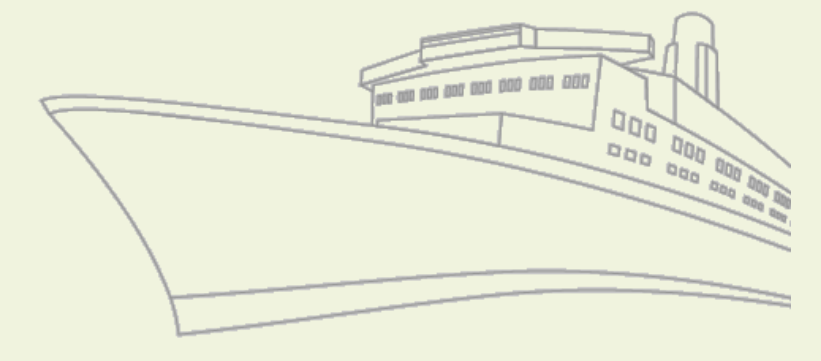


Closed Ballast Dynamic Depth Ship **TRAVISIONS**

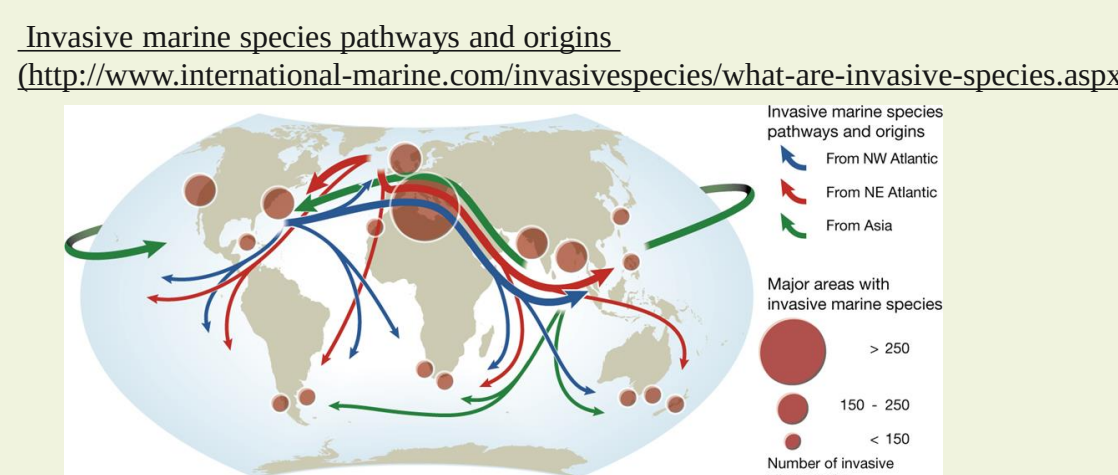
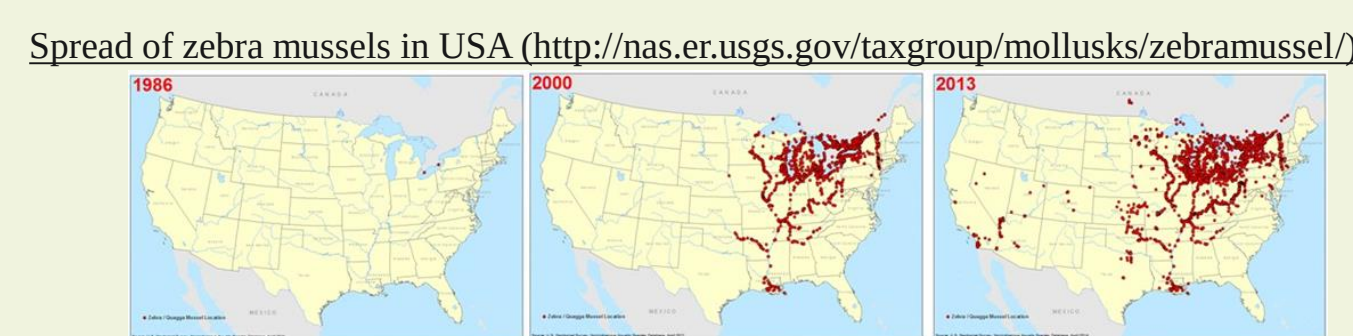
Key Characteristics

- Reduced transportation of invasive species
- Economically feasible to encourage
- Meet upcoming IMO ballast water convention requirements
- Long term economic saving
- Fuel reduction



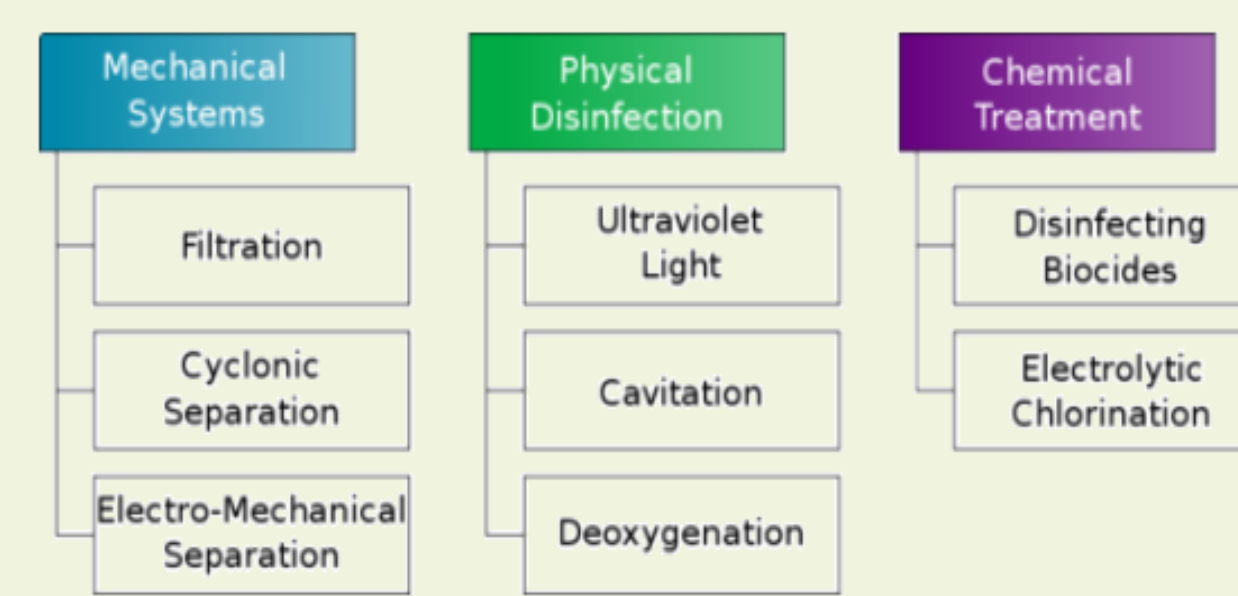
Motivation & Objectives

- 3 to 5 billion tonnes of ballast water is transported internationally each year. This can lead to a significant number of species transported globally. The effects are seen as the greatest threat to aquatic ecosystems and are almost irreversible.
- An example of invasive species is the introduction of zebra mussels on the east coast of the USA (see USA map below). They are notorious for biofouling by colonizing water supply pipes, constricting flow.
- In 2000 it was estimated that costs associated with damage caused by 50,000 invasive species introduced into the US amounted to \$137 Billion.
- Due to danger potential of invasive species, some countries, such as Australia, have adopted stringent ballasting requirement.
 - The International Maritime Organisation (IMO) introduced the ballast water management (BWM) convention in 2004 which will come into force after 30 states and 35% of world fleet tonnage sign the agreement that limits the flexibility of ballasting operations globally. As of 22nd September 2015, 44 states and 32.86%



Methodology

- Current solutions to the problem were assessed. From this research it was found that no fully viable solutions existed.
- An iterative design process was then used working from first principles to look at modifying a ship and checking it would still be structurally sound and has sufficient stability.
- The internal systems were then developed to permit the ships depth to increase and decrease as desired.

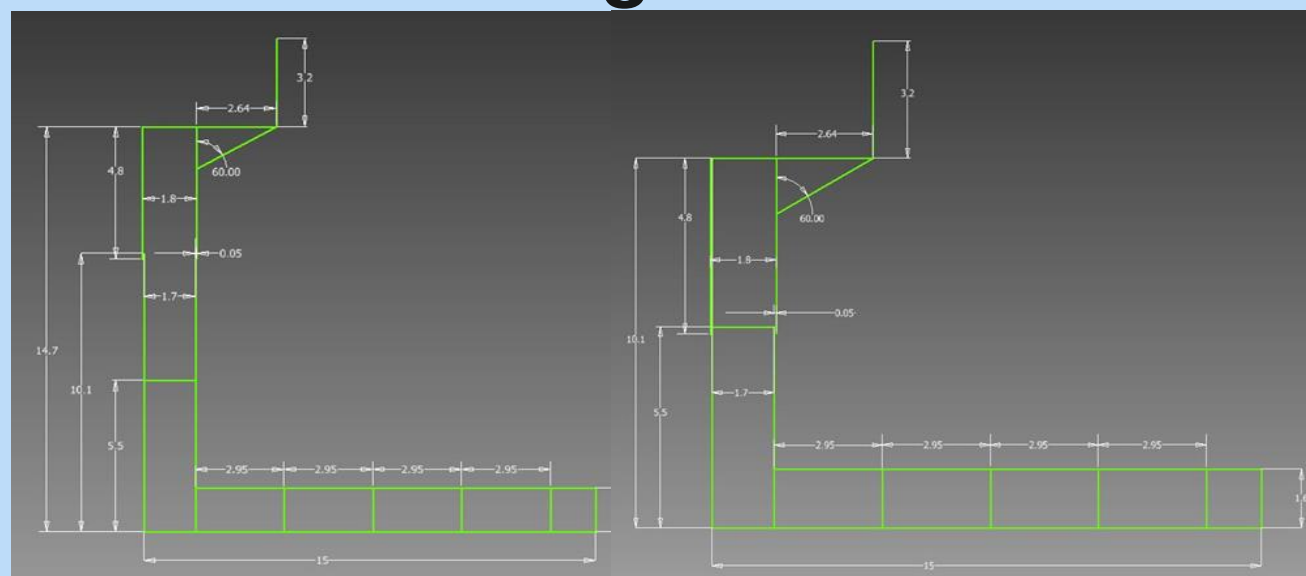


The various solutions assessed are shown in the diagram to the left which each have their own problems.

The Solution

The proposed design aim is to remove the need for conventional ballasting operations during loading and unloading of cargoes. This can be achieved by altering the ship depth to improve the stability and cope with changing displacement, compensating for the addition or removal of cargo. When the ship is fully loaded, the depth of the ship will be fully extended to its maximum position and when unloaded, the depth of the ship is kept at its minimum to increase the ship's stability by lowering the centre of gravity of the lightship resulting in overall increase in GM. This will be achieved through the use of hydraulic pistons positioned around the ships hull and the bulkheads.

Strength results

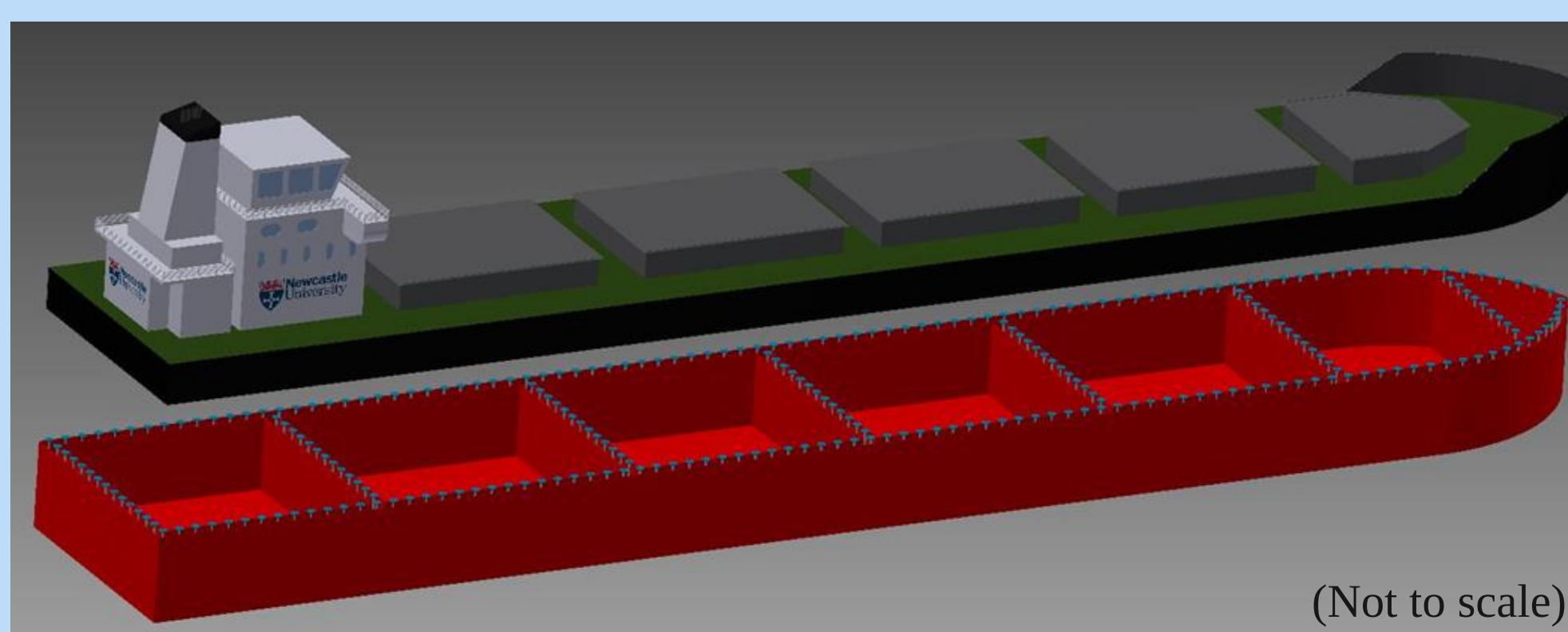


Cross-section of the expanded (left) and collapsed case (right)

To determine the structural strength of the ship, a mid-ship cross-section was assumed for the expanded and collapsed case. The steel stress of 315N/m². And 40% stiffer factor. The concept ship was proven to be safe as shown below

IACS Z _{MIN} (m ³)		Z (m ³)	
		Expanded Case	Collapse Case
9.875038776	Hatch	14.8513	9.9533
	Keel	31.1023	19.4901
	Deck	20.1820	15.6368
Dragonera Seahorse			
Web height h_w (m)		0.39	
Web thickness t_w (m)		0.027	
Area of stiffener (m ²)		0.01053	
Deck length (m)	4.44		12.32
Number of stiffeners	7		14
Stiffener spacing (m)	0.6343		0.88

Concept design with lifting mechanism



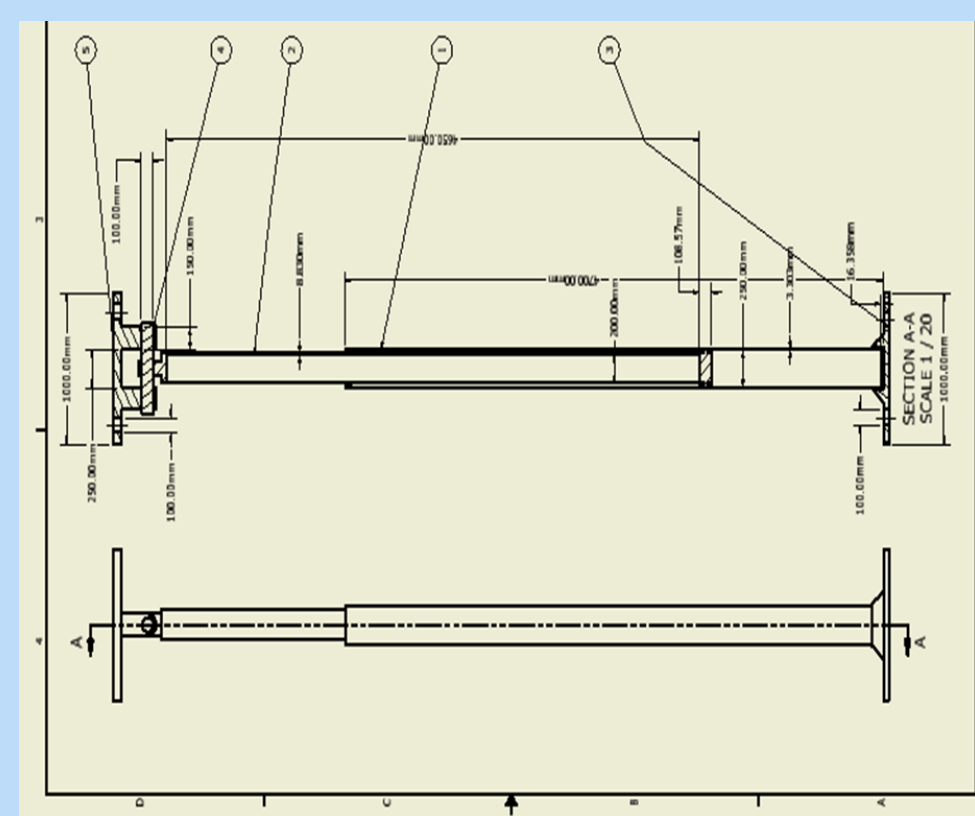
(Not to scale)

Stability results

Parameter	Extended Case	Collapsed Case
KB	5.05m	1.16m
BM	7.43m	32.95m
KG	9.01m	4.55m
GM	3.47m	29.54m

The GM of the vessel in both conditions also meets the requirements by the International Maritime Organisation (IMO) that the GM of the vessel must be greater than 0.15m.

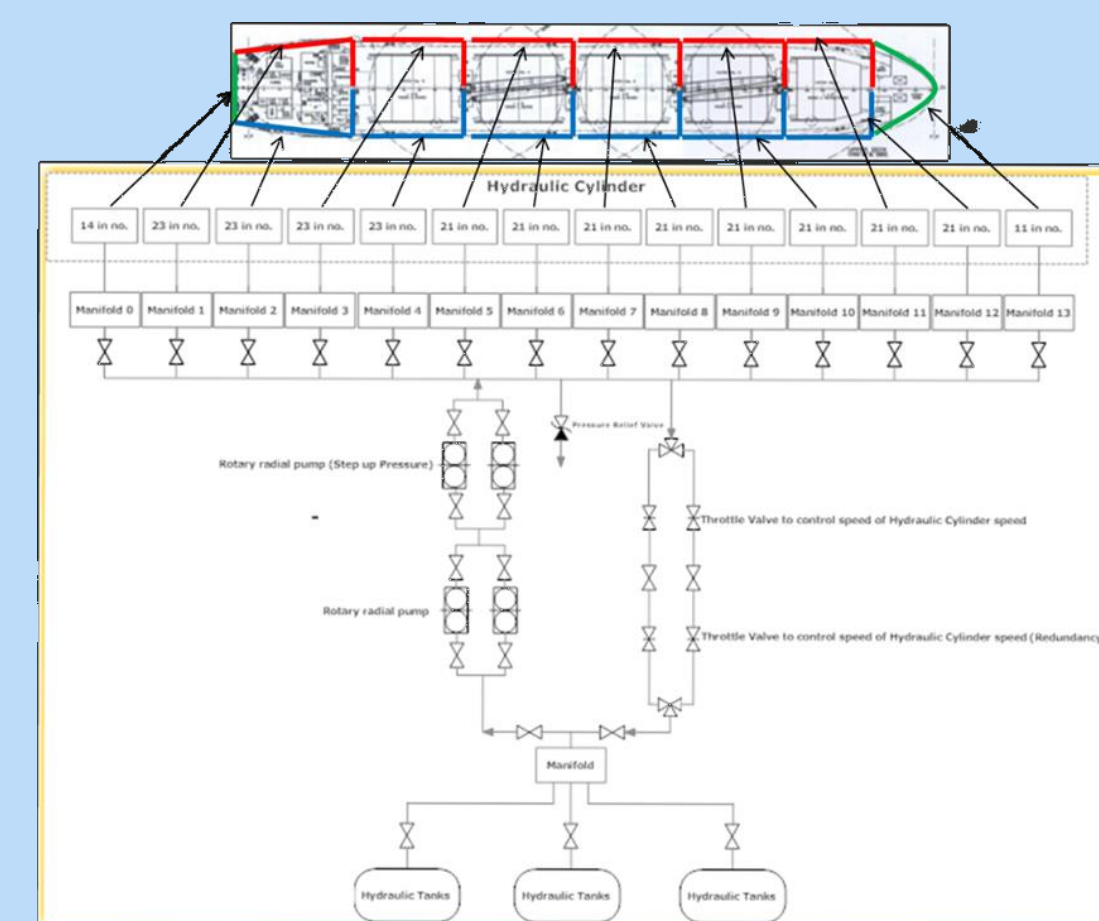
Hydraulic system



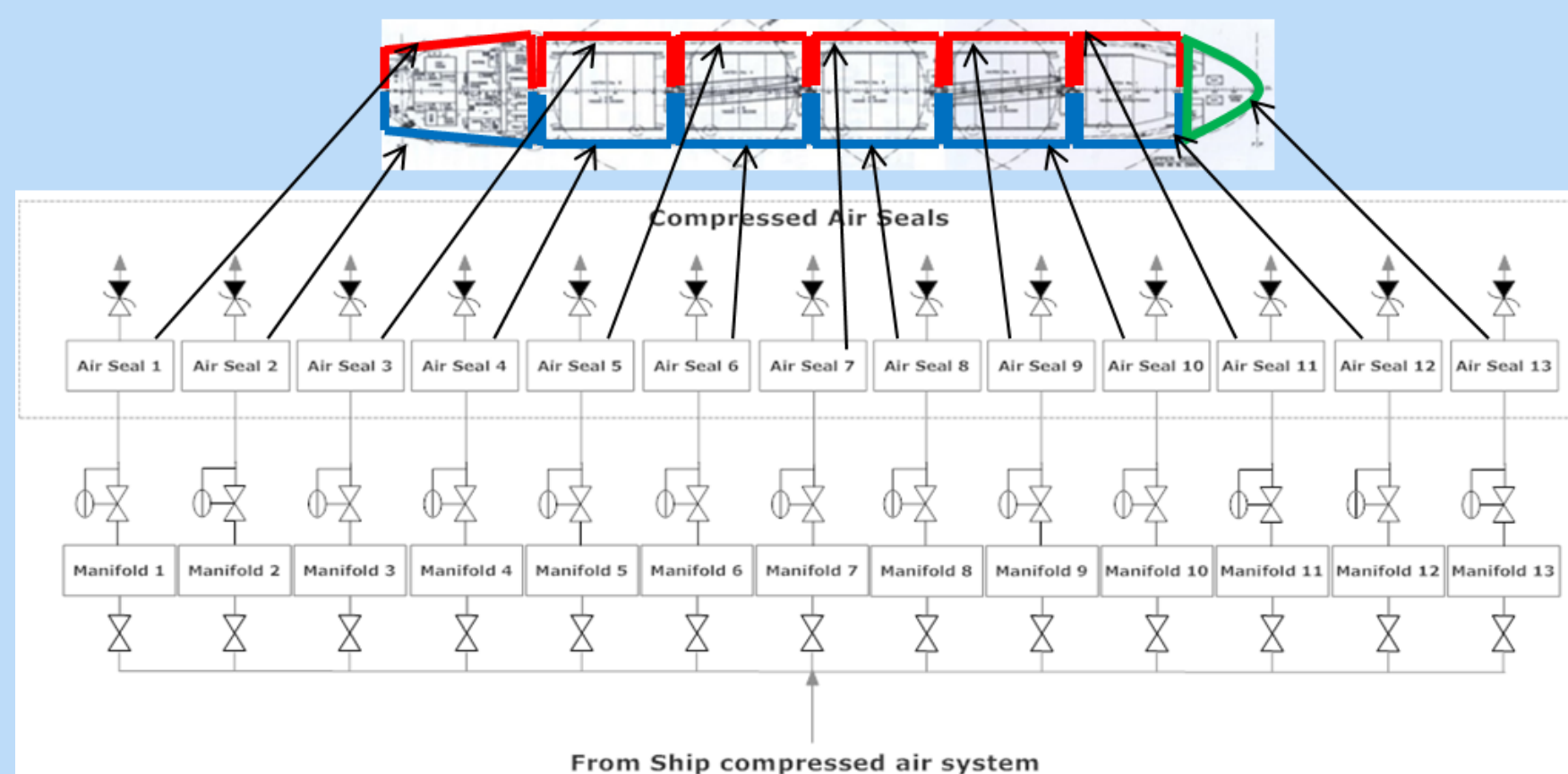
Hydraulic cylinder design

Using Stainless steel, austenitic, A151 205 a the cylinder dimensions were found:

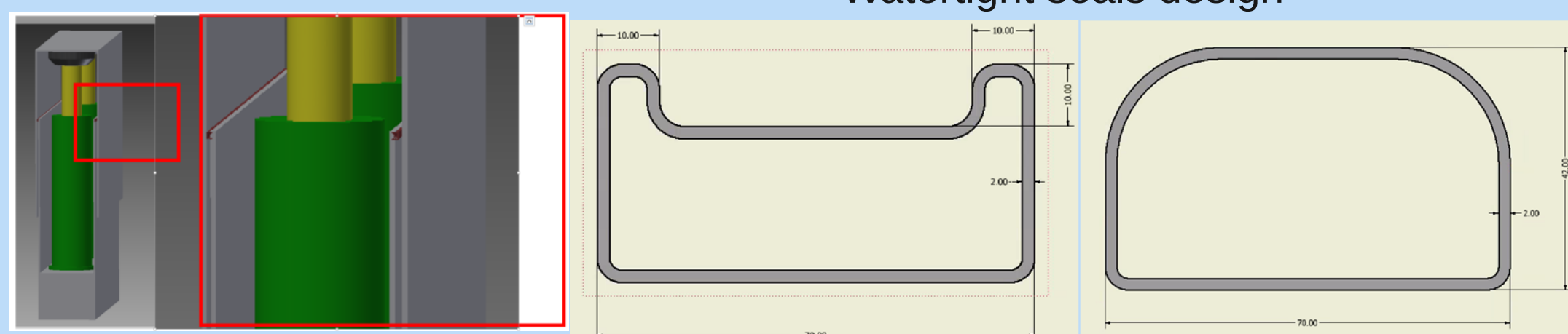
Item	Thickness (mm)
Cylinder	3.303
Cylinder end plug	12.355
Piston	8.830



Watertight compressed air system



Watertight seals design



Material:

Perfluoro elastomer this was chosen because of its durability in water (both salt and fresh), its durability in oil and fuel and its ability to be injection moulded. Perfluoro elastomer is currently used in extreme chemical environments such as seals in offshore oil supply which reassures the selection of the material.

Damage Assurance:

Should the rubber seals fail due to corrosion and a lack of maintenance, the air compressors and pumps will be able to blow a constant volume of air through the seal to limit any water ingress. The seals will be inspected before and after each inflation and will be replaced when required.

Propulsion and engine system



http://www.mandieselturbo.com/download/project_gui_des_002/epub/S46ME-BB_5.pdf
<http://www.bing.com/images/search?q=azipod+propeller&view=detail&id=28&id=BARBA33A9BA&id=7799C66567B95A921134081401D8&selectedIndex=7&ccid=2c0PA%2F5b&simid=608015744614000755&shuf=OIP.M81c8c193f49b8039e49063bf6bf677990a08ajashist=0>

The engine selected is the MAN SE46ME-B* as it meets the operating envelope required. The ship is propelled with 2 5.2m azipod propellers.

The estimated total economic saving for each ship over its entire life (assumed 25 years):

\$11, 800, 000

Research Outlook

The current solution is a proof of concept and therefore an optimal solution should be found in time. Firstly all of the internal systems (hydraulic systems, air compressor system) should be optimised and the structural strength and stability of the vessel should be checked after each iteration. The propulsion method of the ship needs to be improved to find a more optimal solution for propelling the ship in its varying operational conditions.

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