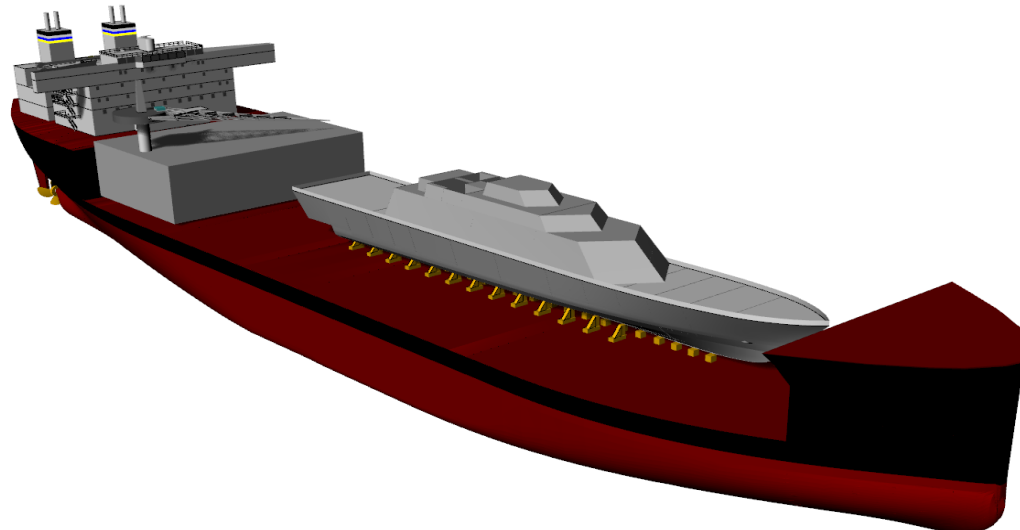




# LCS Heavy Lift Tender (AL-1)

## MIT 2.704 Conversion Project

LT Jeff White  
LT Matt Williams  
LT Ryan Zachar





# ***USNS Montford Point (MLP-1)***

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- Design based on Alaska oil tanker – cost savings & design reliability
- \$500 million procurement cost
- Maritime pre-positioning ship
- Semi-submersible mission deck (3 LCAC vessel lanes)
- Launched Nov. 2012, now in outfit of core capability set. IOC 2015



- Length: 239 m
- Beam: 50 m
- Navigational draft: 12 m
- Max. draft: 20.5 m
- Depth to mission deck: 15.468 m
- Mission Deck Length: 154 m
- Water over deck: ~5.5 m
- Nav. draft displacement: 96,706 MT



# Customer Requirements

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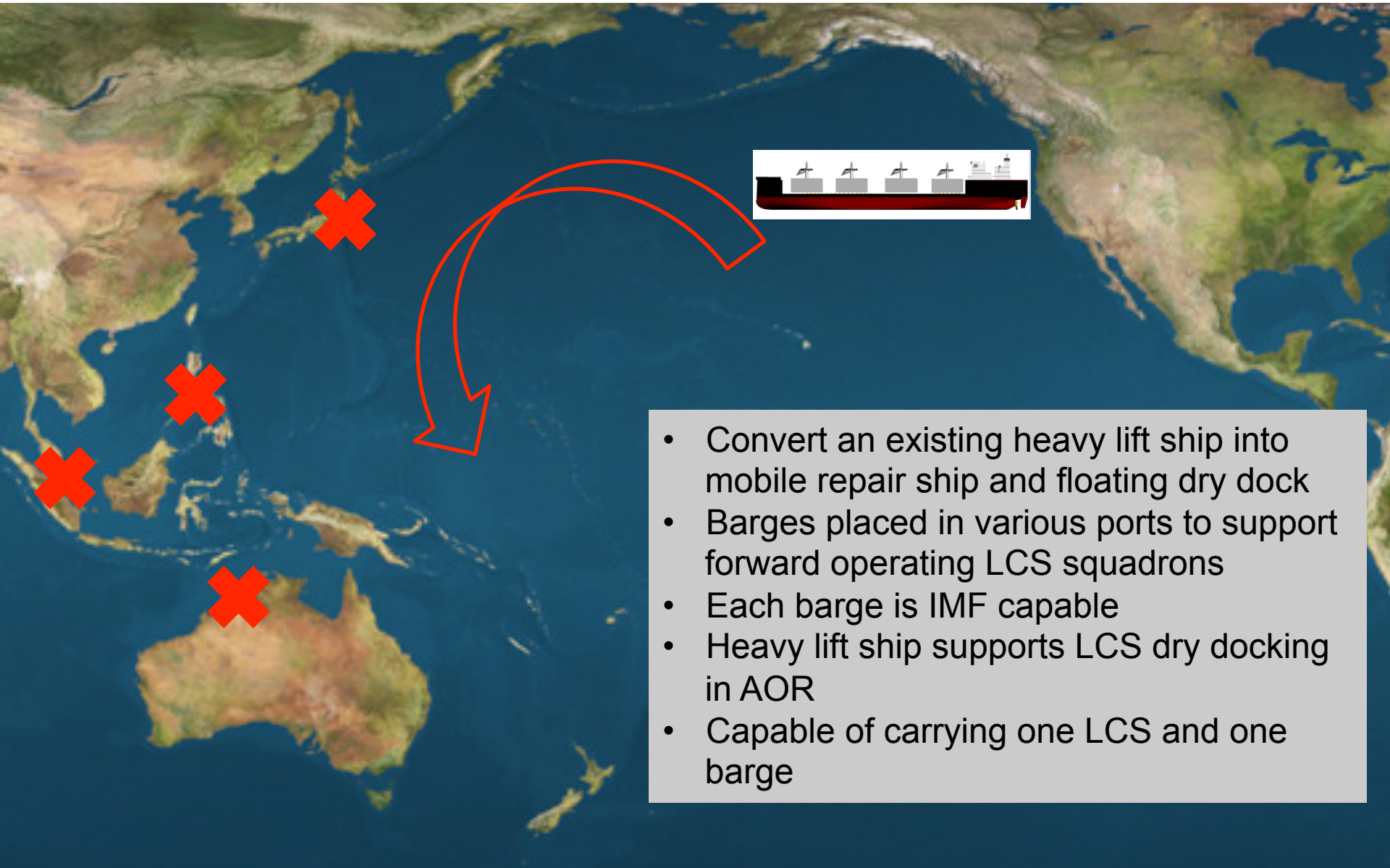
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- Convert an existing heavy lift ship into a mobile repair ship and floating dry-dock to service the forward deployed LCS fleet.
- Replicate IMF level capability on a barge carried by AL-1 to support the flexible LCS CONOPS of longer deployments and forward operations.
- Provide capability to transport up to four maintenance barges to different ports within a theater of operations.
- Offer equal or greater capability than shore based IMF at a lower cost.



# Sponsor Notional CONOPS

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- Convert an existing heavy lift ship into mobile repair ship and floating dry dock
- Barges placed in various ports to support forward operating LCS squadrons
- Each barge is IMF capable
- Heavy lift ship supports LCS dry docking in AOR
- Capable of carrying one LCS and one barge



# Barge Design

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- Deck space and equipment weight determination made from weight report of submarine tender
  - Included applicable shop and spare part space
- Simple ADINA finite element model made to verify structure
  - Barge structure  $\sim 75 \text{ m}^3$  of steel
- Dimensions: 30 m x 45 m x 12 m
- 1650 MT
- Workshop/Services area:  $3200 \text{ m}^2$



# Geometry Problems

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Freedom-class LCS mean draft = **4.3 m**

Highest keel block = **1.2 m**

+Min. 12" clearance between block and ship = **.3m**  
= **5.8 m** of water on deck required

MLP-1 mission deck length = **154 m**

- Independence-class LCS length = **128 m**  
= **26 m** available for barge and clearances

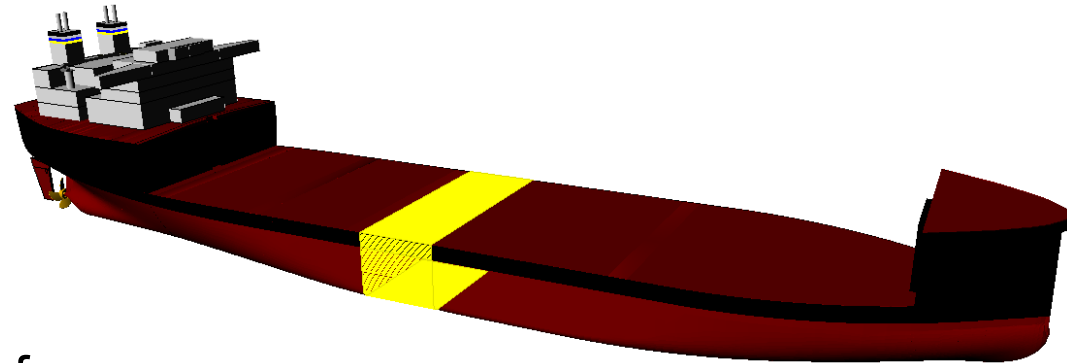
**Take away: AL-1 must ballast down further and have a larger mission deck to meet LCS heavy lift tender requirements**



# AL-1 Design Changes

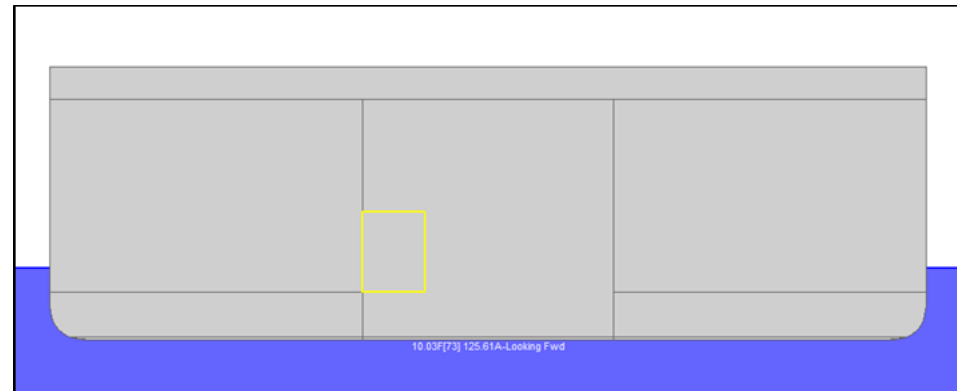
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- Dock both classes of LCS (intact and partially damaged)
- Carry LCS and barge
- Meet strength and stability criteria of MLP-1



## Changes

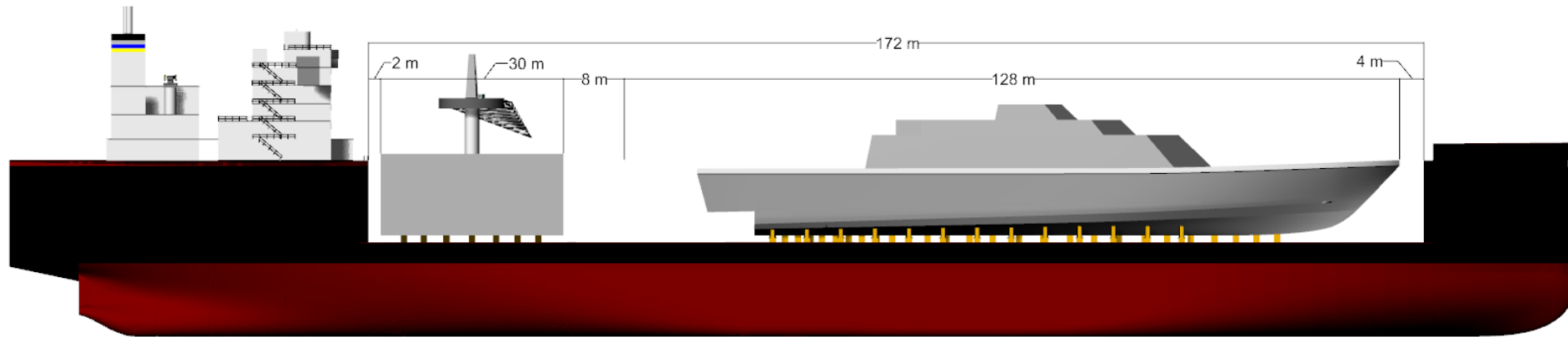
- Inserted an 18 meter section of parallel mid-body at 117 meters aft of the FP
- Increased variable ballast volume by 25,793 m<sup>3</sup> (13%)
- Added 9976 MT of fixed ballast





# AL-1 Loading Concept

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	MLP-1	AL-1
LOA [m]	239	257
LBP [m]	233	251
Beam [m]	50	50
Mission deck length [m]	154	172
Depth to mission deck [m]	15.5	15.5
Max. draft [m]	21	24.1
Max. water over deck [m]	5.5	8.6
Navigational draft displacement, SW [MT]	96,706	117,676

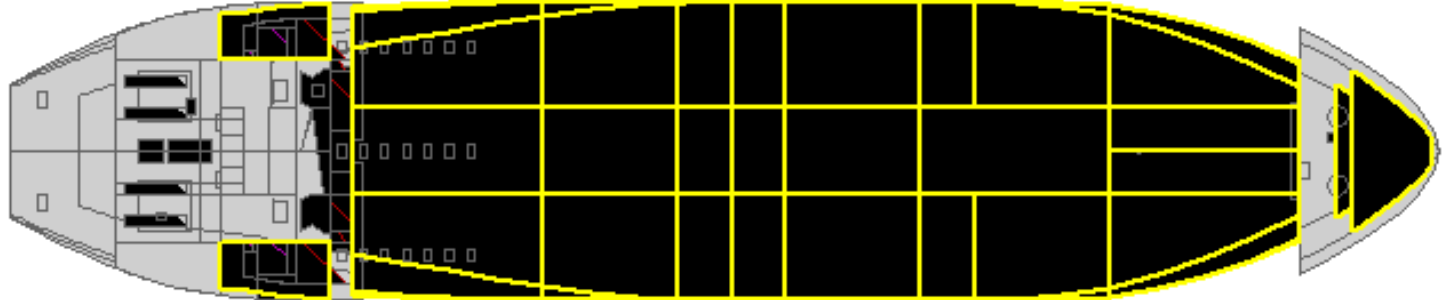




# AL-1 Ballast Operations

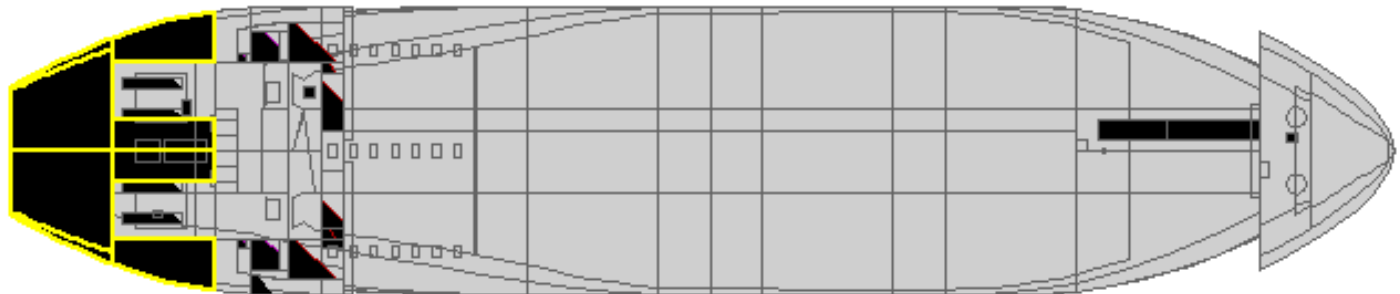
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**Forward:**  
**42 Tanks**  
**126,530 m<sup>3</sup>**



**3 pumps @ 2900 m<sup>3</sup> /hr**

**Aft:**  
**7 Tanks**  
**12,504 m<sup>3</sup>**



**Firemain @ 680 m<sup>3</sup> /hr**



# Docking Test Case

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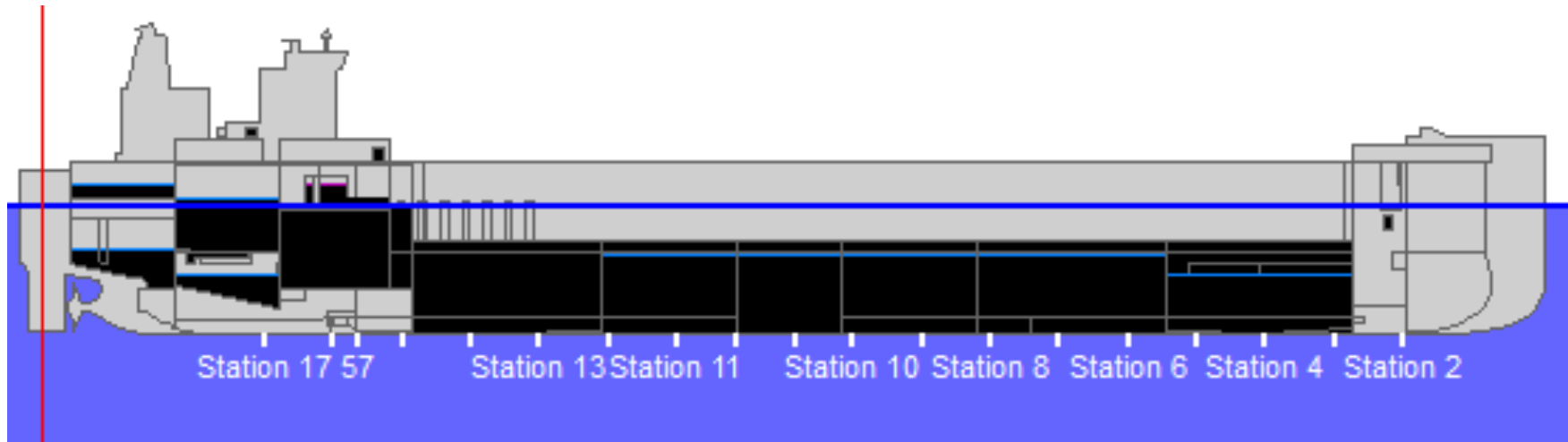
- Simulated typical docking of LCS and barge
  - Fully loaded Freedom-class LCS with 4.3 m draft in good conditions
- Used Heavy Lift function in POSSE 5 to develop ballast sequence
  - AL-1 initially ballasted to 21.3 m, with 5.8 m WOD
  - LCS lands on blocks when there is 5.5 m WOD
  - Barge lands on blocks when there is 1.3 m WOD
  - Deballasting continues until AL-1 is at 12 m draft
- Total evolution time: 12.5 hr



# Initial Condition

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5.8 m WOD

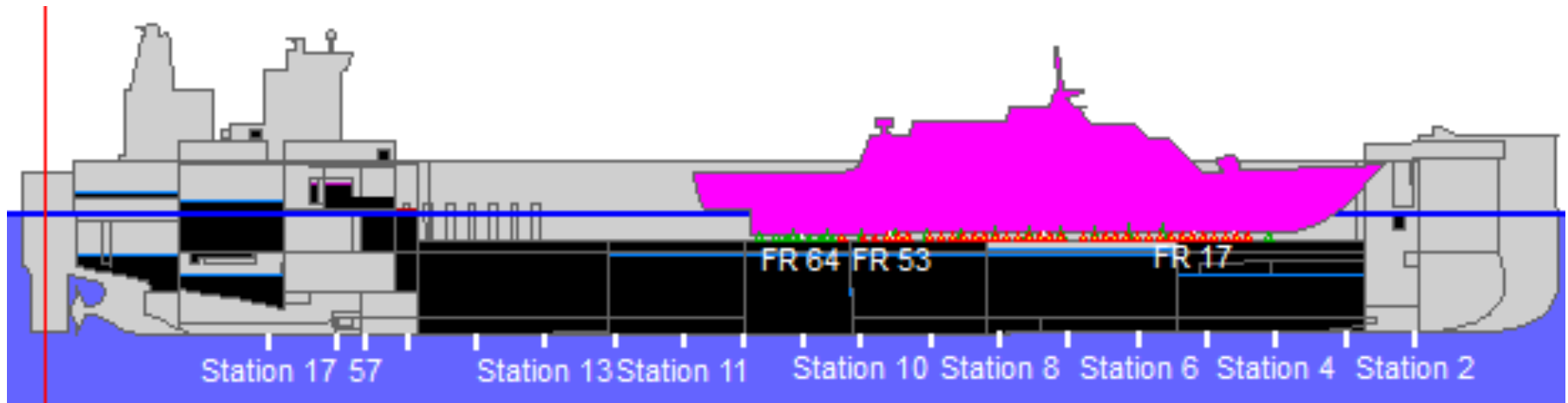




# LCS Lands

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5.5 m WOD

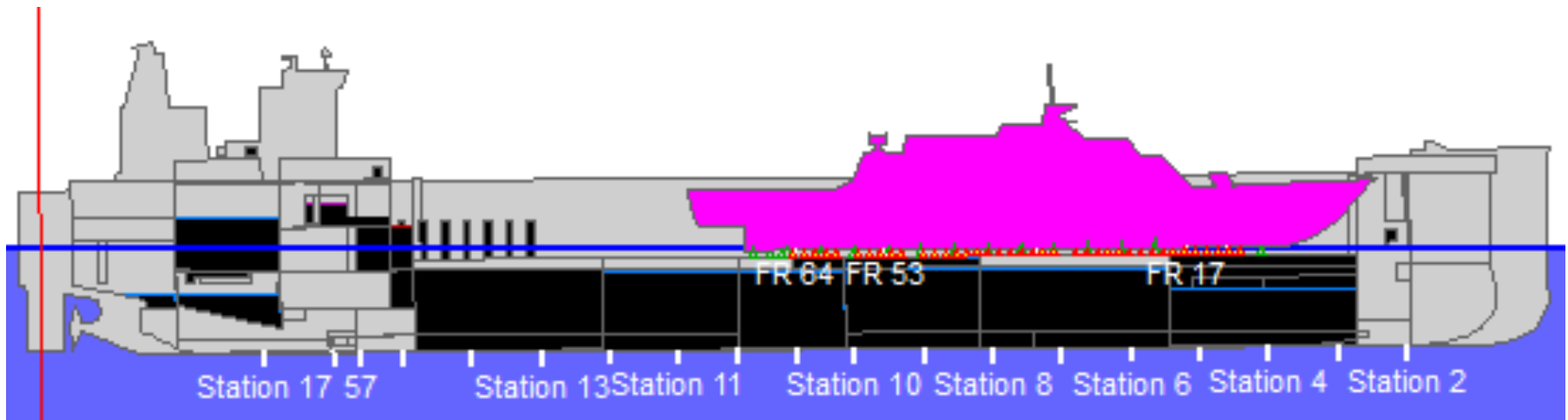




# Barge Lands

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1.3 m WOD



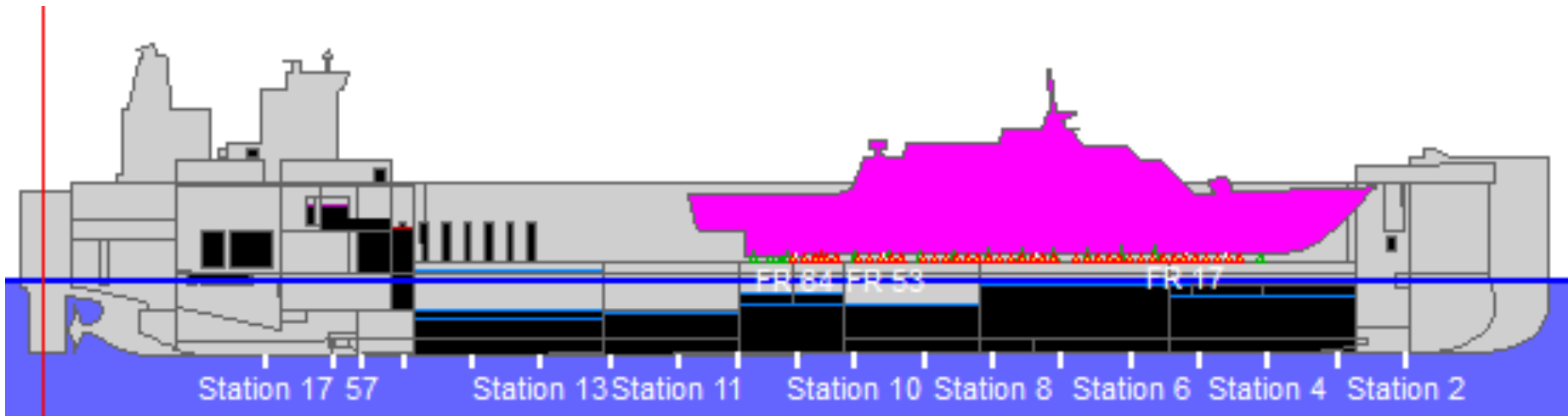


# Final Condition

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12 m draft

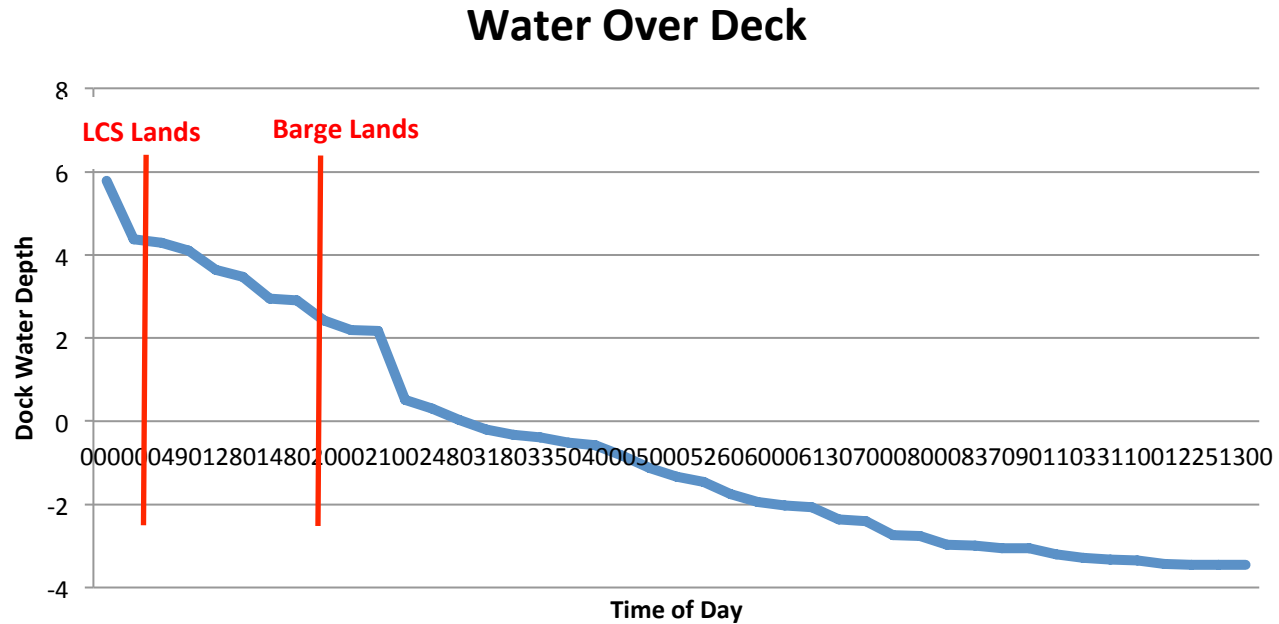
3.5 m Freeboard





# Docking Test Case

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# Docking Test Case

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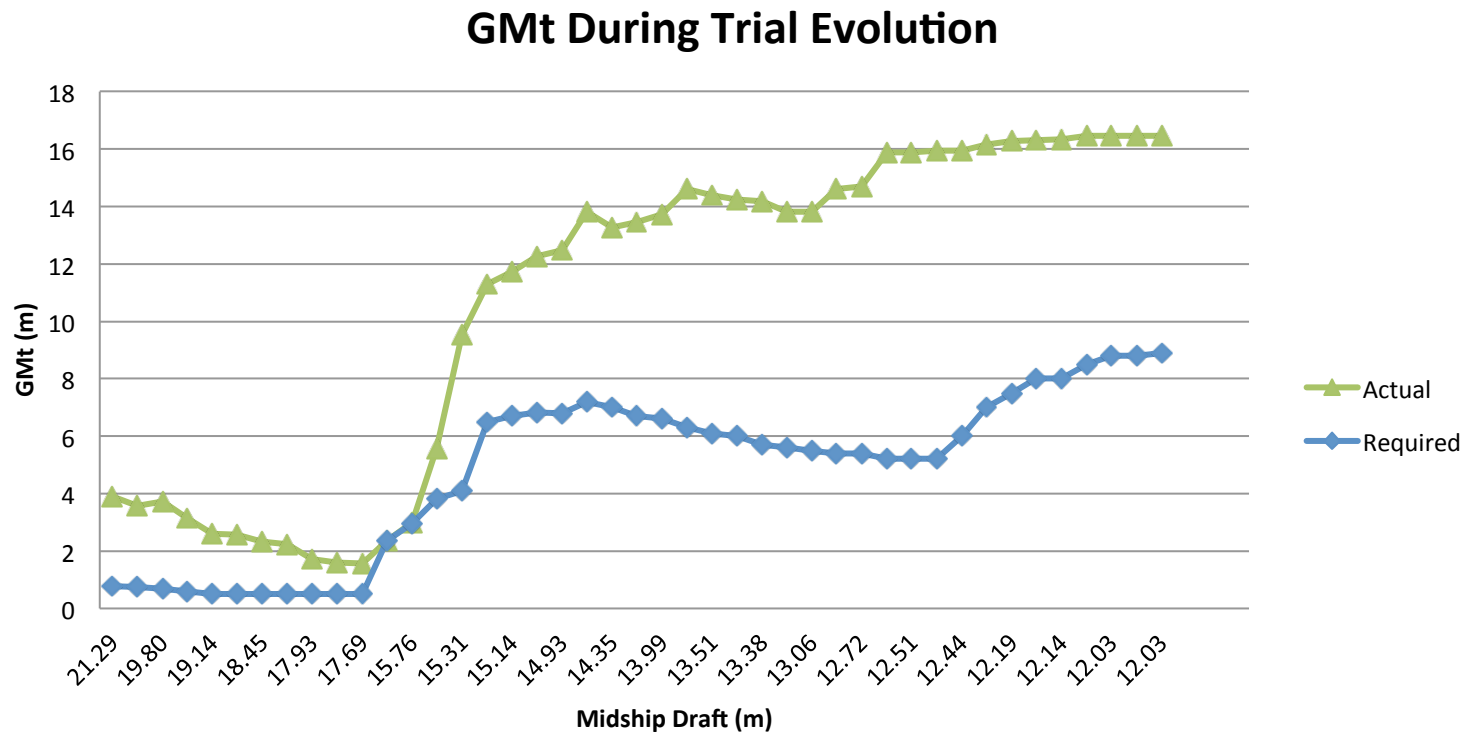
- POSSE 5 simulation gives data at 41 points during evolution
  - Every hour and alignment change
- Data analyzed at each point included:
  - Stability of AL-1 and LCS
    - GMt margin, list, trim
    - Most unstable point is when LCS is partially landed
  - Strength analysis of AL-1 and LCS
    - Shear and bending moments, block and knuckle reaction





# Stability During Docking

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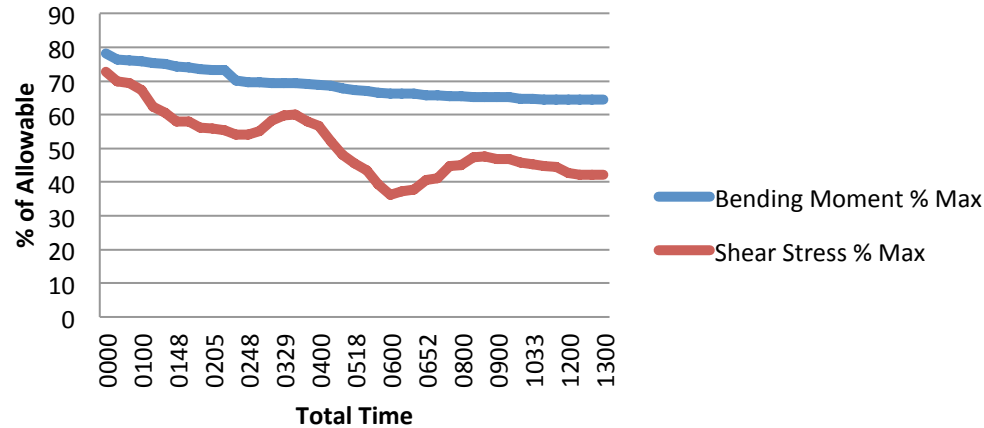




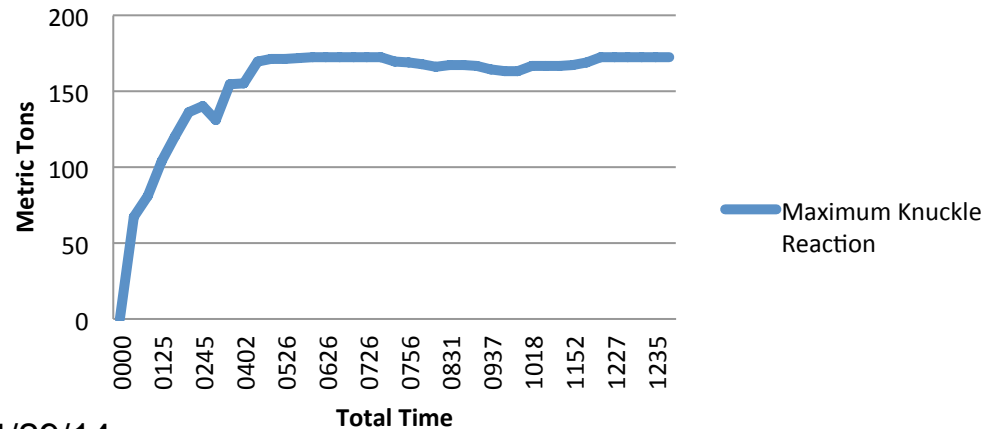
# Strength Analysis

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## Strength of AL-1



## Ground Reaction



Name	LCG m-FP	Shear Force		Bending Moment	
		Positive MT	Negative MT	Hog/Max m-MT	Sag/Min m-MT
Station 2	23.16A	9,775	-9,775	217,375H	217,375S
Station 3	34.75A	10,000	-10,000	515,875H	515,875S
Station 4	46.34A	10,500	-10,500	667,525H	667,525S
Station 5	57.93A	11,525	-11,525	743,100H	743,100S
Station 6	69.52A	12,450	-12,450	739,500H	739,500S
Station 7	81.11A	13,400	-13,400	742,000H	742,000S
Station 8	92.70A	11,150	-11,150	747,400H	747,400S
Station 9	104.28A	11,150	-11,150	753,925H	753,925S
Station 10	115.87A	11,150	-11,150	745,075H	745,075S
Station 10.5a	125.61A	11,150	-11,150	741,050H	741,050S
Station 10.5b	135.61A	11,150	-11,150	741,050H	741,050S
Station 11	145.46A	11,350	-11,350	741,050H	741,050S
Station 12	157.05A	11,200	-11,200	712,150H	712,150S
Station 13	168.64A	12,125	-12,125	681,150H	681,150S
Station 14	180.23A	12,675	-12,675	597,600H	597,600S
Station 15	191.82A	13,250	-13,250	529,625H	529,625S
57	199.00A	13,150	-13,150	392,300H	392,300S
Station 16	203.41A	13,000	-13,000	355,250H	355,250S
Station 17	215.00A	12,850	-12,850	244,725H	244,725S



# Sea Keeping Analysis

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- Design condition: 15 knot transit with barge and LCS docked
  - Desire no water on the mission deck
- 2 meter waves with 13 second period produce 1 to 2 deck wetness events per hour in head and forward quarter seas
  - Smaller waves produced no deck wetness events
- Wave loads under these conditions are within structural limits



# Weight Based Cost Difference Estimate

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- 2N Auxiliary Cost Model
- Construction costs only

Weights	LT
SWBS 100	2095
Fixed Ballast	9818
SWBS 300	1
SWBS 400	0
SWBS 500	5
SWBS 600	0
SWBS 700	0

- CER - labor and materials
- Planning, change orders, profit as % of basic construction cost
- Modified repeat considerations
- **Bottom Line: 17% increase over MLP-1**





# Areas for Further Study

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1. Detailed barge design
2. AL-1 CONOPS development
  - Operations and life cycle costs
  - Shore based IMA cost comparison
3. Improved ballast system



# Questions

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