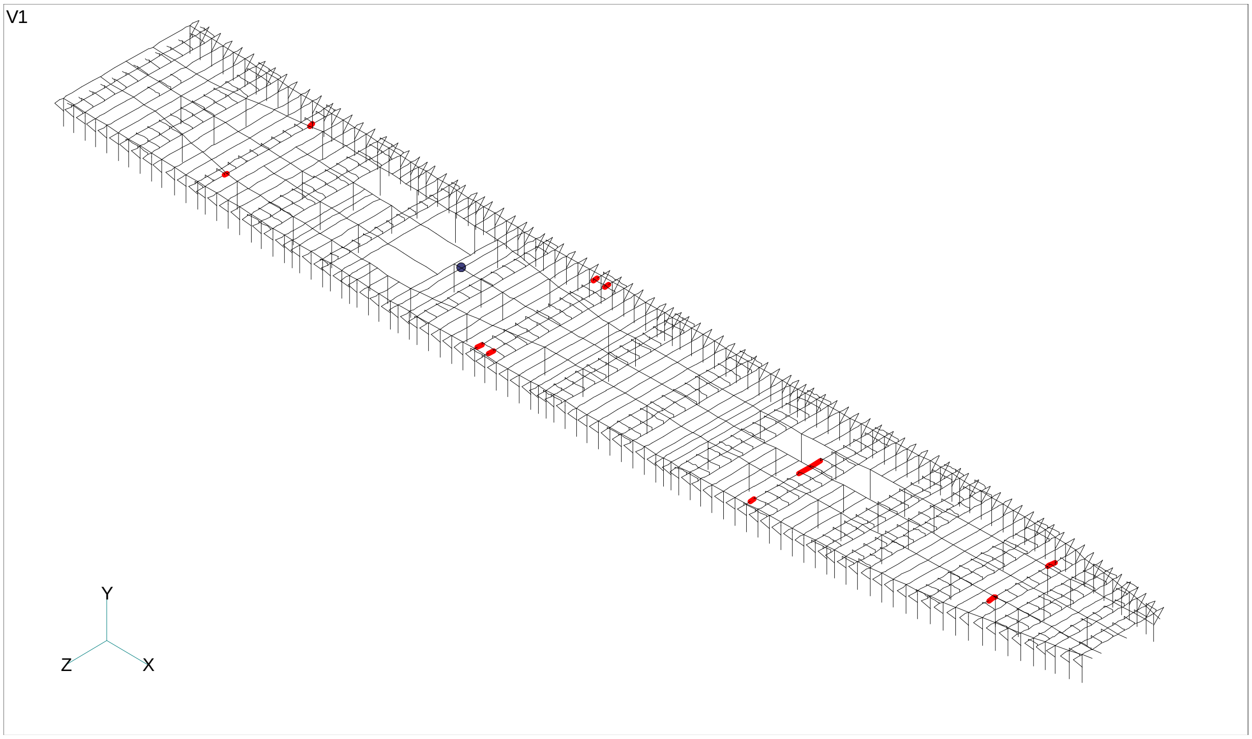


Figure 7 - Failed Transverse Members

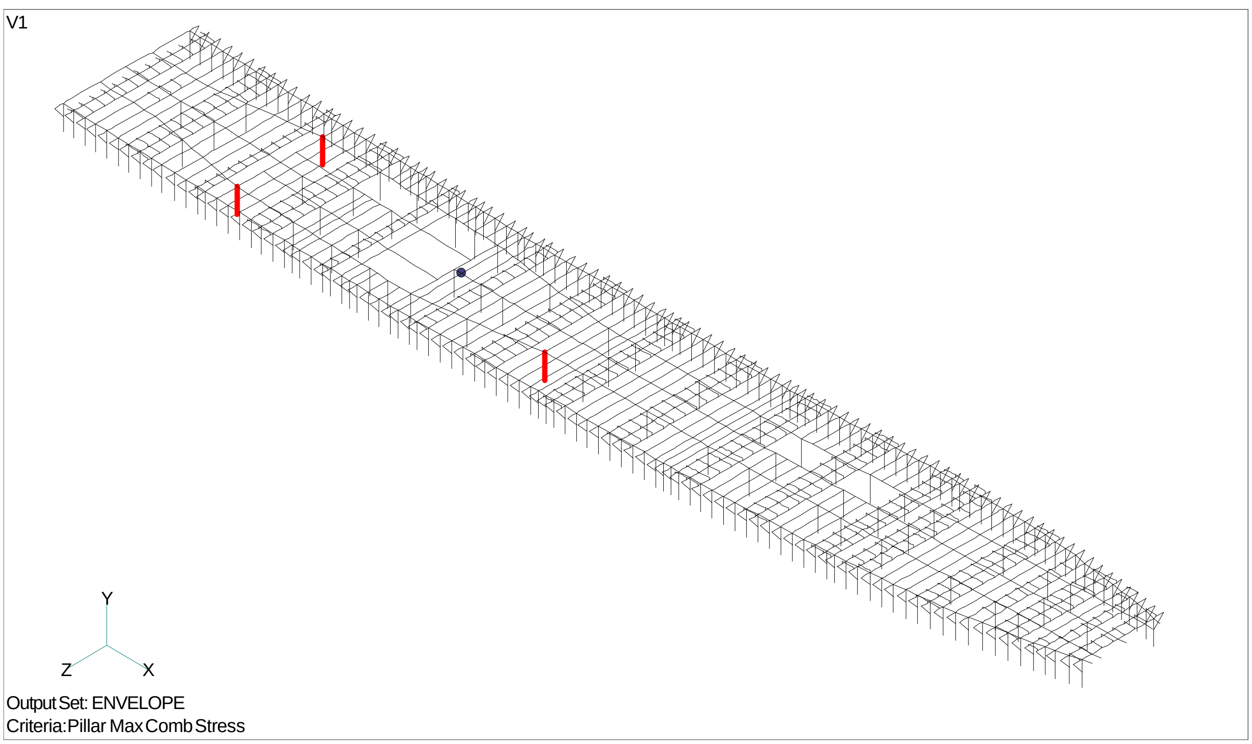


Figure 8 - Failed Pillars – combined stress evaluation criteria

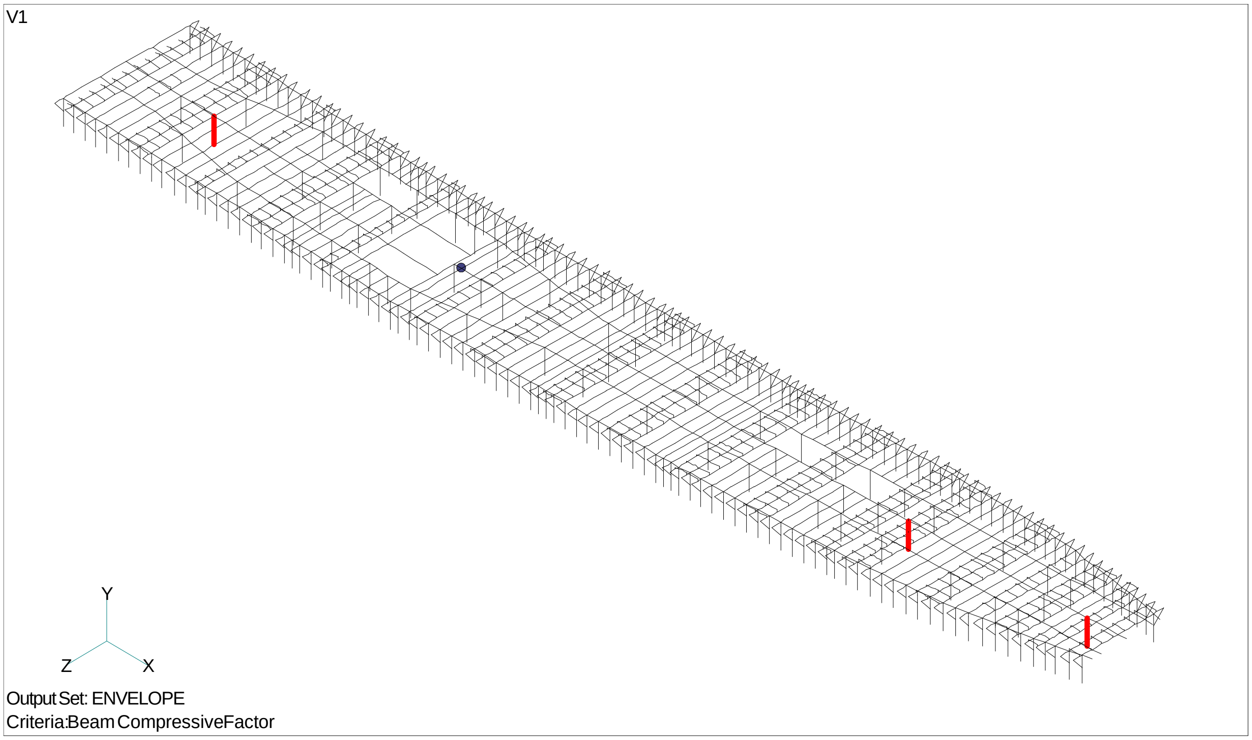


Figure 9 - Failed Pillars – compressive buckling evaluation criteria

Structural Upgrades

General

Upgrades for the overstressed details are detailed in Table 3. The repairs are mostly doubler plates on the flanges of the overstressed members. The exceptions are the pillars that fail the buckling criteria, where extra flanges are fitted on the flanges of the I-beams to give the members extra support in the weak direction.

Results after Upgrade

The proposed upgrades take care of all the discussed overstressed areas. Figure 10 shows a stress plot of the maximum absolute value of the combined stresses for all 7 load cases. Note that the maximum and minimum values of the scale are set at the corresponding maximum (tension) and minimum (compression) stress values, while the rest of the scale is customized to include limits at the set evaluation criteria.

There are some high compressive stresses reported in the side shell elements at the location of the large deck bracket on Frames 144 and 147. These stresses occur at locations where the support from the bracket will give enough stress relief that this is not an issue.

Figure 11 and Figure 12 show the maximum shear stresses from all load cases in the two primary element directions. All shear stresses are below the limit of 15 ksi.

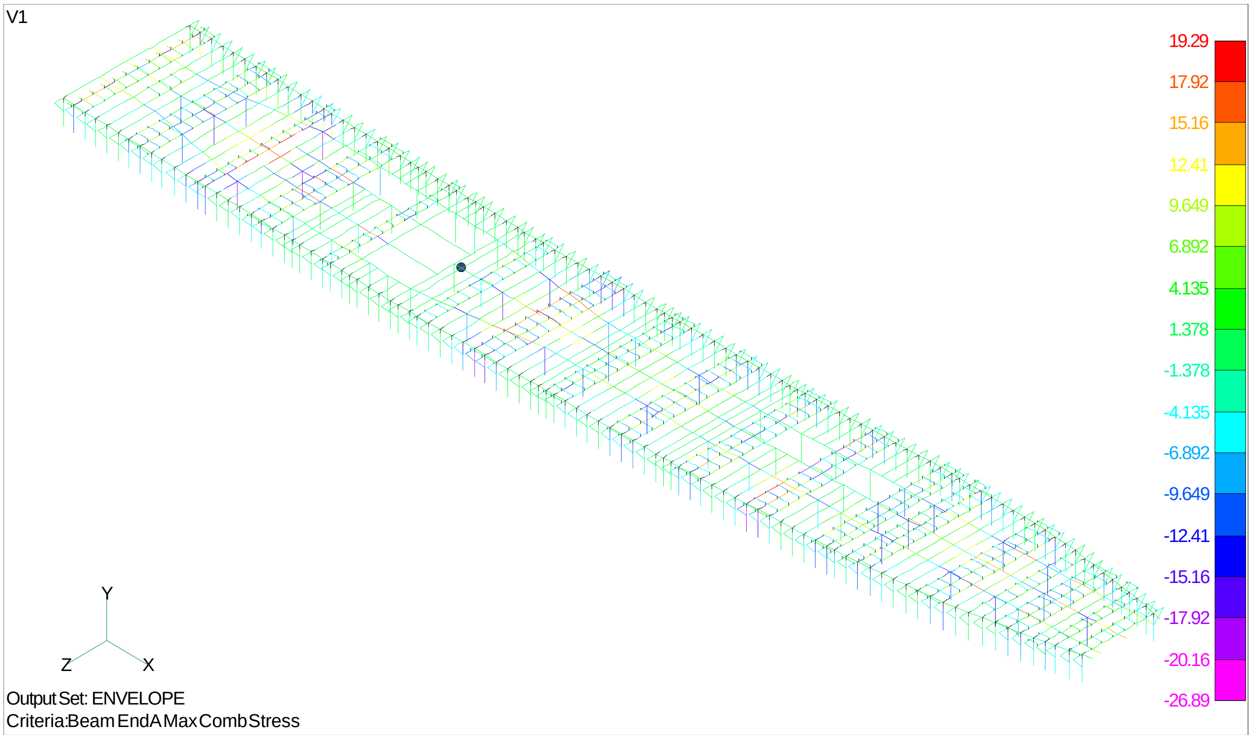


Figure 10 - Maximum combined stresses for all load cases

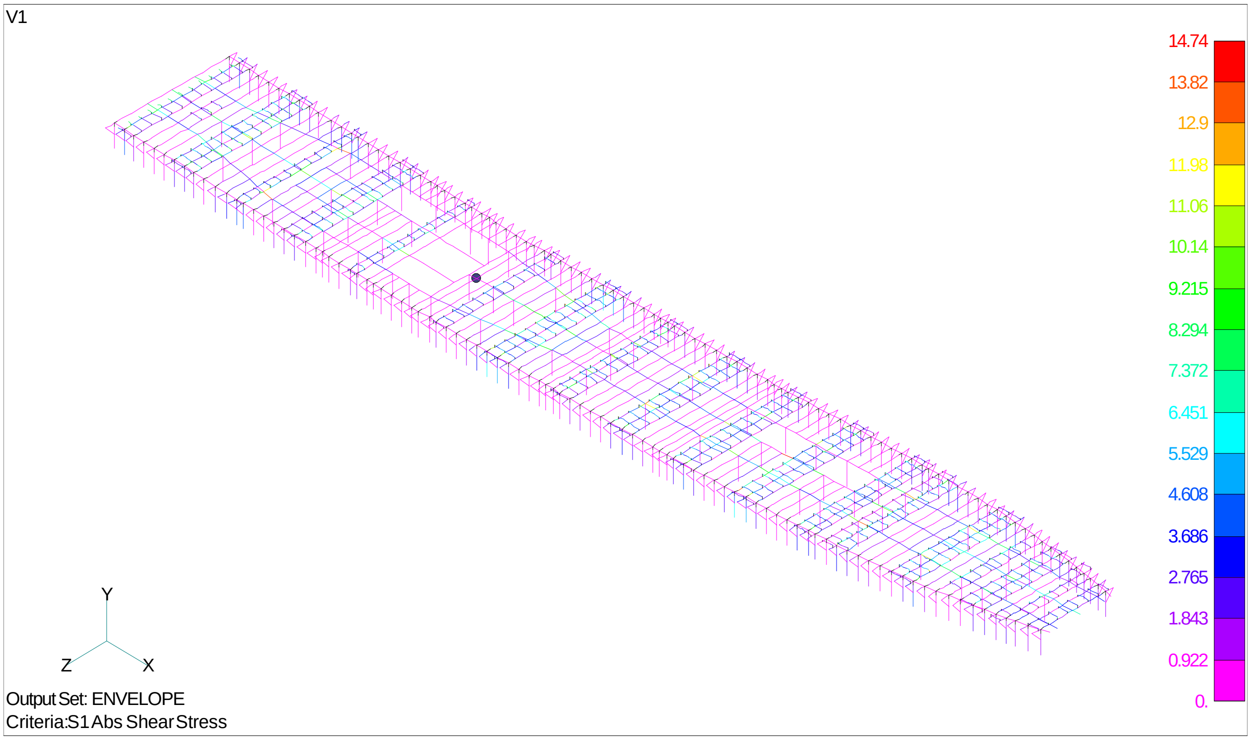


Figure 11 - Maximum S1 shear stress for all load cases (absolute value)

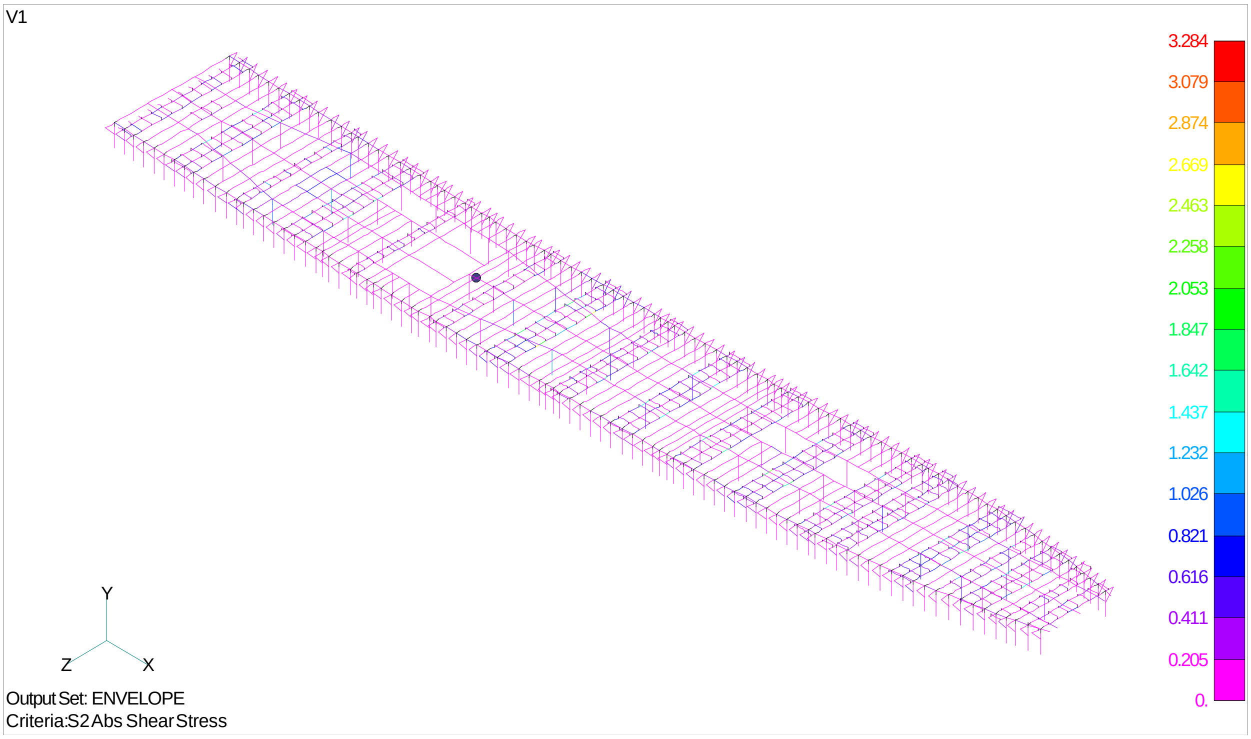


Figure 12 - Maximum S2 shear stress for all load cases (absolute value)

Pillar Reinforcements

Ref #	Frame / Location		Pillar Scantling - W	No & Size of Proposed Flange Flange NxThk		No & Size of Proposed Covr PL NxThk Width	
13	34	CL	12x79#	None		1x.5	17.0
16	82	CL	14x84#	None		1x.5	5.0
18	138	S	12x85#	2x1.0	8.0	None	
22	215	P	14x127#	2x.75	7.0	None	
23	215	S	14x127#	2x.75	7.0	None	
24	234	CL	14x95#	None		1x.5	6.0

Girder Reinforcements

Ref #	Member	Frames	Existing Scantling	New Doublers Width	Thickness	Doubler Frames
1	Transverse girder at pillars	52	34x0.5+8x0.75	4.00	0.50	4 feet
2	Transverse girder at CL	108	34x0.5+8x0.75	5.00	0.50	4 feet
3	Stbd Long Girder	144-150	34x0.75+25x1	14.00	0.75	138-156
4	Port Long Girder	144-153	34x0.75+25x1	7.00	0.50	138-153
5	CL Long Girder	144-150	35x0.75+25x1.12	24.00	1.25	138-156
5a	Stbd Transverse Girders	144 &147	34x0.5+8x0.75	5.00	0.50	4 feet
5b	Port Transverse Girders	144 &147	34x0.5+8x0.75	5.00	0.50	4 feet
6	CL Long Girder	156-159	35x0.56+25x1	None		
7	Stbd 12' Long Girder	185	34x7/16+6x1	4.00	0.50	10 feet long
8	CL Long Girder	206-209	35x0.56+20x1	10.00	1.00	206-209
9	CL long girder	215-218	35x1+30x1.375	21.00	1.00	212-226
10	CL long girder	220-223	35x1+30x1.375	See Ref # 9 above		
11	Stbd Transverse girder	218	34x0.5+8x0.75	2.00	0.50	4 feet
12	Port Transverse girder	218	34x0.5+8x0.75	2.00	0.50	4 feet

Table 3 – Reinforcements for Overstressed Members

Appendix A – Additional Stack Weights

An investigation was made to study possibility of increasing the stack weights in areas not reported as overstressed in the initial analysis. The stress plots in Figures 6 thru 9 indicate that stack weight increases might be possible in the following areas:

1. Port side of Bay 8/9, outboard of the port longitudinal girder
2. Port side of Bay 10, outboard of the port longitudinal girder
3. Bay 11
4. Bay 13
5. Port side of Bay 16, outboard of the port longitudinal girder

The following give the details of the results from the analysis.

Port side of Bay 8/9 and Bay 10, outboard of the port longitudinal girder

Any significant increase in stack weights in this location will cause the transverse girder outboard of the port pillar at Frame 108 to be overstressed. Therefore, no stack weight increases are recommended at this location.

Bay 11 and Bay 13

Any significant increase in stack weights inboard of the longitudinal girders will cause the transverse girder at Frame 134/10 to be overstressed in shear. However, increases in stack weights outboard of the longitudinal girders are possible, and the studies indicate that stack weights of 160 kips are possible in the 3 outboardmost stacks, outboard of the longitudinal girders, both port and starboard..

Port side of Bay 16, outboard of the port longitudinal girder

The studies done indicate that in this area, it is possible to increase the stack weights up to 160 kips in the 4 outboard-most stacks, outboard of the longitudinal girder, on the port side.

The following figures give the stress results for the load cases with these additional loads applied. The additional loads are applied to all container sizes and hence, all load cases described in this report. The maximum reported S1 shear stress is slightly higher than the allowable stress of 15 ksi. However, this occurs in the container support beams which are conservatively modeled as all having the same properties as the inboard-most beam. Since the outboard beams where the high stresses occur are actually much deeper than modeled, the actual stresses should be acceptable.

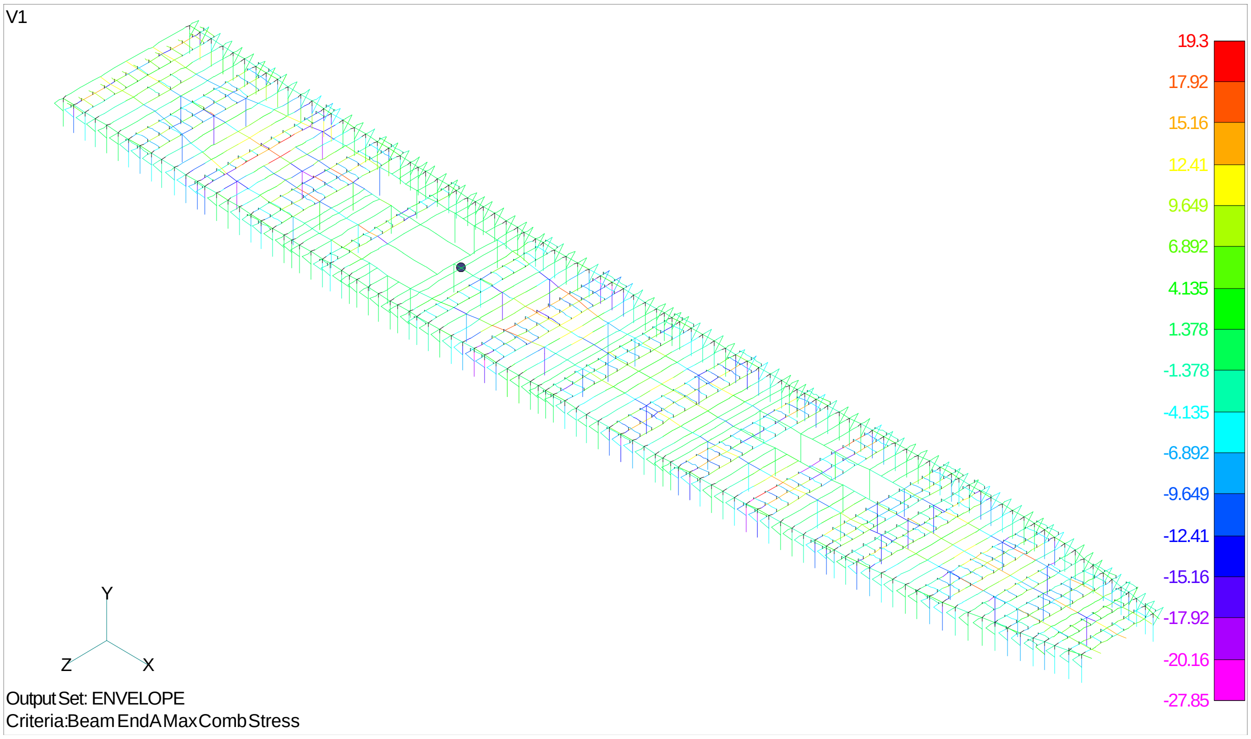


Figure 13 - Maximum combined stresses for all load cases

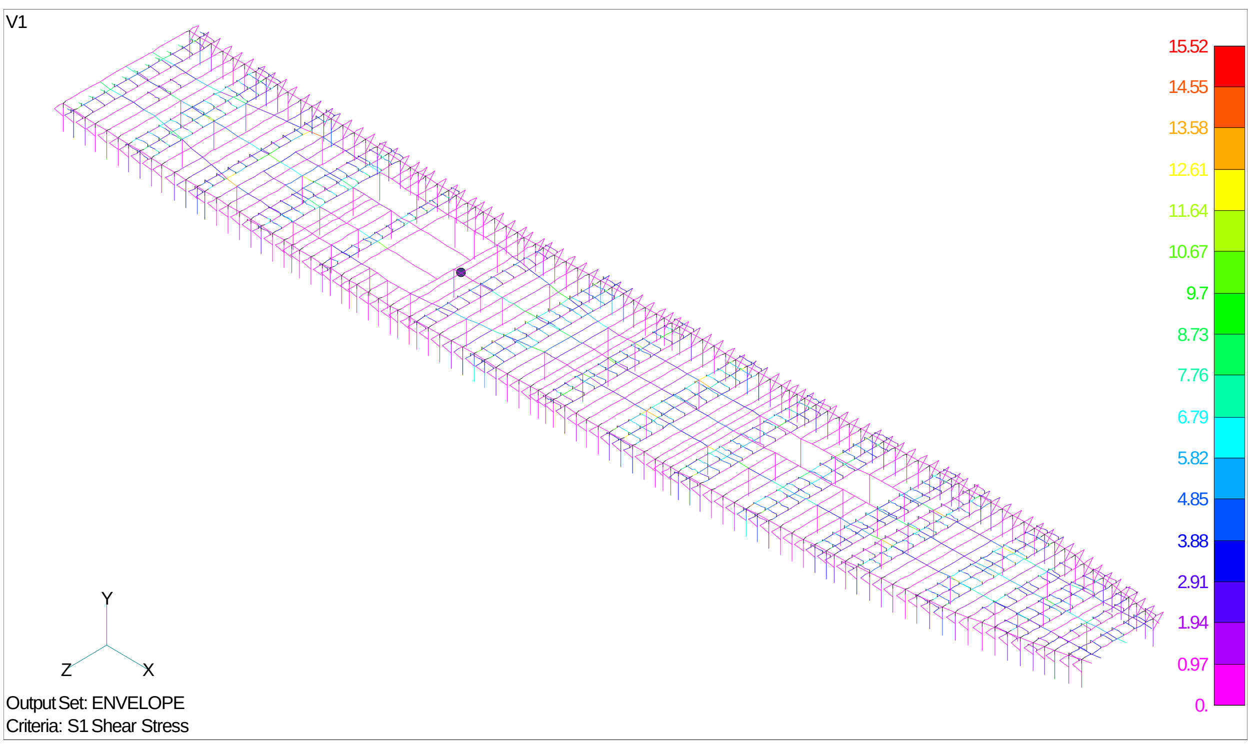


Figure 14 - Maximum S1 shear stress for all load cases (absolute value)

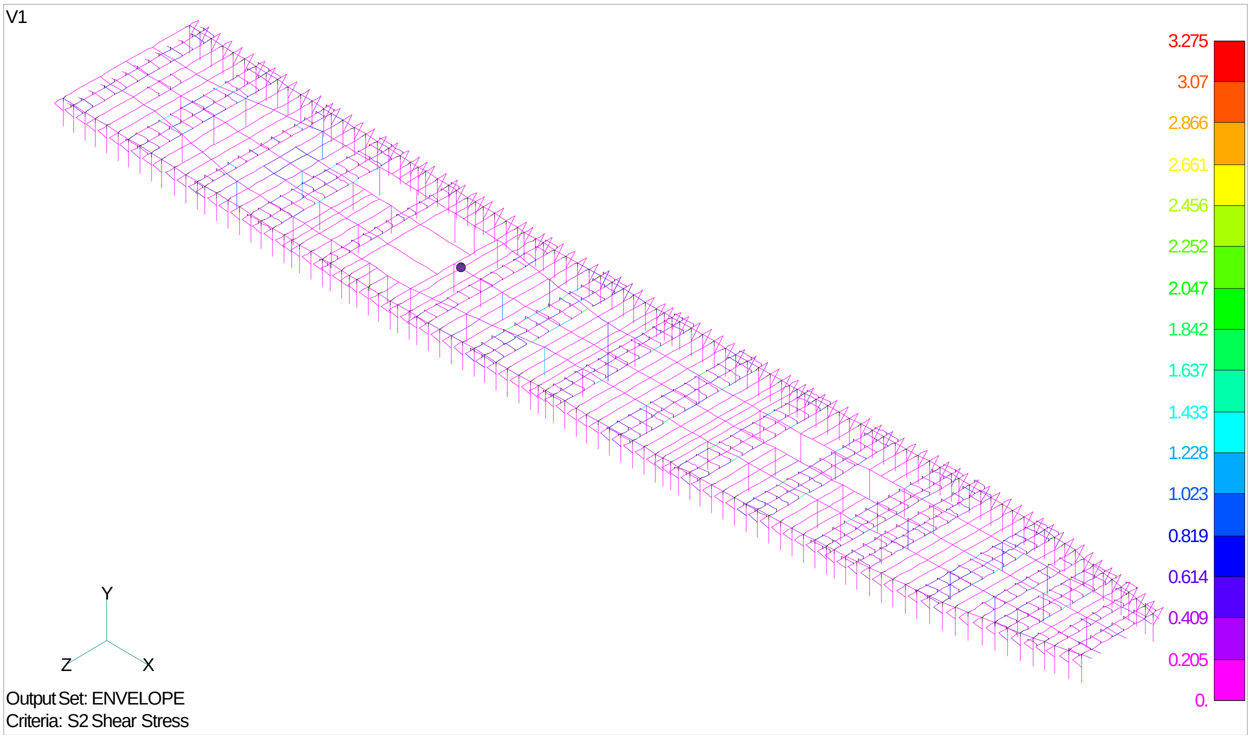


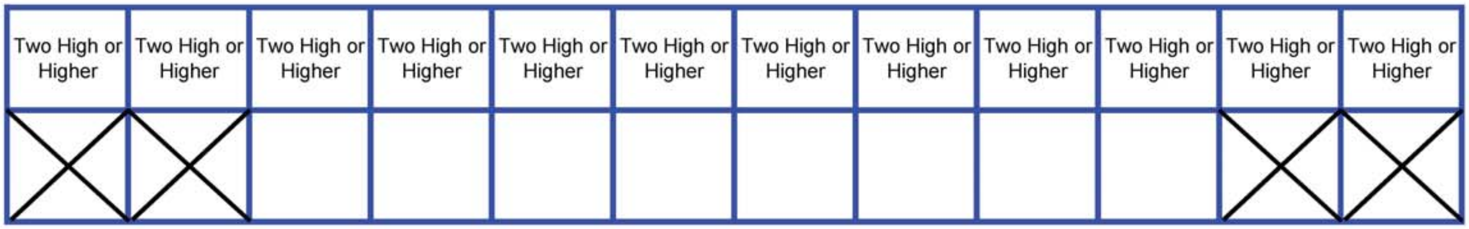
Figure 15 - Maximum S2 shear stress for all load cases (absolute value)

Exhibit B

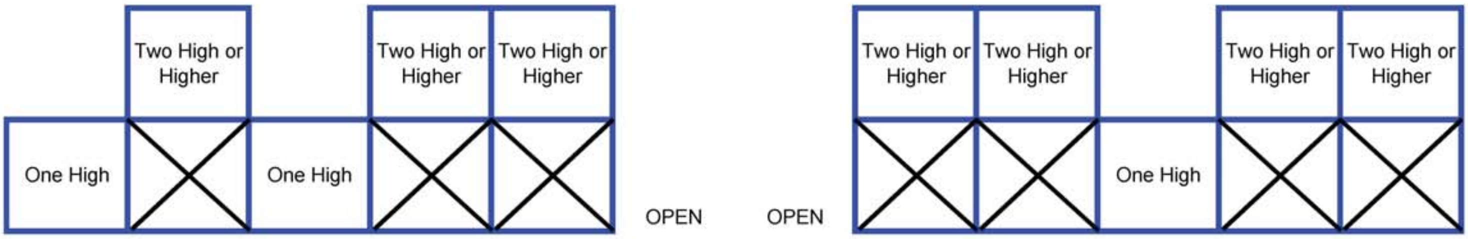
SSL EL Class Minimum Lashing Requirements - LoLo

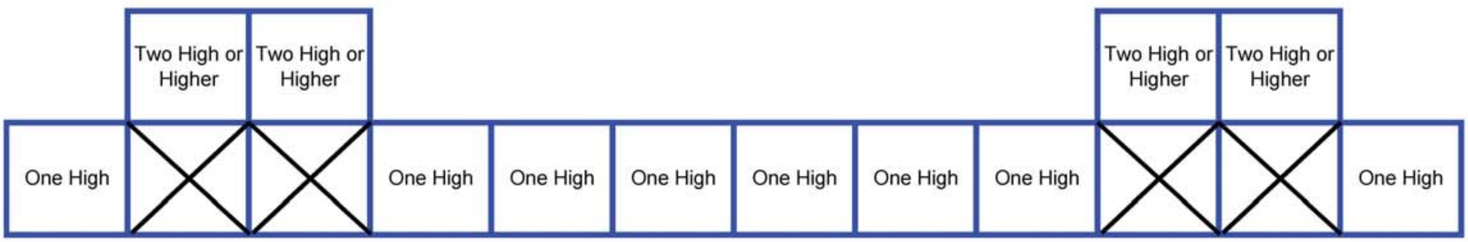
Additional lashing may be required for individual stacks as determined by Marine Operations.

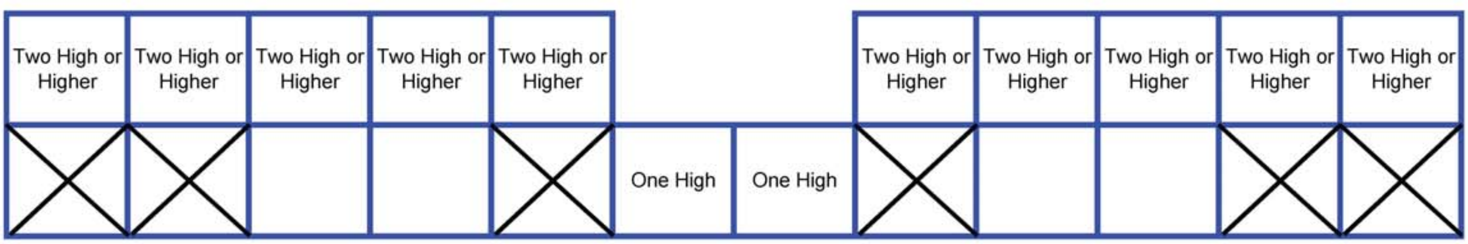
All bays will have the outer two high container stacks lashed regardless of where the outside box is located.



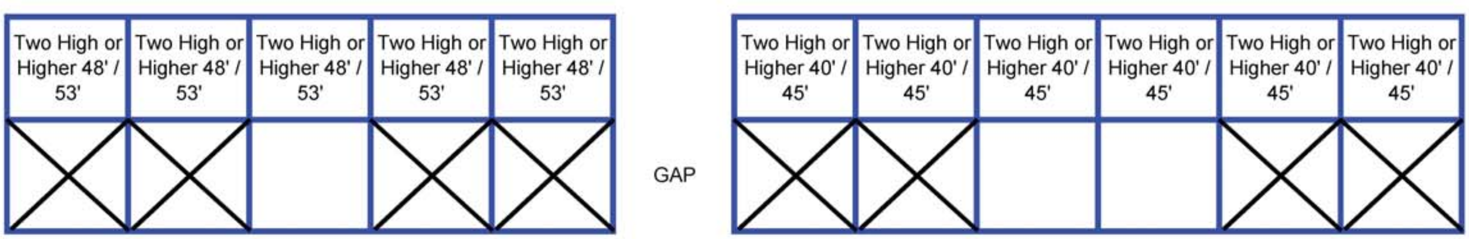
If there are two high containers next to an open cell located in the interior of the bay they will be treated as outer stacks.







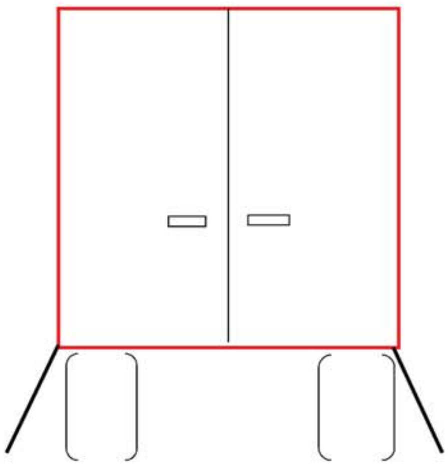
If there are two high 48' / 53' containers next to a stack of 40' / 45' containers in the interior of a bay - a gap is created.
Both the 2 high 48' / 53' stacks and 40' / 45' stacks of the bay they will be treated as outer stacks and lashed.



SSL EL Class Minimum Lashing Requirements - RoRo

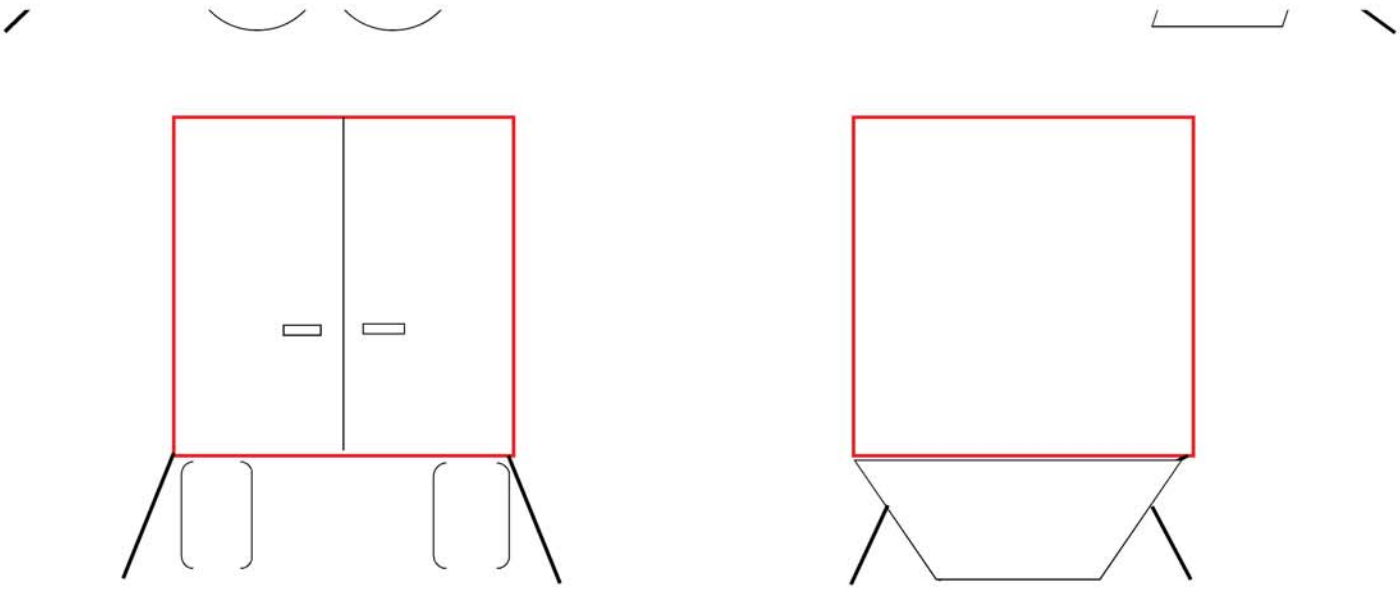
With Trailer Roloc locked on the button two lashings required off the rear of the unit.

Lashing points on trailers should be to main structural framing and not to lightweight crossmembers or other inappropriate locations



With Trailer Roloc stowed off of a button lashing is required both on the forward end and rear of the unit.

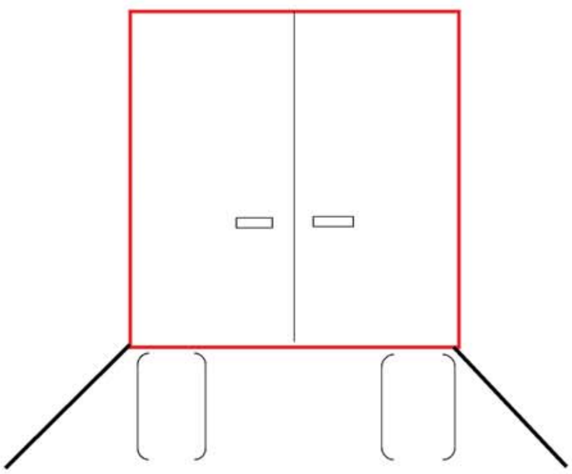
Forward lashings can connect directly to the Roloc or to a main structural point on the trailer.

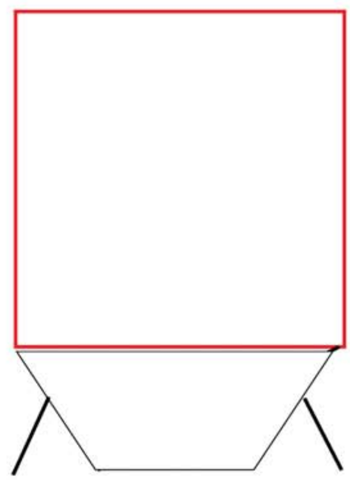


SSL EL Class Heavy Weather Lashing Requirements - RoRo

With Trailer Roloc locked on the button two lashings required off the rear of the unit and two 0ff the front.

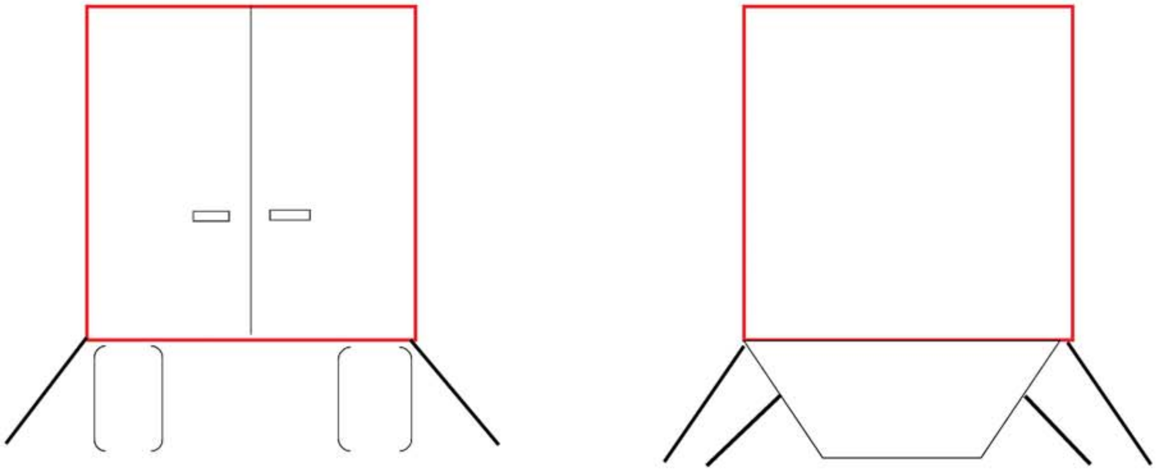
Lashing points on trailers should be to main structural framing and not to lightweight crossmembers or other inappropriate locations





With Trailer Roloc stowed off of a button 2 lashings are required off of the rear and 4 lashings on the forward end.

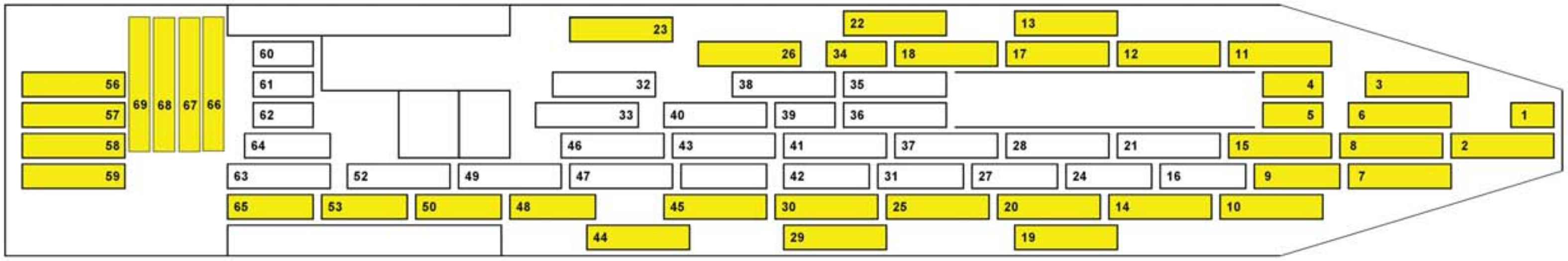
Forward lashings can connect directly to the Roloc or to a main structural point on the trailer.



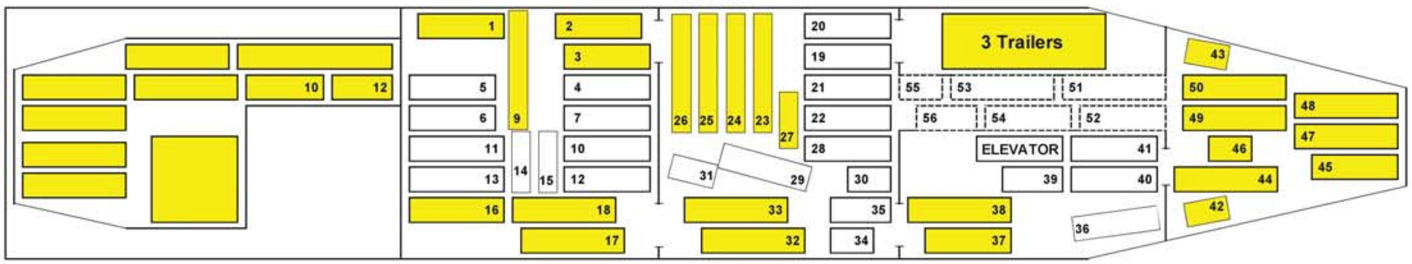
TOTE01182801

RoRo Heavy Weather Lashing

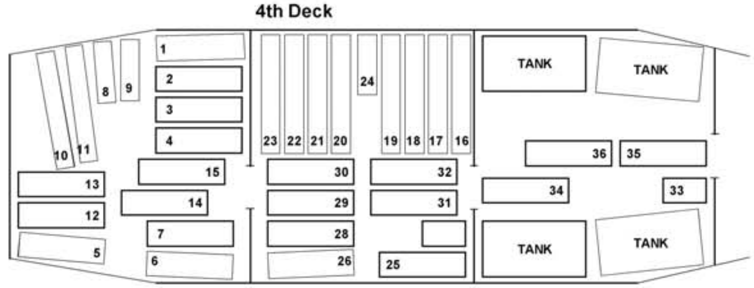
2nd Deck



3rd Deck

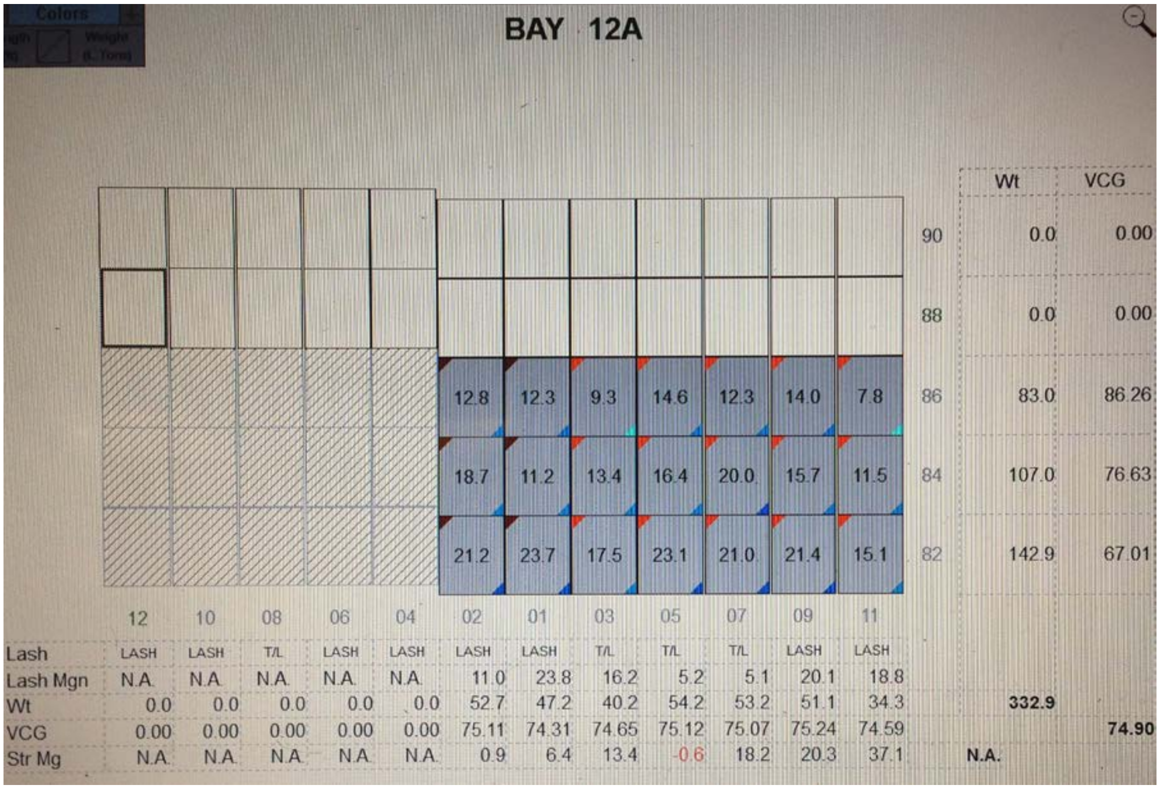


4th Deck



TOTE01182802

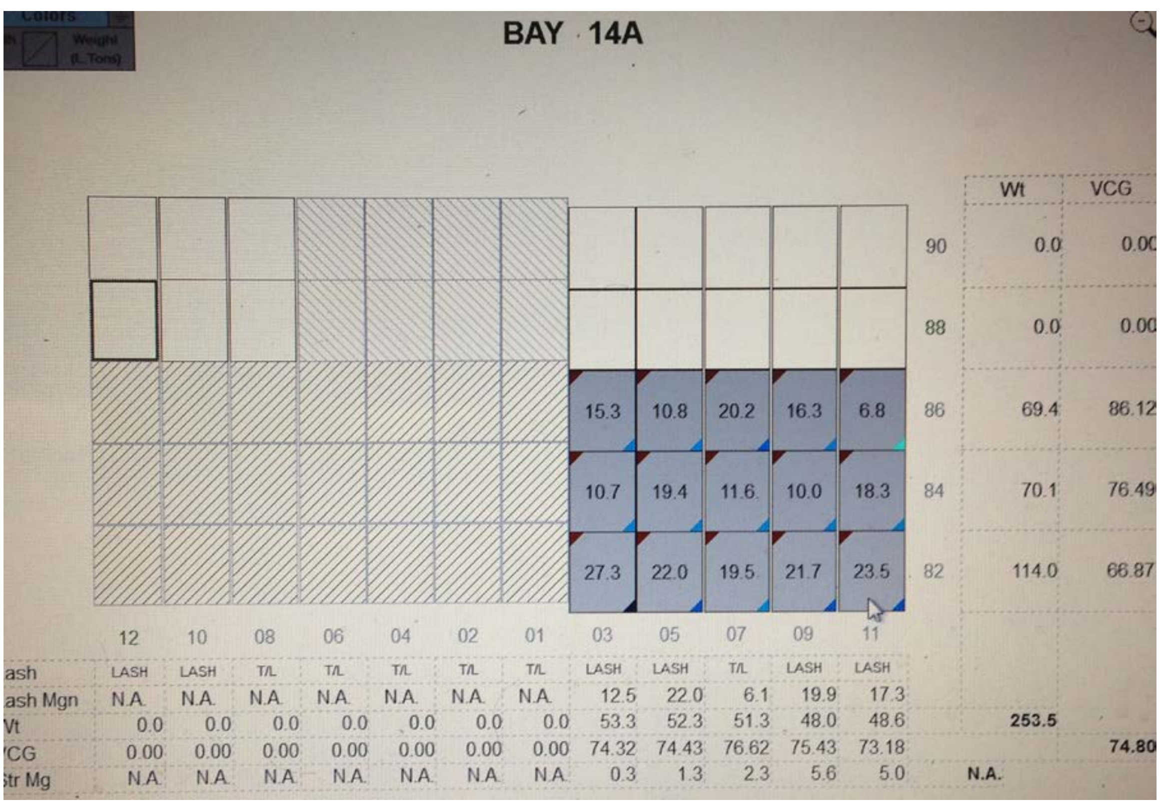
Exhibit C



BAY 12A

Tier	12	10	08	06	04	02	01	03	05	07	09	11	Wt	VCG
90													0.0	0.00
88													0.0	0.00
86						12.8	12.3	9.3	14.6	12.3	14.0	7.8	83.0	86.26
84						18.7	11.2	13.4	16.4	20.0	15.7	11.5	107.0	76.63
82						21.2	23.7	17.5	23.1	21.0	21.4	15.1	142.9	67.01

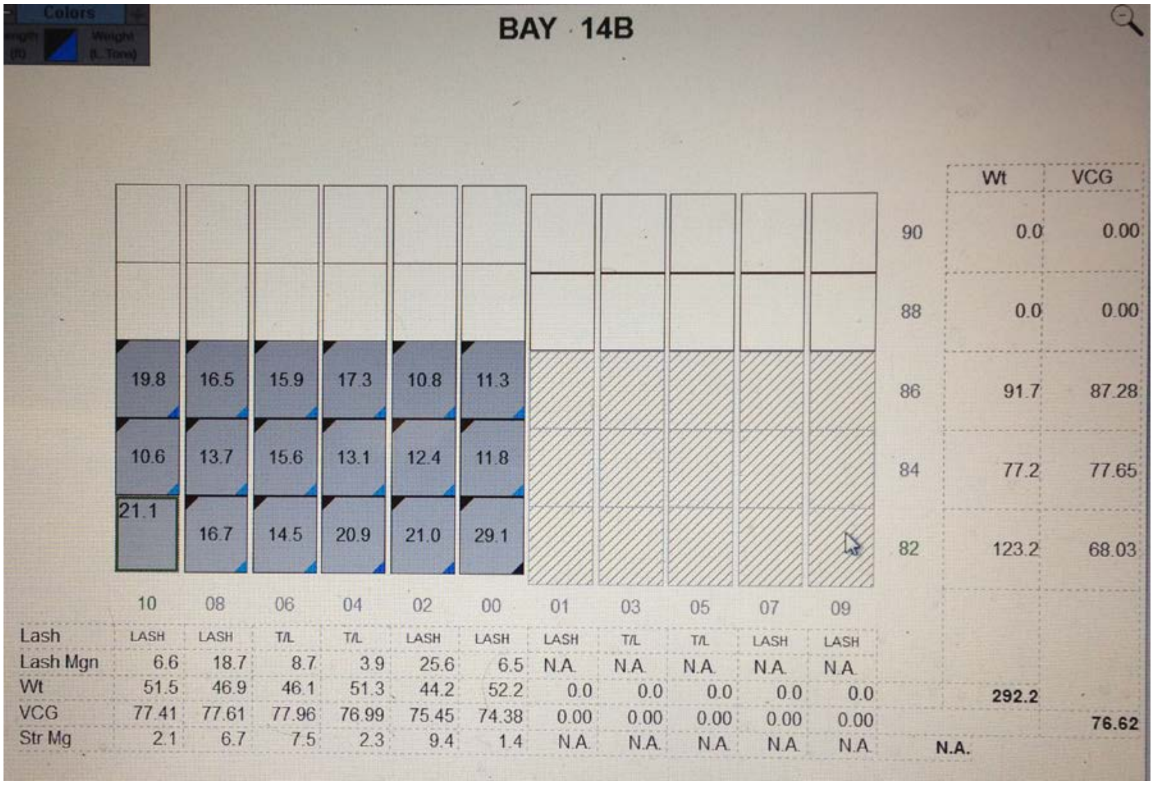
	12	10	08	06	04	02	01	03	05	07	09	11		
Lash	LASH	LASH	T/L	LASH	LASH	LASH	LASH	T/L	T/L	T/L	LASH	LASH		
Lash Mgn	N.A.	N.A.	N.A.	N.A.	N.A.	11.0	23.8	16.2	5.2	5.1	20.1	18.8		
Wt	0.0	0.0	0.0	0.0	0.0	52.7	47.2	40.2	54.2	53.2	51.1	34.3	332.9	
VCG	0.00	0.00	0.00	0.00	0.00	75.11	74.31	74.65	75.12	75.07	75.24	74.59		74.90
Str Mg	N.A.	N.A.	N.A.	N.A.	N.A.	0.9	6.4	13.4	-0.6	18.2	20.3	37.1	N.A.	

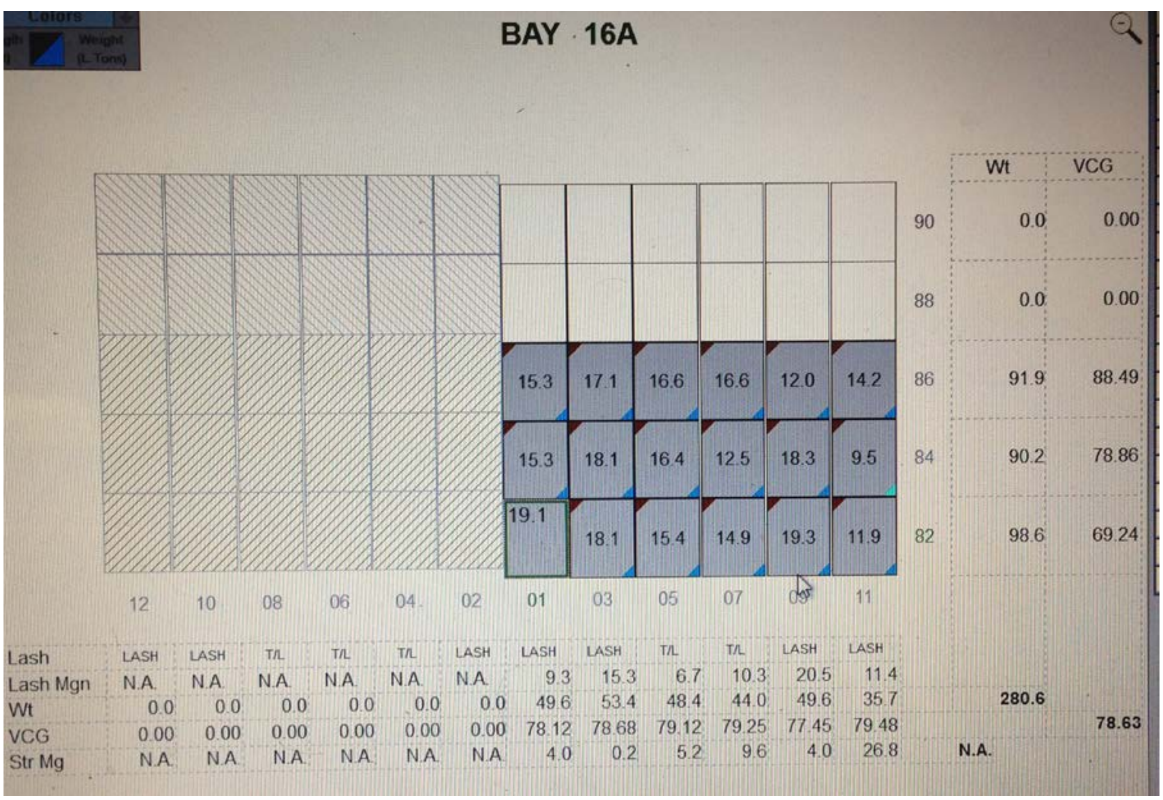


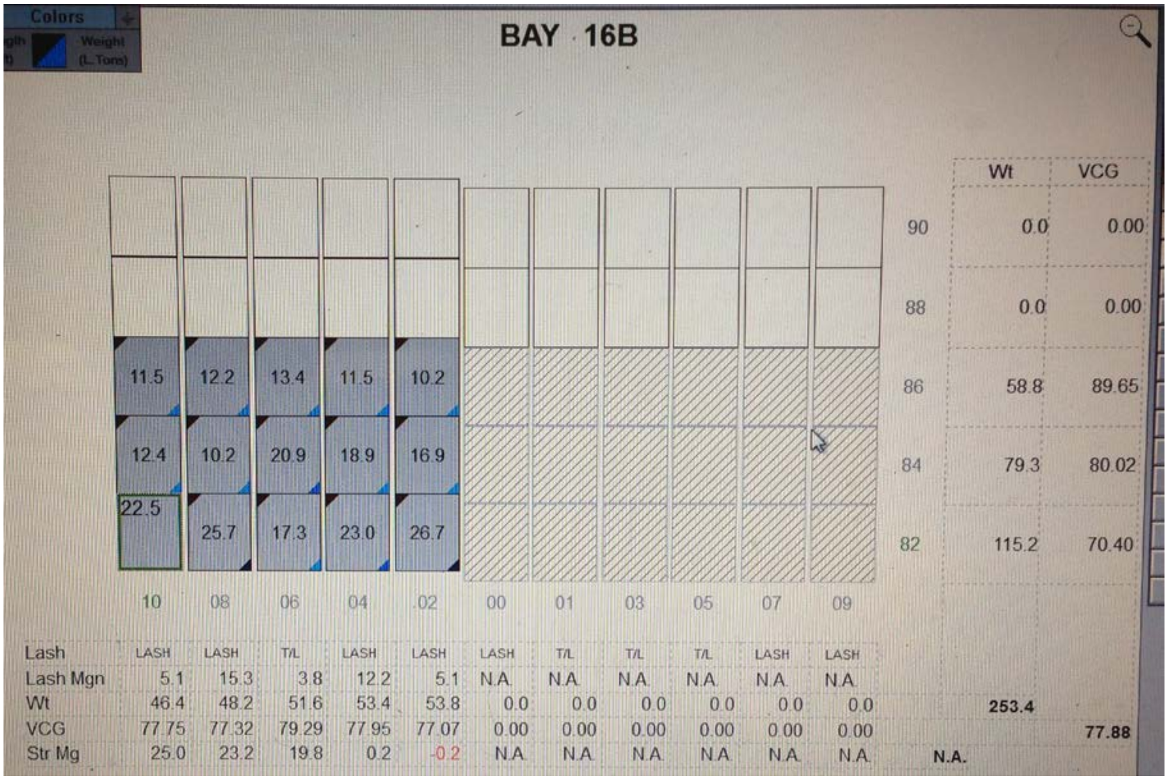
BAY 14A

Tier	12	10	08	06	04	02	01	03	05	07	09	11	Wt	VCG
90													0.0	0.00
88													0.0	0.00
86								15.3	10.8	20.2	16.3	6.8	69.4	86.12
84								10.7	19.4	11.6	10.0	18.3	70.1	76.49
82								27.3	22.0	19.5	21.7	23.5	114.0	66.87

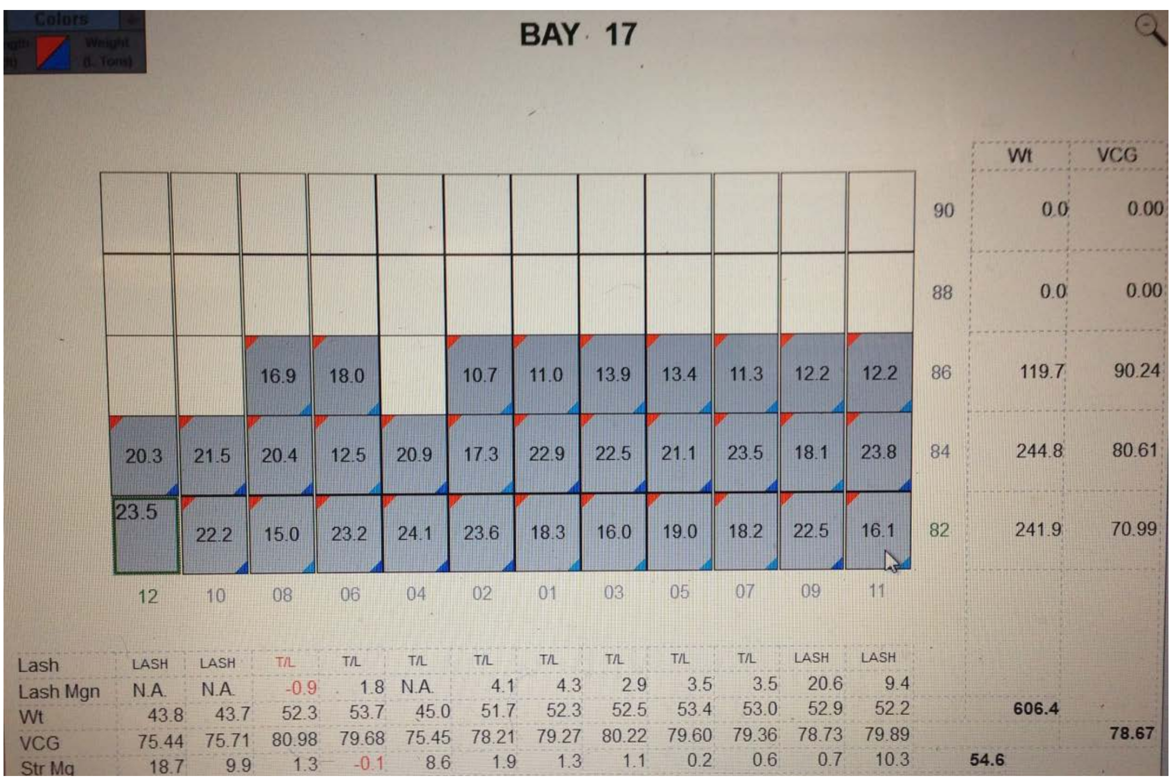
	12	10	08	06	04	02	01	03	05	07	09	11		
Lash	LASH	LASH	T/L	T/L	T/L	T/L	T/L	LASH	LASH	T/L	LASH	LASH		
Lash Mgn	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	12.5	22.0	6.1	19.9	17.3		
Wt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.3	52.3	51.3	48.0	48.6	253.5	
VCG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.32	74.43	76.62	75.43	73.18		74.80
Str Mg	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.3	1.3	2.3	5.6	5.0	N.A.	

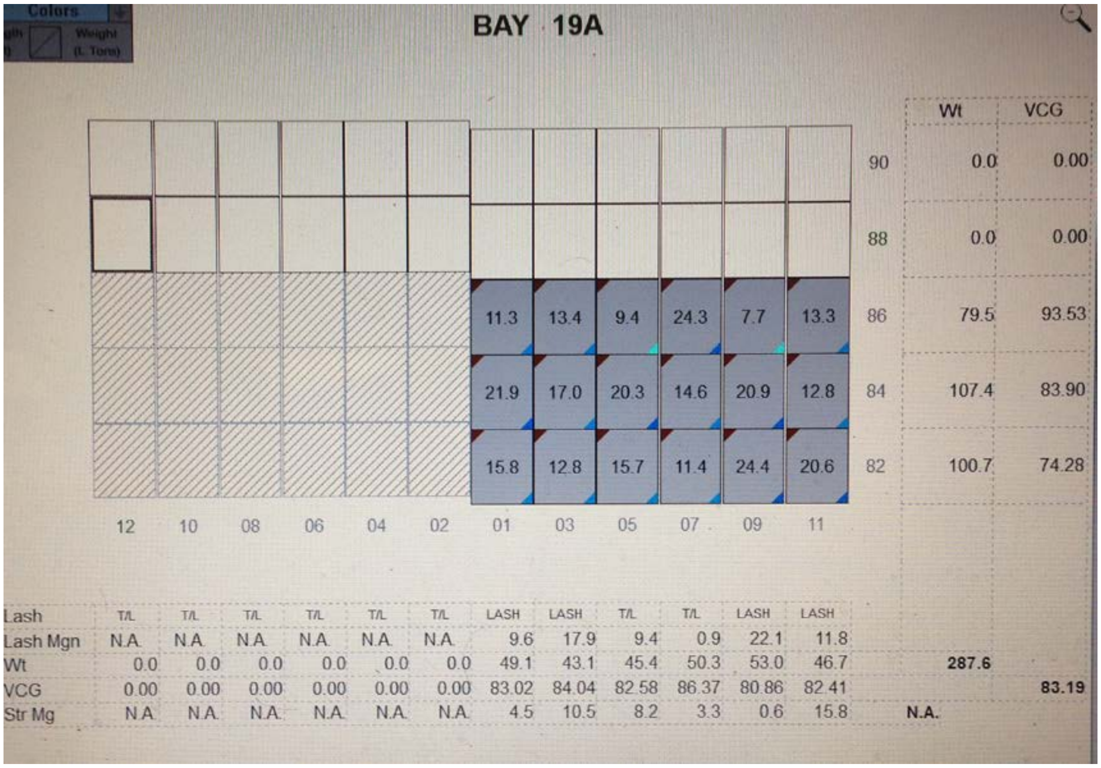

BAY 14B
Colors
Weight (L.Tons)
Wt VCG
90 0.0 0.00
88 0.0 0.00
86 91.7 87.28
84 77.2 77.65
82 123.2 68.03
19.8 16.5 15.9 17.3 10.8 11.3
10.6 13.7 15.6 13.1 12.4 11.8
21.1 16.7 14.5 20.9 21.0 29.1
10 08 06 04 02 00 01 03 05 07 09
Lash LASH LASH T/L T/L LASH LASH LASH T/L T/L LASH LASH
Lash Mgn 6.6 18.7 8.7 3.9 25.6 6.5 N.A. N.A. N.A. N.A. N.A.
Wt 51.5 46.9 46.1 51.3 44.2 52.2 0.0 0.0 0.0 0.0 0.0 292.2
VCG 77.41 77.61 77.96 76.99 75.45 74.38 0.00 0.00 0.00 0.00 0.00 76.62
Str Mg 2.1 6.7 7.5 2.3 9.4 1.4 N.A. N.A. N.A. N.A. N.A. N.A.


BAY 16A
Colors
Weight (L.Tons)
Wt VCG
90 0.0 0.00
88 0.0 0.00
86 91.9 88.49
84 90.2 78.86
82 98.6 69.24
15.3 17.1 16.6 16.6 12.0 14.2
15.3 18.1 16.4 12.5 18.3 9.5
19.1 18.1 15.4 14.9 19.3 11.9
12 10 08 06 04 02 01 03 05 07 09 11
Lash LASH LASH T/L T/L T/L LASH LASH LASH T/L T/L LASH LASH
Lash Mgn N.A. N.A. N.A. N.A. N.A. N.A. 9.3 15.3 6.7 10.3 20.5 11.4
Wt 0.0 0.0 0.0 0.0 0.0 0.0 49.6 53.4 48.4 44.0 49.6 35.7 280.6
VCG 0.00 0.00 0.00 0.00 0.00 0.00 78.12 78.68 79.12 79.25 77.45 79.48 78.63
Str Mg N.A. N.A. N.A. N.A. N.A. N.A. 4.0 0.2 5.2 9.6 4.0 26.8 N.A.


Colors
Weight (L.Tons)
BAY 16B
Wt VCG
90 0.0 0.00
88 0.0 0.00
86 58.8 89.65
84 79.3 80.02
82 115.2 70.40
11.5 12.2 13.4 11.5 10.2
12.4 10.2 20.9 18.9 16.9
22.5 25.7 17.3 23.0 26.7
10 08 06 04 02 00 01 03 05 07 09
Lash LASH LASH T/L LASH LASH LASH T/L T/L T/L LASH LASH
Lash Mgn 5.1 15.3 3.8 12.2 5.1 N.A. N.A. N.A. N.A. N.A. N.A.
Wt 46.4 48.2 51.6 53.4 53.8 0.0 0.0 0.0 0.0 0.0 0.0 253.4
VCG 77.75 77.32 79.29 77.95 77.07 0.00 0.00 0.00 0.00 0.00 0.00 77.88
Str Mg 25.0 23.2 19.8 0.2 -0.2 N.A. N.A. N.A. N.A. N.A. N.A. N.A.

\

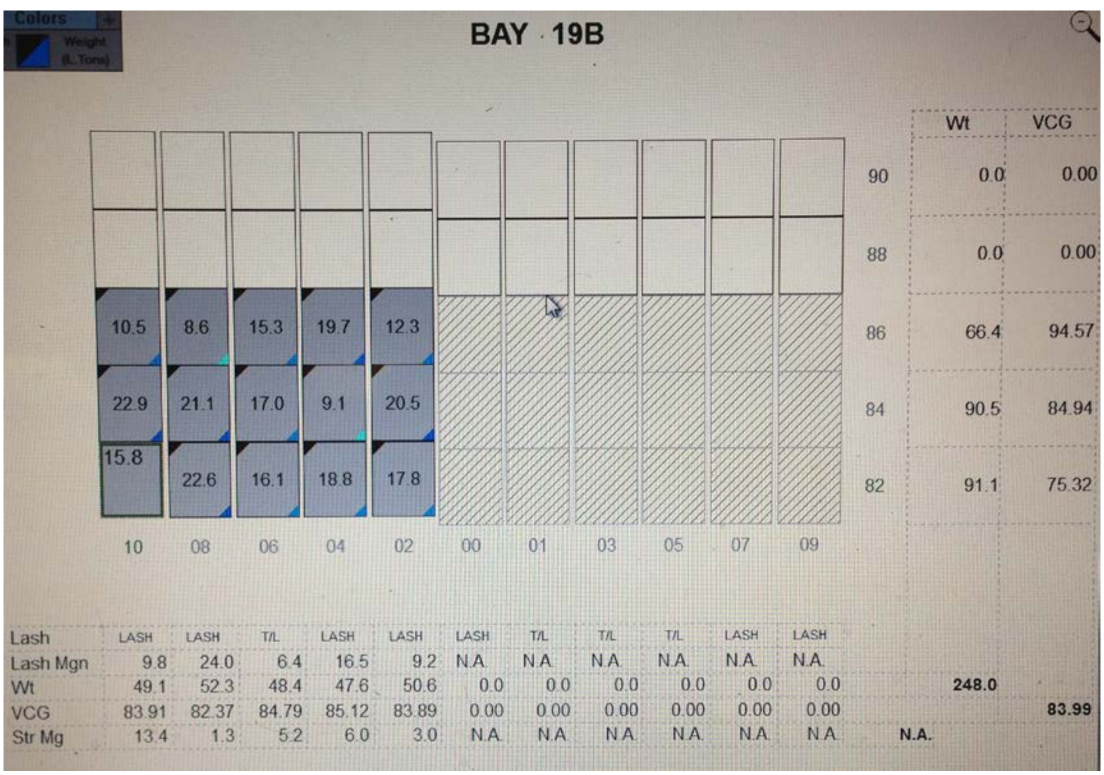

Colors
Weight (L.Tons)
BAY 17
Wt VCG
90 0.0 0.00
88 0.0 0.00
86 119.7 90.24
84 244.8 80.61
82 241.9 70.99
16.9 18.0 10.7 11.0 13.9 13.4 11.3 12.2 12.2
20.3 21.5 20.4 12.5 20.9 17.3 22.9 22.5 21.1 23.5 18.1 23.8
23.5 22.2 15.0 23.2 24.1 23.6 18.3 16.0 19.0 18.2 22.5 16.1
12 10 08 06 04 02 01 03 05 07 09 11
Lash LASH LASH T/L T/L T/L T/L T/L T/L T/L T/L LASH LASH
Lash Mgn N.A. N.A. -0.9 1.8 N.A. 4.1 4.3 2.9 3.5 3.5 20.6 9.4
Wt 43.8 43.7 52.3 53.7 45.0 51.7 52.3 52.5 53.4 53.0 52.9 52.2 606.4
VCG 75.44 75.71 80.98 79.68 75.45 78.21 79.27 80.22 79.60 79.36 78.73 79.89 78.67
Str Mg 18.7 9.9 1.3 -0.1 8.6 1.9 1.3 1.1 0.2 0.6 0.7 10.3 54.6



BAY 19A

Tier	12	10	08	06	04	02	01	03	05	07	09	11	Wt	VCG
90													0.0	0.00
88													0.0	0.00
86							11.3	13.4	9.4	24.3	7.7	13.3	79.5	93.53
84							21.9	17.0	20.3	14.6	20.9	12.8	107.4	83.90
82							15.8	12.8	15.7	11.4	24.4	20.6	100.7	74.28

	12	10	08	06	04	02	01	03	05	07	09	11		
Lash	T/L	T/L	T/L	T/L	T/L	T/L	LASH	LASH	T/L	T/L	LASH	LASH		
Lash Mgn	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	9.6	17.9	9.4	0.9	22.1	11.8		
Wt	0.0	0.0	0.0	0.0	0.0	0.0	49.1	43.1	45.4	50.3	53.0	46.7	**287.6**	
VCG	0.00	0.00	0.00	0.00	0.00	0.00	83.02	84.04	82.58	86.37	80.86	82.41		**83.19**
Str Mg	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	4.5	10.5	8.2	3.3	0.6	15.8	**N.A.**	



BAY 19B

Tier	10	08	06	04	02	00	01	03	05	07	09	Wt	VCG
90												0.0	0.00
88												0.0	0.00
86	10.5	8.6	15.3	19.7	12.3							66.4	94.57
84	22.9	21.1	17.0	9.1	20.5							90.5	84.94
82	15.8	22.6	16.1	18.8	17.8							91.1	75.32

	10	08	06	04	02	00	01	03	05	07	09		
Lash	LASH	LASH	T/L	LASH	LASH	LASH	T/L	T/L	T/L	LASH	LASH		
Lash Mgn	9.8	24.0	6.4	16.5	9.2	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.		
Wt	49.1	52.3	48.4	47.6	50.6	0.0	0.0	0.0	0.0	0.0	0.0	**248.0**	
VCG	83.91	82.37	84.79	85.12	83.89	0.00	0.00	0.00	0.00	0.00	0.00		**83.99**
Str Mg	13.4	1.3	5.2	6.0	3.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	**N.A.**	

Exhibit D

A These, even if they got put on a button because they're in a thwart position, they'd get two chains in the front and the back. But a lot of times, this section of the boat, we couldn't necessarily land them on but ons, so they got six.

Q Which ones would get six on this bun?

A The ones in the thwart position.

Q The ones in the thwart position. What about the ones that are oriented fore and aft?

A They would get the two in the back if they were on a button and four -- six total if they were not on a button.

Q Okay. So these did not always get the four chains unless -- except the ones on the fore ship orientation.

A Correct.

Q So before we move on from second deck, during Mr. Callaway's testimony in the first hearing, there was some discussion about buttons and some of the trailers stowed off the button. He indicated that it was more common on the second deck. It was more difficult to land on the button. Is that your recollection?

A Absolutely.

Q So can you explain that in a little more detail? So this discussion that we just had, we went down second deck, and you described who I think is the standard, the ideal, and that's -- that ideal would include a provision that if you were able to get it on the button, but if it's uncommon for them to land on the button, can you walk us through for the final voyage to the best of your recollection, what you did encounter as far as how many were on the button versus not?

A I --

Q -- or what was typical?

A I have no recollection of the exact number, because, I mean, the boats -- both boats we got in a week were so similar, they just -- you know, a week later, you couldn't remember which boat it was that you did so-and-so.

But if anything on deck 2 that was not on a button got four chains in the front and four chains -- two chains in the back. There would be two chains on the container forward and then you'd have two chains on the box, the sun box as we called them, pulling it back. But deck 2 was definitely -- especially on the *El Faro*, I do -- that one had the least amount of buttons as compared to the other boat. So a lot of times, I would say, 60 percent of the cargo on deck 2 would not necessarily make it on a button, and it would have to have the six chains.

Exhibit E

NATIONAL TRANSPORTATION SAFETY BOARD

```
--------------------------
IN RE:                    :
                          : NTSB Accident No.
THE EL FARO INCIDENT OFF  : DCA16MM001
THE COAST OF THE BAHAMAS  :
ON OCTOBER 1, 2015        :
--------------------------
```

INTERVIEW OF: CAPT. JOHN HEARN

Wednesday,
March 30, 2016

Smith, Katzenstein & Jenkins, LLP
Wilmington, Delaware

BEFORE:

MIKE KUCHARSKI, NTSB
CARRIE BELL, NTSB
JON FURUKAWA, NTSB
MIKE RICHARDS, NTSB*
TOM ROTH-ROFFY, Investigator-in-Charge, NTSB
ERIC STOLZENBERG, NTSB*
MIKE MILLAR, ABS*
PATTY FINSTERBUSCH, TOTE Services*
JIM FISKER-ANDERSON, TOTE Services*
LEE PETERSON, TOTE Services*
KEVIN STITH, TOTE Services*
CDR MATT DENNING, USCG*
KEITH FAWCETT, USCG*
CAPT JASON NEUBAUER, USCG
MIKE ODOM, USCG*

*Present via teleconference

This transcript was produced from audio provided by the National Transportation Safety Board.

INVESTIGATOR KUCHARSKI: While you were on-board the vessel, were there a substantial number of off-button stows?

CAPT. HEARN: Not really, no. Most -- if you went down below deck, most of the stows below decks were on a button, unless it was a vehicle that didn't -- wasn't configured to go on a button. So I would say over 90 percent would always be on a button. If it was a case where it was not on a button, there was extra latches put on the roloc box.

INVESTIGATOR KUCHARSKI: And did these -- the ones that were -- the 10 percent that were off-buttoned, did that vary by any season?

CAPT. HEARN: No, not that I remember.

INVESTIGATOR KUCHARSKI: Do you know if the -- somehow the off-button stows were annotated or indicated on any of the stow plans?

CAPT. HEARN: No, they wouldn't be done that way. The chief mate when he was checking cargo would look for that kind of an issue and if the longshoreman didn't latch it correctly, then he would make sure it was done or he would have the crew do it during voyage and try to keep up with it.

INVESTIGATOR KUCHARSKI: Do you know if there was a list of the locations of all fixed cargo securing devices, like D-rings, buttons, pad-eyes, for the El Faro?

CAPT. HEARN: There was an approximate list, but it had changed depending on the operation, especially the El Faro. She had come to SeaStar to be on the Puerto Rican Run, but almost immediately she was transferred to the -- to what -- Charter Service to go to the Mid East. So she was carrying heavy tanks on that run.

And we had added a lot of D-rings on the second deck, which gave that ship a lot more flexibility to secure cargo. So she was, of the class, the best on that deck with extra lashing points.

INVESTIGATOR KUCHARSKI: On the second deck?

CAPT. HEARN: On the second deck.

INVESTIGATOR KUCHARSKI: Um-hum.

CAPT. HEARN: The lower decks had different configurations. They had clover leafs until you got to the tank top and the tank top level had D-rings again welded into the deck.

INVESTIGATOR KUCHARSKI: So you said that the El Faro had the greater capability, D-ring capability?

CAPT. HEARN: Yes, it did.

INVESTIGATOR KUCHARSKI: And that was

predominately on the second deck that those were added?

CAPT. HEARN: Correct. For vehicles. That's to -- you know, the upper deck -- I mean, we are talking about vehicles. We are talking about those type of lashing points. It had about the right flexibility for stows with the roloc box and the pin that went and held those trailers. They were designated stows and they didn't get that much cargo on the ship that was vehicle/ trailer cargo that they weren't prepare for.

So we usually knew what we were getting with that. And it went into a stow position where it could be handled. And because that ship had the extra D-rings, even if it was a different size, it wasn't a standard size trailer, there was usually cargo lashings in position for it normally, you know, through the ship.

INVESTIGATOR KUCHARSKI: Um-hum. Do you know if there was any -- and I would like to break this into the Alaska Run and I would like to then go to the Puerto Rican Run.

CAPT. HEARN: Okay.

INVESTIGATOR KUCHARSKI: Was there a testing program in place for the permanent securing arrangements on the vessel?

Exhibit F

To: Tote Service, Inc. / Sea Star Line.		Voyage:	185
From:	SS EL FARO	Z.D.:	+4
Date:	09/30/15		
Subject:	NOON REPORT		

Geographic Position:	LAT: 27 - 24.4 N		LONG: 077 - 29.1 W
Drafts:	FWD:		AFT:

		Last Day Run	Voyage Totals
B	Course:	139	
C	Distance To Go:	828	
D	ETA:	10/02/0800	Joaquin
E	Speed:	19.3 K	19.3 K
F	Wind (Dir/Force):	N 3	
G	Sea Condition (Dir/Ht(ft)):	NNW 1	
H	Swell (Dir/Ht(ft)):	ENE 7	
I	Length of Day / Total Time:	14.2 H	14.2 H
J	Observed Miles:	274	274
K	Engine Miles:	349	349
L	Slip:	21.49%	21.49%
M	Avg. RPM:	114.39	114.39
N	Shaft (Brake) HP:	28,000	28,000
O	Bunkers Onboard bbls/LT:	7621 / 1172	---
P	Bunkers Consumed bbls/LT:	580 / 89	580 / 89
Q	Mileage Inbound:		
R	Bunkers Consumed Last Port bbls/LT:		260 / 40
S	ETD / Next Port:		

T Remarks:

HP 1st Stage:	440
LP Ext Temp:	115
Vacuum:	27.3
SW in/out(F):	82 / 93
#Main Circ:	F/A
Cond. Temp (hotwell):	108
Cond. Temp (shell):	106
H2O Made:(L/T)	11
Distilled Used:(L/T)	10
Potable Used:(L/T)	8
Water On Board:	338

NOTES: Precautions observed regarding Hurricane Joaquin.

TSI-V-DCK-008 Rev 2/13

Exhibit G

Annex 13 - CALCULATION			**Hold A Maximun Weight**						
			pounds	81700					
L=	**223.7**		Cargo WT=	**37.07**	Table 4 CSM				
Vk=	**19.5**		Wt. Button	14.27	0.385	0.385	0.5		
B=	**28**		Wt. Wheels	22.80	0.615	0.615	0.5		
GM=	**1.31**			18.53					
B/GM=	21.37								
		CSS		Acceleration Correction			9.81		
	a_t=	4.29		F1=	0.4498	6.2	0.54		
	a_l=	1.38		F2=	0.2414	2	0.22		
	a_v=	6.36		f=	0.6912	9.2	1.97		
	Applied forces								
	Transverse	**79.42**	79.42	**158.85**					
	Longitudinal	25.62	51.24						
	Vertical	117.86	235.71			μ=	0.4	0.1	
						α=	60	1.0471 sin	0.8660
	Restraining Forces		Wheels	Button off	button on	f=	0.8465	0.5867 cos	0.5001
	chain 1	15.84		15.83997					
	chain 2	15.84		15.83997			27		
	Chain 3	22.8545	22.85446				27		
	Chain 4						27		
	friction w	44.7285	89.45705						
	friction b	18.1823		14.00039			total off button		
		117.445	**112.3115**	45.68033	355.00		**157.9918**		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
Vertical Az	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION			**Hold B Maximun Weight**						
			pounds	112000					
L=	**223.7**		Cargo WT=	**50.82**	Table 4 CSM				
Vk=	**19.5**		Wt. Button	19.56	0.385	0.385	0.5		
B=	**28**		Wt. Wheels	31.25	0.615	0.615	0.5		
GM=	**1.31**			25.41					
B/GM=	21.37								
		CSS		Acceleration Correction			9.81		
	a_t=	3.87		F1=	0.4498	5.6	0.54		
	a_l=	1.38		F2=	0.2414	2	0.22		
	a_v=	5.25		f=	0.6912	7.6	1.97		
	Applied forces								
	Transverse	**98.34**	98.34	**196.69**					
	Longitudinal	35.12	70.25				wheel	off button	
	Vertical	133.47	266.93			μ=	0.4	0.1	
						α=	60	1.0471 sin	0.8660
	Restraining Forces		Wheels	Button off	button on	f=	0.8465	0.5867 cos	0.5001
	chain 1	15.83997		15.83997					
	chain 2	15.83997		15.83997			27		
	Chain 3	22.85446	22.85446				27		
	Chain 4						27		
	friction w	61.31695	122.6339						
	friction b	24.92559		19.1927			total off		
		140.7769	**145.4884**	50.87264	355.00		**196.361**		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
Vertical Az										
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION			**Maximum Weight Hold D**						
			pounds	118500					
L=	**223.7**		Cargo WT=	**53.77**	Table 4 CSM				
Vk=	**19.5**		Wt. Button	20.70	0.385	0.385	0.5		
B=	**28**		Wt. Wheels	33.07	0.615	0.615	0.5		
GM=	**1.31**			26.88					
B/GM=	21.37								
		CSS		Acceleration Correction			9.81		
a_t=		3.80		F1=	0.4498	5.5	0.54		
a_l=		1.38		F2=	0.2414	2	0.22		
a_v=		3.46		f=	0.6912	5	1.97		
Applied forces									
Transverse		**102.19**	102.19	**204.39**					
Longitudinal		37.16	74.32				wheel	off button	
Vertical		92.90	185.81			μ=	0.4	0.1	
						α=	60	1.0471 sin	0.8660
Restraining Forces			Wheels	Button off	button on	f=	0.8465	0.5867 cos	0.5001
chain 1		15.83997		15.83997					
chain 2		15.83997		15.83997			27		
Chain 3		22.85446	22.85446				27		
Chain 4							27		
friction w		64.87552	129.751						
friction b		26.37216		20.30657			total off		
		145.7821	**152.6055**	51.9865	355.00		**204.592**		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Exhibit H

Annex 13 - CALCULATION			**Hold A**						
			pounds	79000					
L=	**223.7**		Cargo WT=	**35.84**	Table 4 CSM				
Vk=	**19.5**		Wt. Button	13.80	0.385	0.385	0.5		
B=	**28**		Wt. Wheels	22.04	0.615	0.615	0.5		
GM=	**1.31**			17.92					
B/GM=	21.37								
		CSS		Acceleration Correction			9.81		
	a_t=	4.29		F1=	0.4498	6.2	0.54		
	a_l=	1.38		F2=	0.2414	2	0.22		
	a_v=	6.36		f=	0.6912	9.2	1.97		
	Applied forces								
	Transverse	**76.80**	76.80	**153.60**					
	Longitudinal	24.77	49.55						
	Vertical	113.96	227.92			μ=	0.4	0.1	
						α=	60	1.0471 sin	0.8660
	Restraining Forces		Wheels	Button off	button on	f=	0.8465	0.5867 cos	0.5001
	chain 1	15.84		15.83997					
	chain 2	15.84		15.83997			27		
	Chain 3	22.8545	22.85446				27		
	Chain 4						27		
	friction w	43.2503	86.5007						
	friction b	17.5814		13.53771			total off button		
		115.366	**109.3552**	45.21765	355.00		**154.5728**		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION			**Hold B**						
			pounds	78000					
L=	**223.7**		Cargo WT=	**35.39**	Table 4 CSM				
Vk=	**19.5**		Wt. Button	13.63	0.385	0.385	0.5		
B=	**28**		Wt. Wheels	21.76	0.615	0.615	0.5		
GM=	**1.31**			17.70					
B/GM=	21.37								
		CSS		Acceleration Correction			9.81		
	a_t=	3.87		F1=	0.4498	5.6	0.54		
	a_l=	1.38		F2=	0.2414	2	0.22		
	a_v=	5.25		f=	0.6912	7.6	1.97		
	Applied forces								
	Transverse	**68.49**	68.49	**136.98**					
	Longitudinal	24.46	48.92				wheel	off button	
	Vertical	92.95	185.90			μ=	0.4	0.1	
						α=	60	1.0471 sin	0.8660
	Restraining Forces		Wheels	Button off	button on	f=	0.8465	0.5867 cos	0.5001
	chain 1	15.83997		15.83997					
	chain 2	15.83997		15.83997			27		
	Chain 3	22.85446	22.85446				27		
	Chain 4						27		
	friction w	42.70288	85.40575						
	friction b	17.35889		13.36635			total off		
		114.5962	**108.2602**	45.04628	355.00		**153.3065**		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION			**Hold C**						
			pounds	76000					
L=	**223.7**		Cargo WT=	**34.48**	Table 4 CSM				
Vk=	**19.5**		Wt. Button	13.28	0.385	0.385	0.5		
B=	**28**		Wt. Wheels	21.21	0.615	0.615	0.5		
GM=	**1.31**			17.24					
B/GM=	21.37								
	CSS		Acceleration Correction				9.81		
a_t=		3.73		F1=	0.4498	5.4	0.54		
a_l=		1.38		F2=	0.2414	2	0.22		
a_v=		2.97		f=	0.6912	4.3	1.97		
Applied forces									
Transverse		**64.35**	64.35	**128.70**					
Longitudinal		23.83	47.67				wheel	off button	
Vertical		51.24	102.48			μ=	0.4	0.1	
						α=	60	1.0471 sin	0.8660
Restraining Forces			Wheels	Button off	button on	f=	0.8465	0.5867 cos	0.5001
chain 1		15.83997		15.84					
chain 2		15.83997		15.84			27		
Chain 3		22.85446	22.8545				27		
Chain 4							27		
friction w		41.60793	83.2159						
friction b		16.91379		13.0236			total off button		
		113.0561	**106.07**	44.7036	355.00		**150.7739**		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
Vertical Az	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION **Hold D**

		pounds	80000			
L=	**223.7**	Cargo WT=	**36.30**	Table 4 CSM		
Vk=	**19.5**	Wt. Button	13.97	0.385	0.385	0.5
B=	**28**	Wt. Wheels	22.32	0.615	0.615	0.5
GM=	**1.31**		18.15			
B/GM=	21.37					

CSS		Acceleration Correction			9.81
a_t=	3.80	F1=	0.4498	5.5	0.54
a_l=	1.38	F2=	0.2414	2	0.22
a_v=	3.46	f=	0.6912	5	1.97

Applied forces

Transverse	**68.99**	68.99	**137.98**						
Longitudinal	25.09	50.18				wheel	off button		
Vertical	62.72	125.44			μ=	0.4	0.1		
					α=	60	1.0471	sin	0.8660

Restraining Forces	Wheels	Button off	button on						
				f=	0.8465	0.5867	cos	0.5001	
chain 1	15.83997		15.83997						
chain 2	15.83997		15.83997				27		
Chain 3	22.85446	22.85446					27		
Chain 4							27		
friction w	43.79782	87.59564							
friction b	17.80399		13.70907			total off			
	116.1362	**110.4501**	45.38901	355.00		**155.8391**			

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION			**Hold E**							
			pounds	75000						
L=	**223.7**		Cargo WT=	**34.03**	Table 4 CSM					
Vk=	**19.5**		Wt. Button	13.10	0.385	0.385	0.5			
B=	**28**		Wt. Wheels	20.93	0.615	0.615	0.5			
GM=	**1.31**			17.01						
B/GM=	21.37									
		CSS		Acceleration Correction			9.81			
a_t=		4.08		F1=	0.4498	5.9	0.54			
a_l=		1.38		F2=	0.2414	2	0.22			
a_v=		5.25		f=	0.6912	7.6	1.97			
Applied forces										
Transverse		**69.38**	69.38	**138.77**						
Longitudinal		23.52	47.04				wheel	off button		
Vertical		89.38	178.75			μ=	0.4	0.1		
						α=	60	1.0471	sin	0.8660
Restraining Forces			Wheels	Button off	button on	f=	0.8465	0.5867	cos	0.5001
chain 1		15.83997		15.84						
chain 2		15.83997		15.84			27			
Chain 3		22.85446	22.85446				27			
Chain 4							27			
friction w		41.06046	82.12092							
friction b		16.69124		12.8523			total off button			
		112.2861	**104.9754**	44.5322	355.00		**149.508**			

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION			**Hold F**							
			pounds	75000						
L=	**223.7**		Cargo WT=	**34.03**	Table 4 CSM					
Vk=	**19.5**		Wt. Button	13.10	0.385	0.385	0.5			
B=	**28**		Wt. Wheels	20.93	0.615	0.615	0.5			
GM=	**1.31**			17.01						
B/GM=	21.37									
		CSS		Acceleration Correction			9.81			
	a_t=	4.08		F1=	0.4498	5.9	0.54			
	a_l=	1.38		F2=	0.2414	2	0.22			
	a_v=	5.25		f=	0.6912	7.6	1.97			
	Applied forces									
	Transverse	**69.38**	69.38	**138.77**						
	Longitudinal	23.52	47.04				wheel	off button		
	Vertical	89.38	178.75			μ=	0.4	0.1		
						α=	60	1.0471	sin	0.8660
	Restraining Forces		Wheels	Button off	button on	f=	0.8465	0.5867	cos	0.5001
	chain 1	15.83997		15.84						
	chain 2	15.83997		15.84			27			
	Chain 3	22.85446	22.85446				27			
	Chain 4						27			
	friction w	41.06046	82.12092							
	friction b	16.69124		12.8523			total off button			
		112.2861	**104.9754**	44.5322	355.00		**149.508**			

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Exhibit I

Annex 13 - CALCULATION			**Hold A**						
			pounds	79000					
L=	**223.7**		Cargo WT=	**35.84**	Table 4 CSM				
Vk=	**19.5**		Wt. Button	13.80	0.385	0.385	0.5		
B=	**28**		Wt. Wheels	22.04	0.615	0.615	0.5		
GM=	**1.31**			17.92					
B/GM=	21.37								
		CSS		Acceleration Correction			9.81		
	a_t=	4.29		F1=	0.4498	6.2	0.54		
	a_l=	1.38		F2=	0.2414	2	0.22		
	a_v=	6.36		f=	0.6912	9.2	1.97		
	Applied forces								
	Transverse	**76.80**	76.80	**153.60**					
	Longitudinal	24.77	49.55						
	Vertical	113.96	227.92			μ=	0.4	0.1	
						α=	45	0.7853 sin	0.7071
	Restraining Forces		Wheels	Button off	button on	f=	0.9900	0.7779 cos	0.7071
	chain 1	21.0021		21.00207					
	chain 2	21.0021		21.00207			27		
	Chain 3	26.7293	26.7293				27		
	Chain 4						27		
	friction w	43.2503	86.5007						
	friction b	17.5814		13.53771			total off button		
		129.565	**113.23**	55.54184	355.00		**168.7718**		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
Vertical Az	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION			**Hold B**						
			pounds	78000					
L=	**223.7**		Cargo WT=	**35.39**	Table 4 CSM				
Vk=	**19.5**		Wt. Button	13.63	0.385	0.385	0.5		
B=	**28**		Wt. Wheels	21.76	0.615	0.615	0.5		
GM=	**1.31**			17.70					
B/GM=	21.37								
		CSS		Acceleration Correction			9.81		
a_t=		3.87		F1=	0.4498	5.6	0.54		
a_l=		1.38		F2=	0.2414	2	0.22		
a_v=		5.25		f=	0.6912	7.6	1.97		
Applied forces									
Transverse		**68.49**	68.49	**136.98**					
Longitudinal		24.46	48.92				wheel	off button	
Vertical		92.95	185.90			μ=	0.4	0.1	
						α=	45	0.7853 sin	0.7071
Restraining Forces			Wheels	Button off	button on	f=	0.9900	0.7779 cos	0.7071
chain 1		21.00207		21.00207					
chain 2		21.00207		21.00207			27		
Chain 3		26.7293	26.7293				27		
Chain 4							27		
friction w		42.70288	85.40575						
friction b		17.35889		13.36635			total off		
		128.7952	**112.1351**	55.37048	355.00		**167.5055**		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION			**Hold C**						
			pounds	76000					
L=	**223.7**		Cargo WT=	**34.48**	Table 4 CSM				
Vk=	**19.5**		Wt. Button	13.28	0.385	0.385	0.5		
B=	**28**		Wt. Wheels	21.21	0.615	0.615	0.5		
GM=	**1.31**			17.24					
B/GM=	21.37								
		CSS		Acceleration Correction			9.81		
a_t=		3.73		F1=	0.4498	5.4	0.54		
a_l=		1.38		F2=	0.2414	2	0.22		
a_v=		2.97		f=	0.6912	4.3	1.97		
Applied forces									
Transverse		**64.35**	64.35	**128.70**					
Longitudinal		23.83	47.67				wheel	off button	
Vertical		51.24	102.48			μ=	0.4	0.1	
						α=	45	0.7853 sin	0.7071
Restraining Forces			Wheels	Button off	button on	f=	0.9900	0.7779 cos	0.7071
chain 1		21.00207		21.0021					
chain 2		21.00207		21.0021			27		
Chain 3		26.7293	26.7293				27		
Chain 4							27		
friction w		41.60793	83.2159						
friction b		16.91379		13.0236			total off button		
		127.2552	**109.945**	55.0278	355.00		**164.9729**		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION			**Hold D**						
			pounds	80000					
L=	**223.7**		Cargo WT=	**36.30**	Table 4 CSM				
Vk=	**19.5**		Wt. Button	13.97	0.385	0.385	0.5		
B=	**28**		Wt. Wheels	22.32	0.615	0.615	0.5		
GM=	**1.31**			18.15					
B/GM=	21.37								
		CSS		Acceleration Correction			9.81		
	a_t=	3.80		F1=	0.4498	5.5	0.54		
	a_l=	1.38		F2=	0.2414	2	0.22		
	a_v=	3.46		f=	0.6912	5	1.97		
	Applied forces								
	Transverse	**68.99**	68.99	**137.98**					
	Longitudinal	25.09	50.18				wheel	off button	
	Vertical	62.72	125.44			μ=	0.4	0.1	
						α=	45	0.7853 sin	0.7071
	Restraining Forces		Wheels	Button off	button on	f=	0.9900	0.7779 cos	0.7071
	chain 1	21.00207		21.00207					
	chain 2	21.00207		21.00207			27		
	Chain 3	26.7293	26.7293				27		
	Chain 4						27		
	friction w	43.79782	87.59564						
	friction b	17.80399		13.70907			total off		
		130.3352	**114.3249**	55.71321	355.00		**170.0381**		

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION			**Hold E**							
			pounds	75000						
L=	**223.7**		Cargo WT=	**34.03**	Table 4 CSM					
Vk=	**19.5**		Wt. Button	13.10	0.385	0.385	0.5			
B=	**28**		Wt. Wheels	20.93	0.615	0.615	0.5			
GM=	**1.31**			17.01						
B/GM=	21.37									
		CSS		Acceleration Correction			9.81			
	a_t=	4.08		F1=	0.4498	5.9	0.54			
	a_l=	1.38		F2=	0.2414	2	0.22			
	a_v=	5.25		f=	0.6912	7.6	1.97			
	Applied forces									
	Transverse	**69.38**	69.38	**138.77**						
	Longitudinal	23.52	47.04				wheel	off button		
	Vertical	89.38	178.75			μ=	0.4	0.1		
						α=	45	0.7853	sin	0.7071
	Restraining Forces		Wheels	Button off	button on	f=	0.9900	0.7779	cos	0.7071
	chain 1	21.00207		21.0021						
	chain 2	21.00207		21.0021			27			
	Chain 3	26.7293	26.7293				27			
	Chain 4						27			
	friction w	41.06046	82.12092							
	friction b	16.69124		12.8523			total off button			
		126.4851	**108.8502**	54.8564	355.00		**163.707**			

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay									Longitudinal Ax
On Deck High	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az									
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Annex 13 - CALCULATION **Hold F**

		pounds	75000			
L=	**223.7**	Cargo WT=	**34.03**	Table 4 CSM		
Vk=	**19.5**	Wt. Button	13.10	0.385	0.385	0.5
B=	**28**	Wt. Wheels	20.93	0.615	0.615	0.5
GM=	**1.31**		17.01			
B/GM=	21.37					
	CSS		Acceleration Correction			9.81

a_t=	4.08	F1=	0.4498	5.9	0.54
a_l=	1.38	F2=	0.2414	2	0.22
a_v=	5.25	f=	0.6912	7.6	1.97

Applied forces									
Transverse	**69.38**	69.38	**138.77**						
Longitudinal	23.52	47.04				wheel	off button		
Vertical	89.38	178.75			μ=	0.4	0.1		
					α=	45	0.7853	sin	0.7071
Restraining Forces		Wheels	Button off	button on	f=	0.9900	0.7779	cos	0.7071
chain 1	21.00207		21.0021						
chain 2	21.00207		21.0021			27			
Chain 3	26.7293	26.7293				27			
Chain 4						27			
friction w	41.06046	82.12092							
friction b	16.69124		12.8523		total off button				
	126.4851	**108.8502**	54.8564	355.00		**163.707**			

Table 2: ACCELERATION data in m/sec for L=100 m V=15 knots

	Transverse Ay										Longitudinal Ax
On Deck High		7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
On Deck Low		6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
Tween Deck		5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
Lower Hold		5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L
	Vertical Az										
		7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	