APPENDIX 1 – SOLUTIONS – PONTOONS

How big was the challenge when the Titanic struck the ice berg?

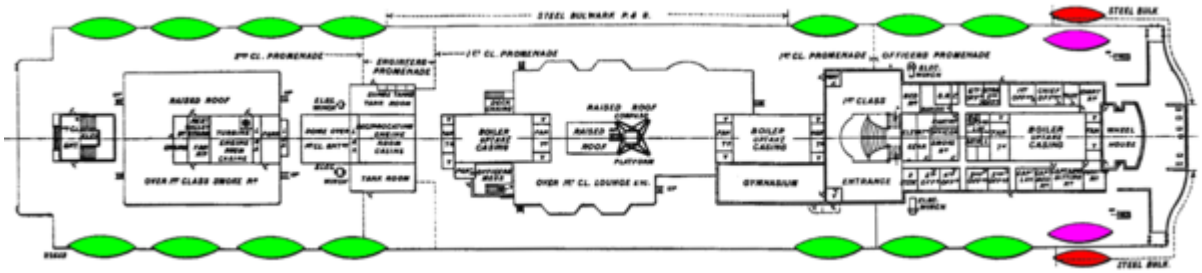
The ship had 20 lifeboats that, in total, could accommodate **1,178** people,

This was 53% of the **2,208** on board the night it sank (which was at 62% of maximum capacity).

RMS Titanic had a maximum capacity of **3,547** passengers and crew.

705 were saved and **1503** died (only 60% of available lifeboat capacity was used).

705 people was 20% of the potential max capacity.

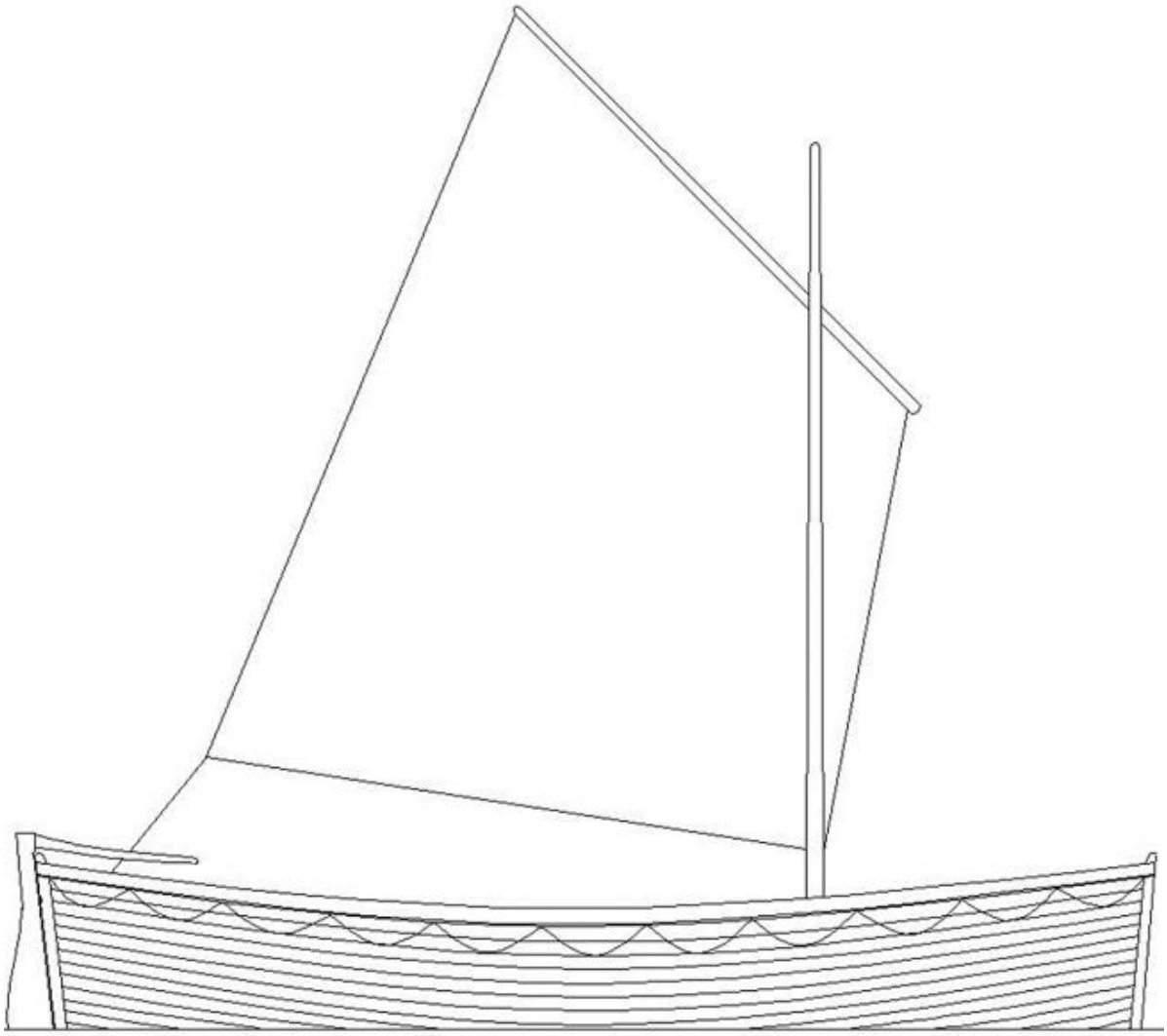


The Plan – Pontoon Practicalities
The weights involved in this simple scenario have been calculated, and there is displacement carrying capacity for 3,562 people on the pontoons if the water is still – see table in appendix 3. This is, in principle, enough for the everyone on board that night, and potentially even the 3,547, fully laden complement of the ship.

- The main lifeboats were brand new, and stocked with masts, sails and ropes.
- Scouts, guides, seamen, riggers, horsemen and many people of the time would have been fully familiar with ropes and lashings.
- Large structures can be built quickly by teams who know what they are doing
- A group of experienced guides who had made a platform before and who were familiar with working together could probably have made a suitable catamaran-type structure within half an hour.
- Once a prototype had been shown, every pair of boats could have converted themselves into pontoons with the materials that were already on board. Sufficient skills were available amongst the passengers and crew, along with plenty of motivation.
- Once the Captain had given the orders, a clear goal would have been provided, there would have been much less hesitancy to leave the ship and more eagerness to move.

How could everyone have been saved? Could pontoons have worked?

The Lifeboats – masts and sails



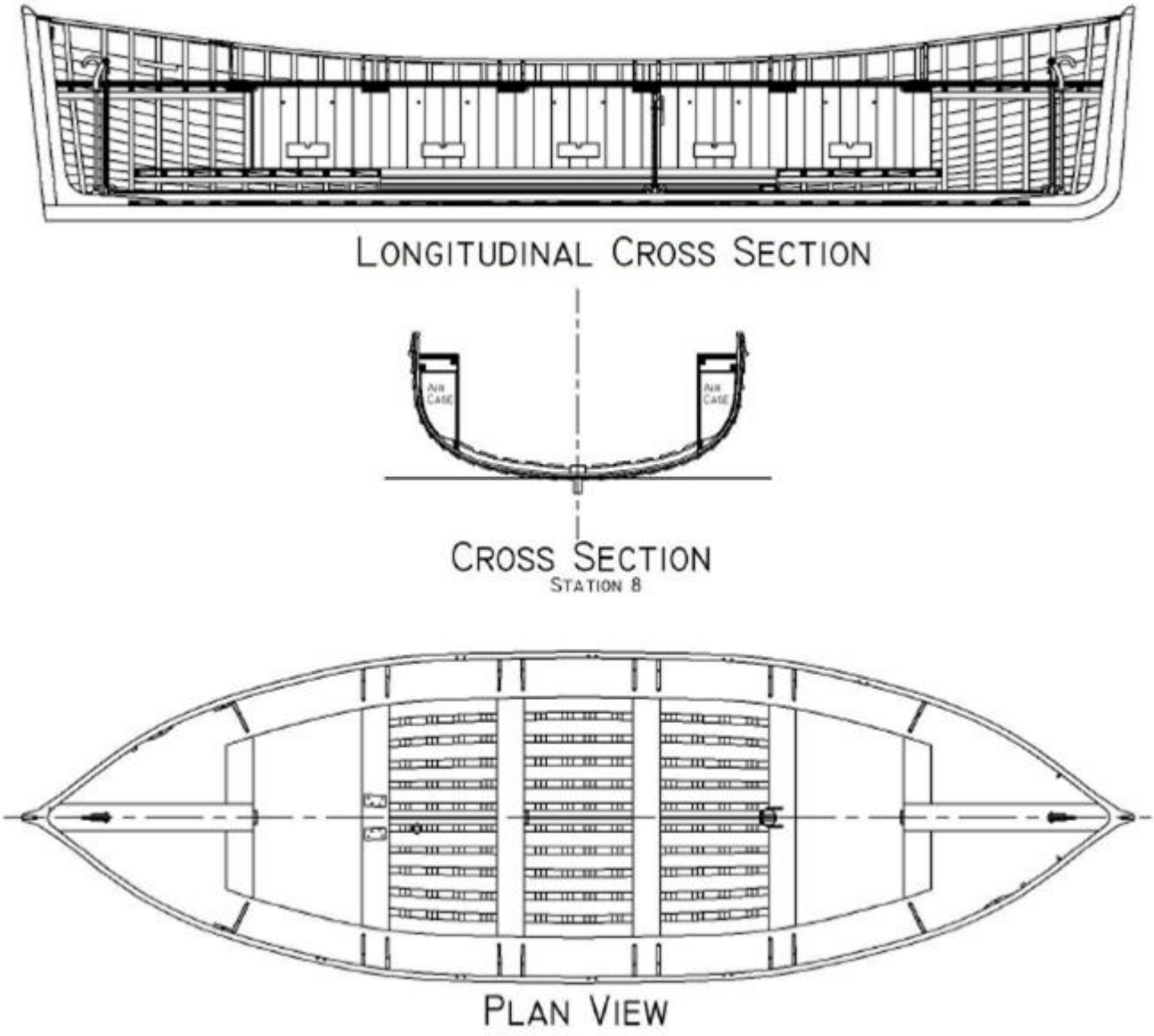
Rigging Plan

(Standing Lug Rig)

The lifeboats on the Titanic were fitted with stout masts and sails.
The sailing rig had been used in many lifeboat situations so was an important part of the equipment
The mast was 24’ long and also had a gaff (a top boom) that was 18’ long.
There were also 10 oars which were 14’ long.

This unusual drawing of the standard 30’ Titanic lifeboat shows the mast and sail in place – courtesy of NMMC Cornwall https://nmmc.co.uk/2017/09/follow-the-titanic-lifeboat-13-reproduction-build/

Side view and plan view



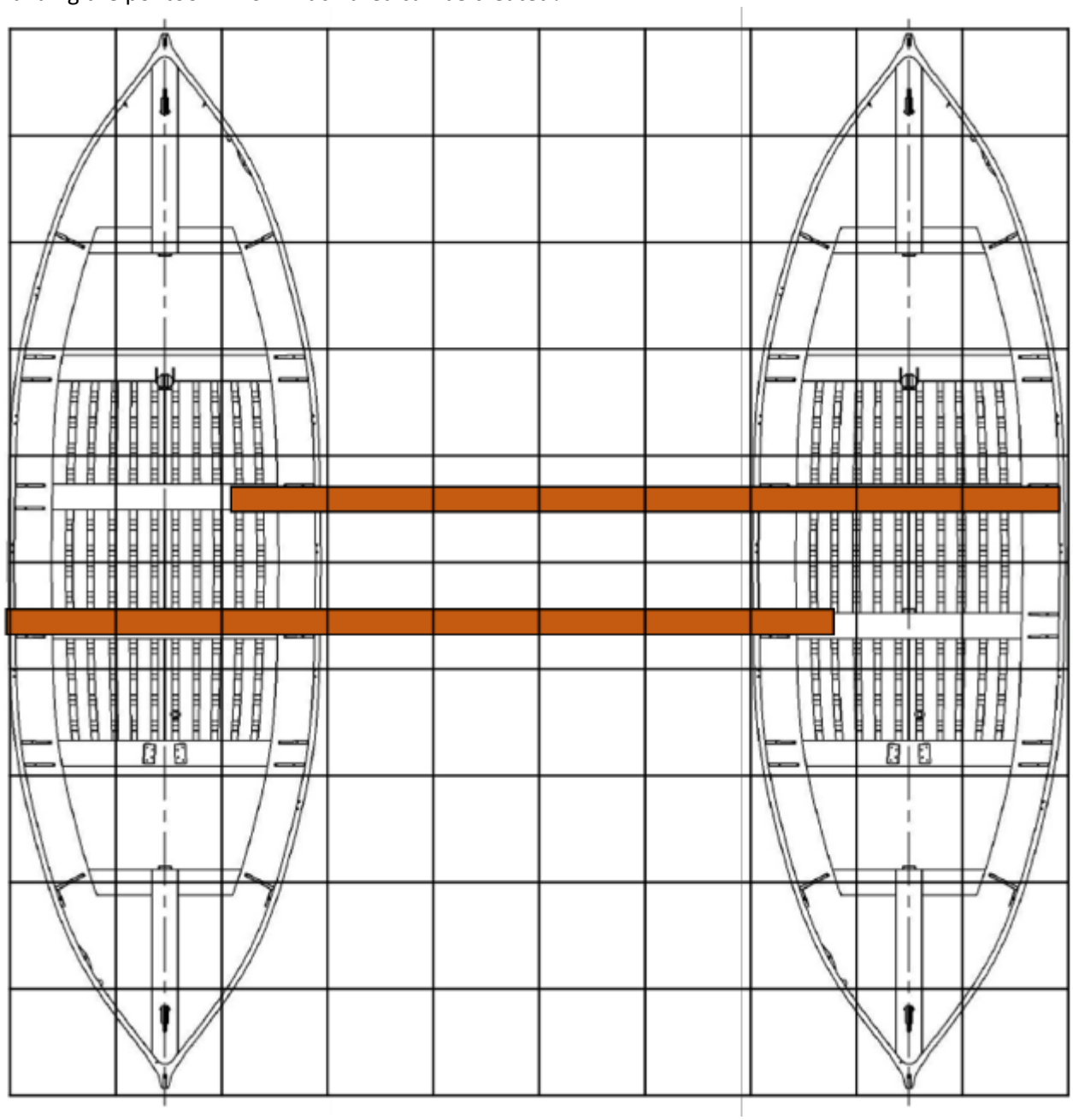
The plan – build pontoons which can carry more people

The lifeboats were beautifully built, substantial boats that were designed for tough sea conditions. Epic journeys had been made in ship lifeboats.
They were 30’ long and 9’ wide.
Crucially, although they had a nominal capacity of 65 people, they had a displacement volume of 19m3 = 19 tonnes of water. 65 people of say 90kg in their gear would weigh 5.85 tonnes. It would take 206 people to sink a single boat – if they could all get on.

Therefore, if 2 boats are lashed together and the space in between them made into a platform, many more people could be supported by the same displacement volume.

Catamarans are recognised examples of such boats. They have a long history and were used by the Polynesians for travelling around the Pacific. http://chevaliertaglang.blogspot.com/2013/08/the-evolution-of-sailing-multihulls.html

Building the pontoon – how much area can be created?



Area of 1 boat = 10 x 3 x 2/3 = **20 square yards**

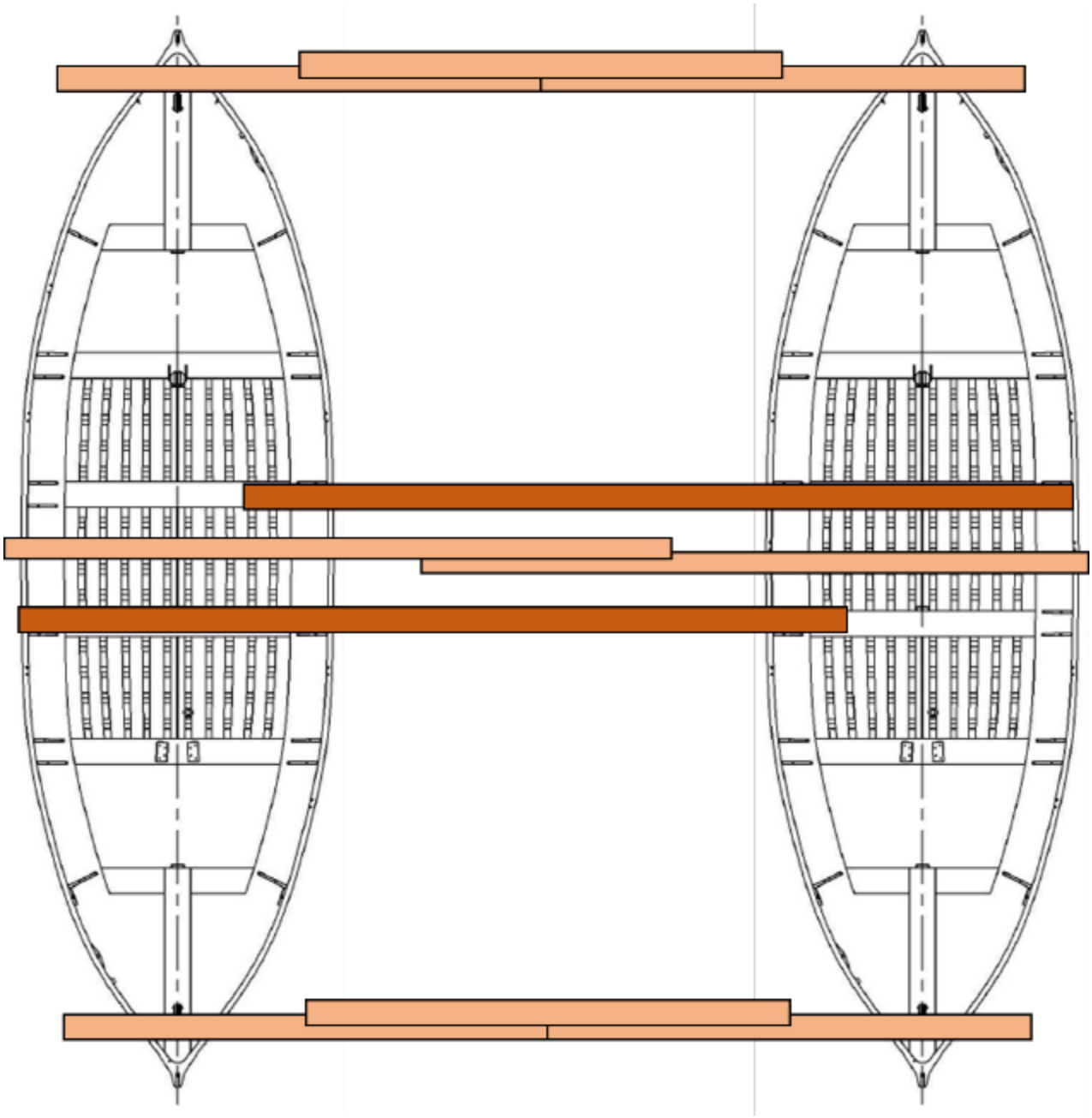
Area of pontoon = **100 – 10 = 90 square yards**

Area increase = 90/40 = 2.25

https://www.gkstill.com/Support/crowd-density/CrowdDensity-1.html

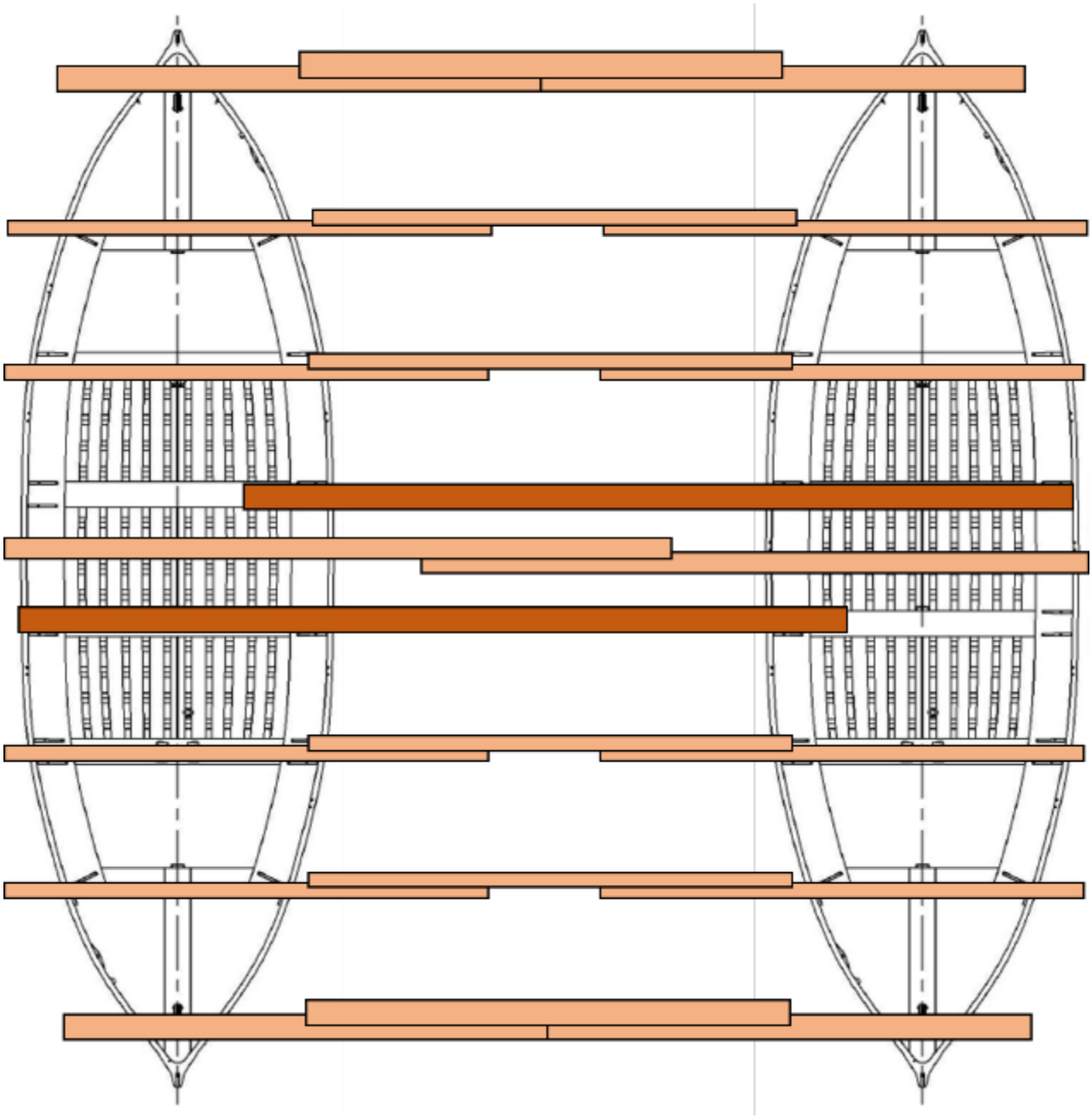
Maximum crowd density = 5 people per m2

The pontoon braced with gaffs and lashed oars



The boats would be brought alongside one another and the masts laid across the rowlocks. They would be lashed to the gunwales of each boat. The three-point contact, two on one boat and one on the other, stabilises the boats so that they become very difficult to capsize.
The gaffs and lashed sets of oars are used to make more cross beams.
The pontoon will be exceptionally heavily loaded so more cross bracing is beneficial.

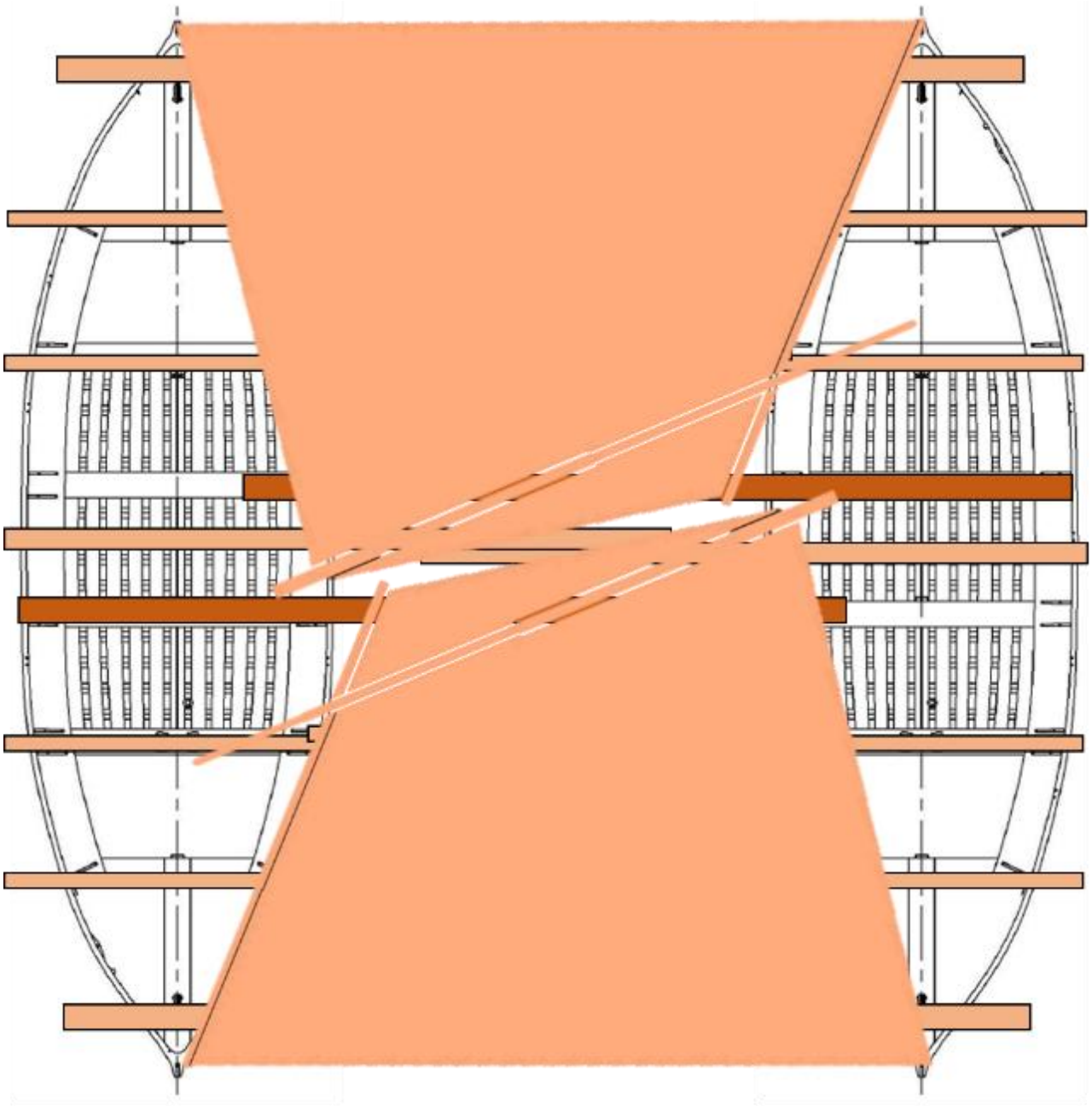
The pontoon braced with more lashed oars



The gaffs and lashed sets of oars are used to make more cross beams.
The pontoon will be exceptionally heavily loaded so more cross bracing is beneficial.

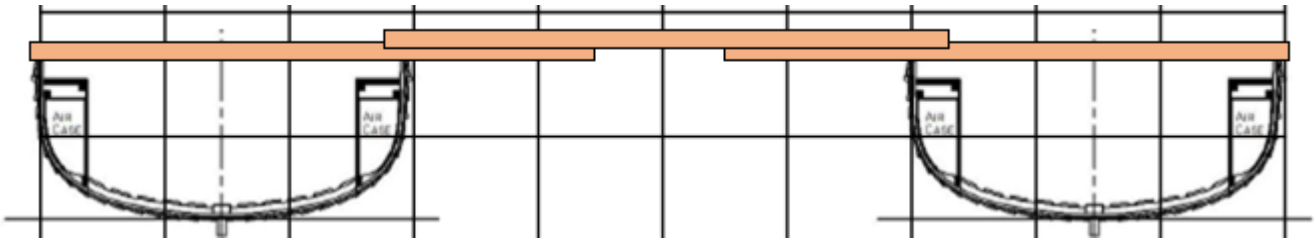
On the night of the wreck, waters were calm.
If the seas were rough, the same approach could have been used with the canvas covers left, secured on the lifeboats. This would have prevented waves splashing into the boats and another sinking problem.

The sails lashed to the cross beams.



The sails are lashed to the ends of the boats and to the cross beams, creating a large canvas deck.

End view



The end view shows how wide the new deck is compared to the original boats, and how much space there is to cram as many people as possible on board. The pontoon is much more stable than a single boat, so people could safely stand if necessary.

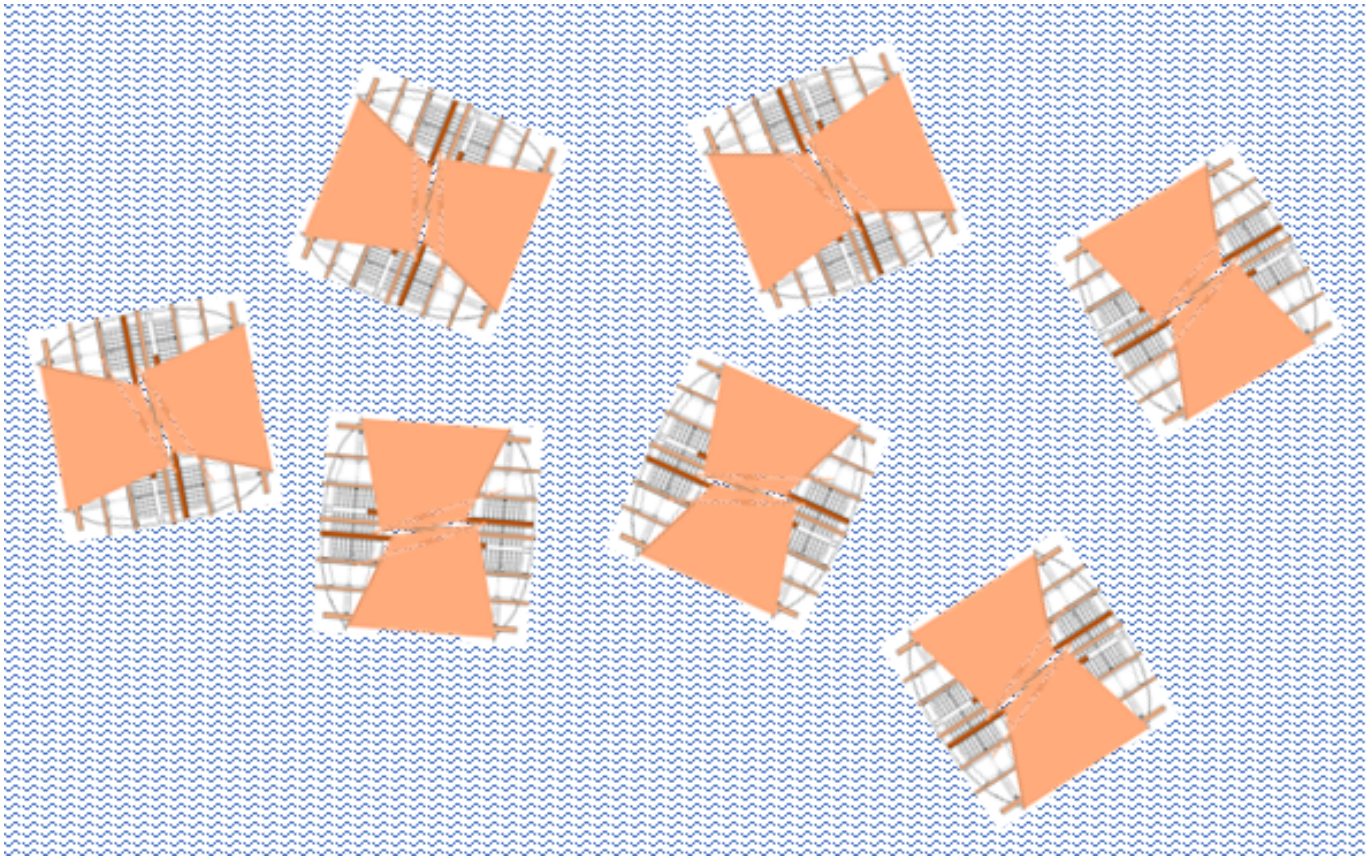
Pontoon carrying capacity – 400 people per pontoon.

The assembled pontoon has the potential to carry 412 people compare to the precarious maximum of130 people on two fully loaded boats.

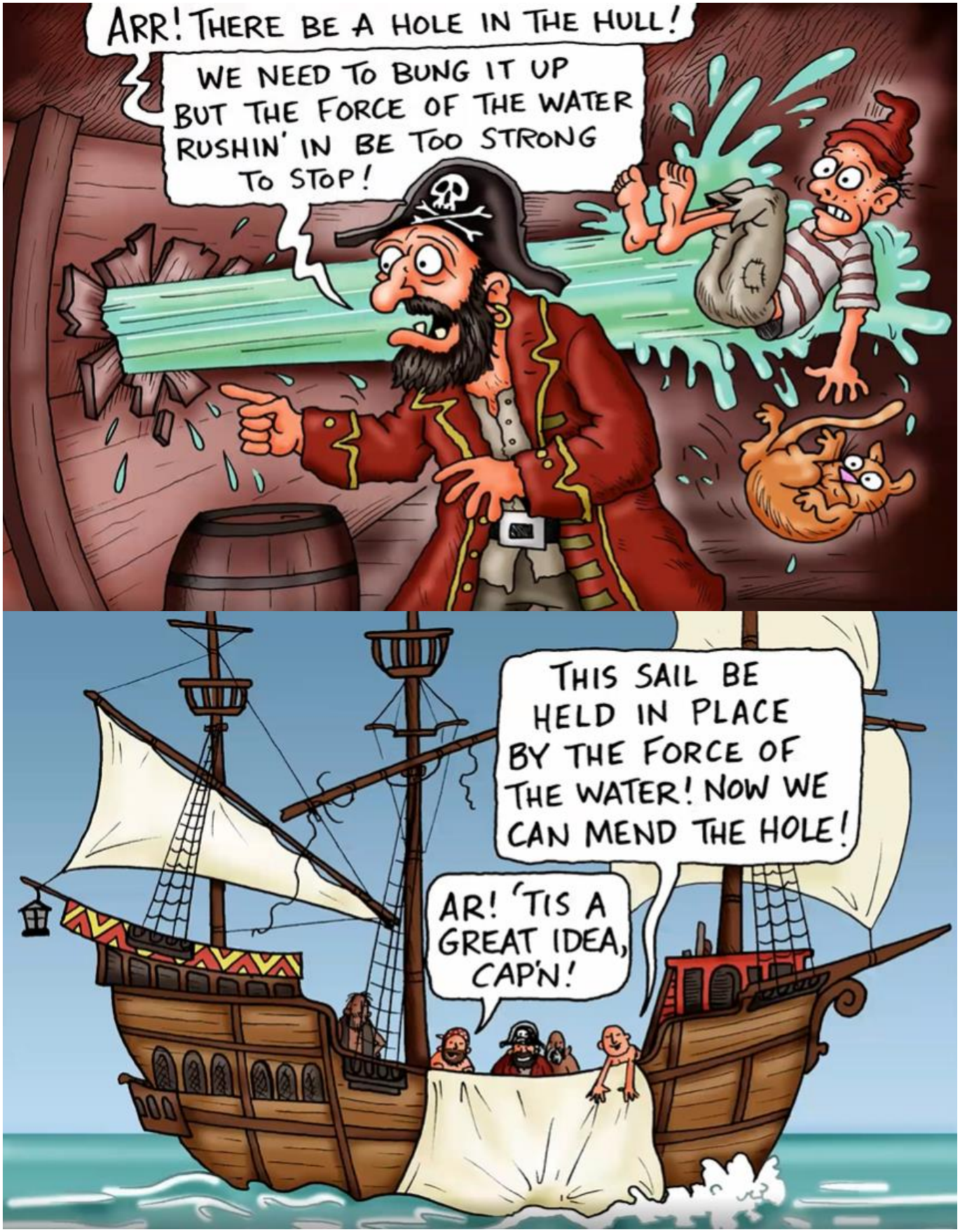
	Number	People ca	Total		Volume	Total m3			Max Passengers	
Main boats	14	65	910		19	260		206	2886	
Cutters	2	40	80		9	18		101	202	
Collapsible	4	47	188		11	43		118	474	
			1178			321			3562	
Average Passenger weight	kg						90			
Pontoons	7	65	455		37	260		412	2886	

The 14 main boats could have been converted into 7 pontoons and carried all of the passengers and crew. The two cutters and the collapsible boats could have been used for shuttling passengers from the ship to the pontoons and for the dogs that were carried on board.

It may be more appropriate to use the 4 collapsible boats to make pontoons and keep 4 main lifeboats for shuttling.



APPENDIX 2 – SOLUTIONS – FOTHERING



Fothering – A history – Shipwreck of Endeavour. 1770

For the next four months, Cook charted the coast of Australia, heading generally northward. Just before 11 pm on 11 June 1770, the ship struck a reef,[45] today called Endeavour Reef, within the Great Barrier Reef system. The sails were immediately taken down, a kedging anchor set and an unsuccessful attempt was made to drag the ship back to open water. The reef Endeavour had struck rose so steeply from the seabed that although the ship was hard aground, Cook measured depths up to 70 feet (21 m) less than one ship's length away.[45]

Cook then ordered that the ship be lightened to help her float off the reef. Iron and stone ballast, spoiled stores and all but four of the ship's guns were thrown overboard, and the ship's drinking water pumped out.[45] The crew attached buoys to the discarded guns with the intention of retrieving them later,[46] but this proved impractical. Every man on board took turns on the pumps, including Cook and Banks.[47]

When, by Cook's reckoning, about 40 to 50 long tons (41 to 51 t) of equipment had been thrown overboard, on the next high tide a second unsuccessful attempt was made to pull the ship free.[48] In the afternoon of 12 June, the longboat carried out two large bower anchors, and block and tackle were rigged to the anchor chains to allow another attempt on the evening high tide. The ship had started to take on water through a hole in her hull. Although the leak would certainly increase once off the reef, Cook decided to risk the attempt and at 10:20 pm the ship was floated on the tide and successfully drawn off.[49] The anchors were retrieved, except for one which could not be freed from the seabed and had to be abandoned.[49]

As expected the leak increased once the ship was off the reef, and all three working pumps had to be continually manned. A mistake occurred in sounding the depth of water in the hold, when a new man measured the length of a sounding line from the outside plank of the hull where his predecessor had used the top of the cross-beams. The mistake suggested the water depth had increased by about 18 inches (46 cm) between soundings, sending a wave of fear through the ship. As soon as the mistake was realised, redoubled efforts kept the pumps ahead of the leak.[49]

The prospects if the ship sank were grim. The vessel was 24 miles (39 km) from shore[40] and the three ship's boats could not carry the entire crew.[50] Despite this, Joseph Banks noted in his journal the calm efficiency of the crew in the face of danger, contrary to stories he had heard of seamen panicking or refusing orders in such circumstances.[51]

Midshipman Jonathon Monkhouse proposed fothering the ship, as he had previously been on a merchant ship which used the technique successfully.[52] He was entrusted with supervising the task, sewing bits of oakum and wool into an old sail, which was then drawn under the ship to allow water pressure to force it into the hole in the hull. The effort succeeded and soon very little water was entering, allowing the crew to stop two of the three pumps.[53]

Endeavour beached at its namesake river, Endeavour River, for repairs after her grounding on the Great Barrier Reef in 1770. By Johann Fritzsch, published 1786.

Endeavour then resumed her course northward and parallel to the reef, the crew looking for a safe harbour in which to make repairs. On 13 June, the ship came to a broad watercourse that Cook named the Endeavour River.[54] Cook attempted to enter the river mouth, but strong winds and rain prevented Endeavour from crossing the bar until the morning of 17 June. She grounded briefly on a sand spit but was refloated an hour later and warped into the river proper by early afternoon. The ship was promptly beached on the southern bank and careened to make repairs to the hull. Torn sails and rigging were also replaced and the hull scraped free of barnacles.[55]

An examination of the hull showed that a piece of coral the size of a man's fist had sliced clean through the timbers and then broken off. Surrounded by pieces of oakum from the fother, this coral fragment had helped plug the hole in the hull and preserved the ship from sinking on the reef.[56]

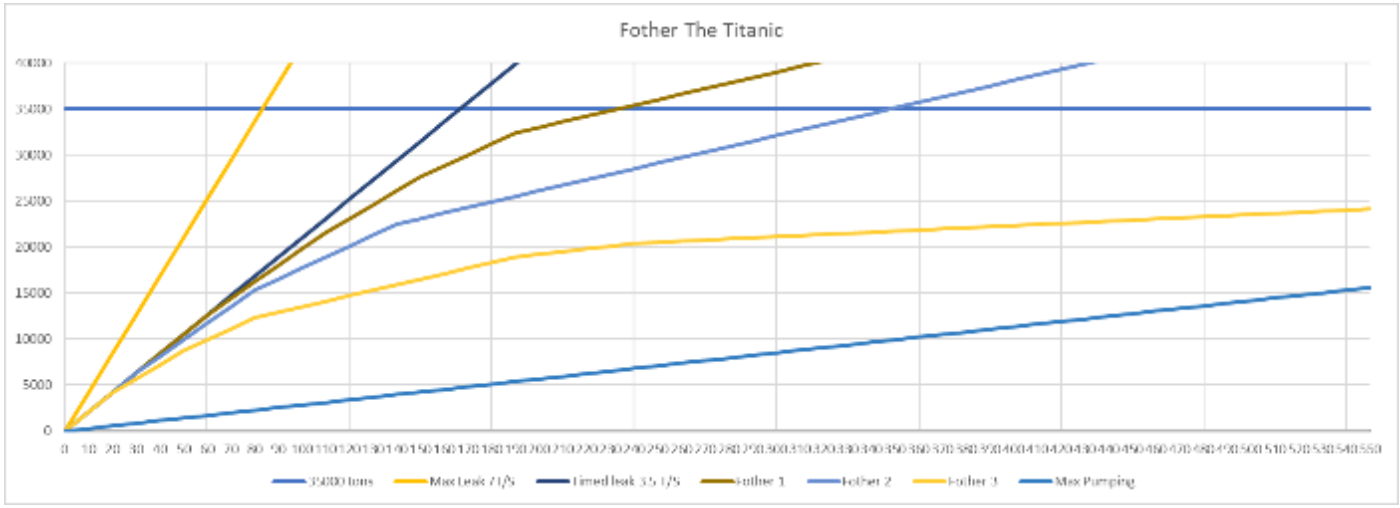
https://en.wikipedia.org/wiki/HMS_Endeavour

Could Fothering Have Worked?

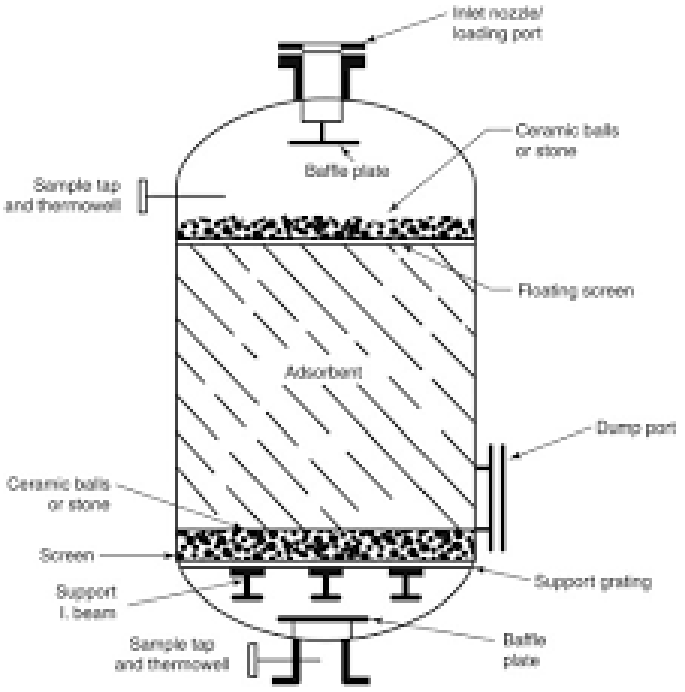
This chart indicates that even limited success with fothering would have bought more time.

The leak rate is understood to have been 3.5 ton per second and that the ship sank when 35,000 tons of water had come on board – although the figures provided are very mixed and inconsistent. However, it is clear that the ship remained afloat for 2 hours and 40 minutes and that whatever the eventual volume of water, the ratio between the incoming flow and the amount that entered would be the same, and the ship overcome in 10,000 seconds

The holes were in lines along the bow and would have been relatively narrow.
If a canvas or carpet were offered up in front of this hole, it would have been sucked in. Enough material would eventually have staunched the flow to some extent. There was plenty of carpet.



An example of fothering from another industry
On oil refineries and gas plants, large vessels are filled with catalyst. There is often a loose mesh or 'floating screen' on the top of the bed. The loose material is discharged through the manhole or dump port on the side.
Before discharge, the mesh is removed – this is often described as just a procedure without much explanation of why.



On one occasion, the mesh was forgotten and the material discharged. The material free flows and 'rat holes' like flowing sand.

This drew the mesh from the top and it appeared at the manhole before the vessel was even half empty. A hole was cut in the mesh to allow the catalyst out, but the moving material dragged ever more mesh into hole, eventually blocking it completely. The team had to enter

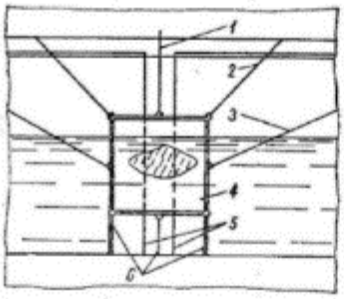
the vessel to dig it out from the top in order to be able to remove the mesh. An awkward job.

While water isn't catalyst, the flow patterns are comparable, and while mesh isn't carpet, as similar blocking of a hole might be expected. While fothering is an unfamiliar practice to most people, this example from another industry gives encouragement that it would work.

So called 'collision mats' are still commercially available today.

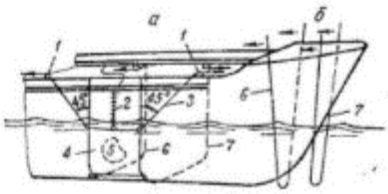
They are a standard piece of safety equipment on Russian ships

https://slideplayer.com/slide/13886664/
https://markogroup.com/en/Production_CollisionMats/
https://www.drewil.pl/category/collision-mats/
http://www.sigo.com.ua/en/production/lightened-thrummed-collision-mats
https://www.turtlepac.com/products/inflatable-collision-mat-ships-oil-leak-containment/



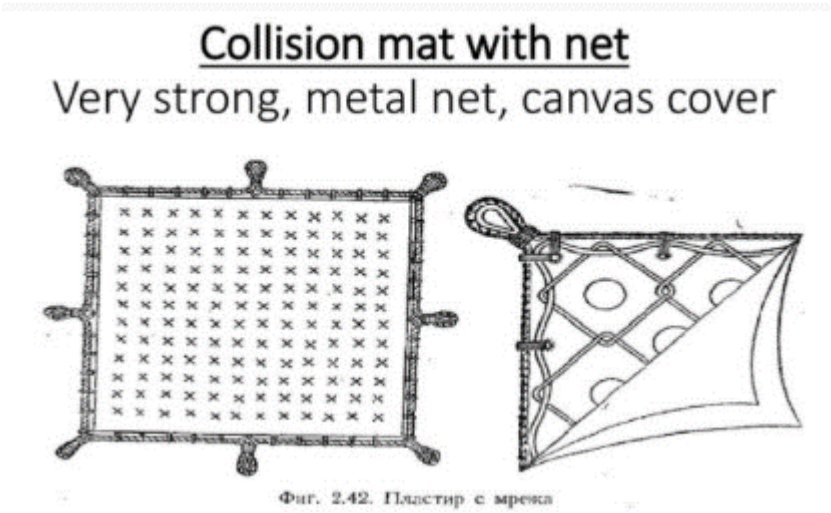
Фиг. 2.44. Схема на поставяне на мек пластир:

1 — измерително (контролно) въже; 2 — задържащо въже; 3 — обтягащо въже; 4 — пластир; 5 — фалшиви ребра; 6 — подхванати въжета



Фиг. 2.45. Схема на поставяне на мек пластир:

а — пластир върху пробойна; б — подвеждане на подкланите въжета: 1 — кницфасбланове; 2 — контролно въже; 3 — обтягащи въжета; 4 — пластир; 5 — пробойна; 6 — първо подклано въже; 7 — второ подклано въже



Фиг. 2.42. Пластир с мрежа

Fothering in Fiction
https://en.m.wikipedia.org/wiki/Desolation_Island_(novel)

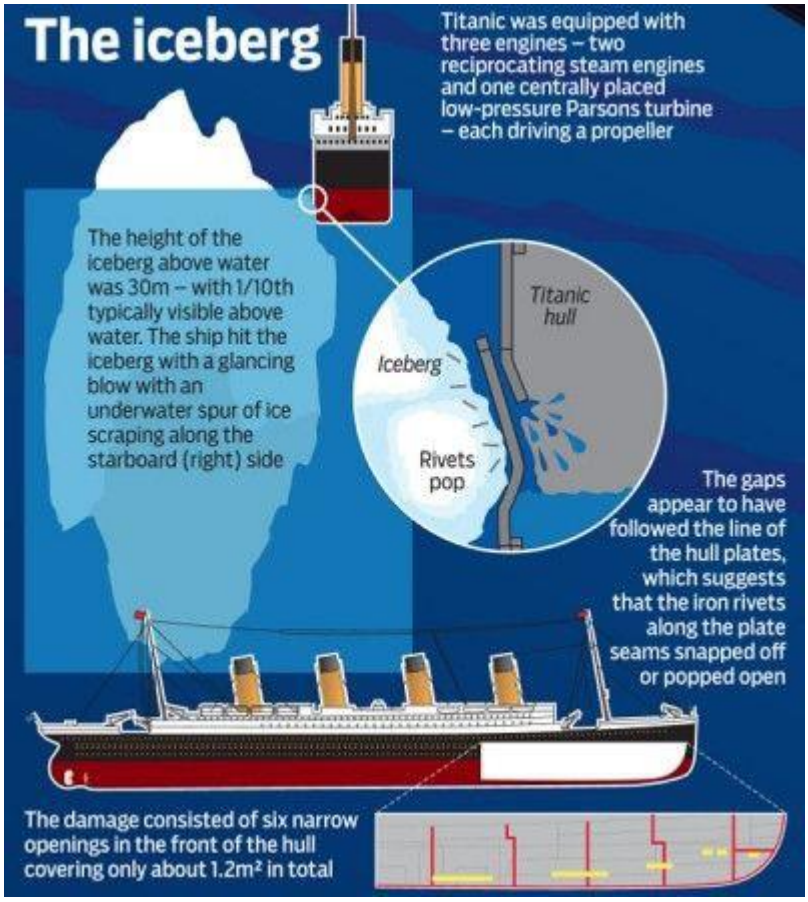
Now east of the Cape, the Leopard aims for New South Wales, but soon strikes an iceberg, damaging the rudder and causing a severe leak.
All hands pump, and the seamen work to fother a sail to stop the leak.
Aubrey was wounded in the battle, but maintains his authority.

Grant, who is more comfortable as captain, disagrees that the Leopard will float, and is given permission to take two smaller boats with the men who wish to leave for the Cape, carrying dispatches from Maturin. The Leopard drifts east with the wind, still rudderless, pumping all the time.
Aubrey, making adroit use of anchors and sails, directs the ship to safe harbour in a bay of Desolation Island.
Despite its name, it is full of fresh food in the rainy Antarctic summer.

Fothering discussions of Titanic forums

https://www.quora.com/How-could-the-sinking-of-the-Titanic-have-been-prevented

https://qr.ae/pGFpLN



https://www.quora.com/Would-fothering-and-sealing-all-portholes-have-bought-Titanic-enough-time-for-Carpathia-to-get-there

https://silo.tips/download/saving-the-titanic-could-damage-control-have-prevented-the-sinking-joseph-m-gree

Closing the forepeak scuttle hatch was a first step. The next action to be taken should have been fothering the leaks. Fothering is an ancient practice at sea to stop or slow down a leak. According to "The Sailor's Word Book" by Admiral W. H. Smyth, published in 1867, fothering is"usually practiced to stop a leak at sea. A heavy sail such as a spritsail is closely thrummed (interwoven) with yarn and oakum, and drawn under the bottom: the pressure of the water drives the thrumming into the apertures. If one does not succeed others are added, using all the sails rather than lose the ship."

Granted the Titanic was not, as far as we know, equipped with any sails. But the canvas hatch covers from the cargo hatches, mattresses, or even the oriental rugs from the First Class lounges would have served equally well. Assuming that the damage found by expeditions to the Titanic is in fact iceberg damage, as seems probable, fothering would have been fairly effective at slowing if not stopping the leaks.

Had Smith retained control of the situation and ordered damage control efforts to start immediately after the collision, it would have been relatively simple to pass lines beneath the ship, take the hatch covers, or carpets and pull them down to cover the damaged areas. Even assuming that the crew did not take time to pitch or tar the canvas or carpets to help waterproof them, a double layer of canvas or thick oriental carpet would have plugged the opening quite effectively.

Since the Titanic was designed to float with the first four compartments holed, it was only necessary to seal the 54-foot opening into Boiler Room 6 to save the ship. While it is unlikely that fothering would have completely stopped the flow of water into Boiler Room 6, it would certainly have reduced it considerably. The time thus gained could be used to extend the damage control efforts to the other affected areas. Every foot of the opening covered reduced the inflow and gave the pumps a better chance of getting ahead of the leak. Further, controlling the flooding this way would have enabled the crew to reach the leaks from the inside and possibly effect further repairs.

Even if fothering did not slow the leaks sufficiently to keep the ship from sinking, it could only have helped the situation. It might well have kept the ship afloat long enough for the Carpathia to arrive, in which case further damage control could have been performed. Even assuming the very worst, that fothering kept the ship afloat for only an hour or so longer, it still would have resulted in more lives being saved. The Carpathia reached the first lifeboat shortly after 4:00 AM, less than two hours after the Titanic sank.

Had the Titanic stayed afloat even an hour longer, it is possible that many of those who died might have been saved. In addition, slowing the rate of sinking might have allowed a more orderly abandonment, meaning that lifeboats would not have been sent away only half filled.

Could the leaks on the Titanic have been fothered? The answer must be yes.

The materials necessary were ready to hand and there were more than enough people to do the work. Why was it not done? Certainly the fact that the Titanic was a new ship with a new crew who were not used to working together added to the difficulties, as did her reputation as “unsinkable,” a claim, it must be noted, never made by the White Star Line.

Pumps

https://www.encyclopedia-titanica.org/community/threads/slowing-titanics-flooding.8146/page-8 Fothering page...
https://www.encyclopedia-titanica.org/community/threads/slowing-titanics-flooding.8146/page-9
Bill Sauder Titanic pumps
https://www.youtube.com/watch?v=fz7bRnlOIbs&feature=emb_imp_woyt&ab_channel=TheTitanicChannel

https://web.mst.edu/~rogersda/american&military_history/TITANIC%20LECTURE%20NOTES.pdf

BILGE PUMP CAPACITY
Five ballast and bilge pumps were fitted to the ship's amidships area, each capable of delivering 250 tons of water
per hour (or 2.23 cubic feet per second), and three bilge pumps were capable of sustaining 150 tons per hour. These made for an aggregate capacity of 1,700 tons per hour of pump capacity, or 407,564 gallons per hour, sufficient to keep pace with an maximum inflow rate of 15 cubic feet per second (which should theoretically have kept her afloat for a week).

However, three bilge pumps were distributed in the boiler rooms, two in the reciprocating engine room and the other in the turbine engine room. There were no sluice valves incorporated into the bilge system, so no means of joining the pumps in series to allow water to be pumped from one compartment to another. The enormity of this oversight was appreciated in TITANIC's post-failure assessments, which suggested that it took the ship 2 hrs 20 min to take on 16,000 tons of sea water. This back-calculates to approximately 12 ft2 of hull opening allowing sea water to infiltrate the hull.

https://titanic19120412.weebly.com/buoyancy.html
https://www.simscale.com/blog/2018/01/why-did-titanic-sink-engineer/

This information indicates that the pumps alone did not have sufficient capacity to pump out the full flow of incoming water – and in any case, they were not joined up in a way which allowed them to all work together and pump out the water.
However, if the flow could have been reduced by even 20%, an extra hour could have been bought. A significant reduction in incoming water could have allowed a more organised effort to avoid the loss of the ship.

https://www.reddit.com/r/titanicfacts/comments/9fxpid/the_rate_of_water_entering_the_titanic_solved_or/

I posted this a year ago; not trying to double dip on votes, but it's too good not to share:

It was later estimated that the Titanic was taking on 7 long tons of water per second (1 long ton is 268 gal, so 1876 gal per second). Given the weight of a gallon of water at 8.6 lbs, this 16133.6 lbs per second, or 968,016 lbs per minute. Sweating yet?

The displacement of the Titanic was 53,310 tons meaning for every bit of water you displace, you create equal buoyancy (I think it's one of Archimedes laws). As you take on water, you displace less and less water, and therefore lose buoyancy, or more accurately, become neutrally buoyant. The kicker here is, the mass of the ship stays the same, so once that buoyancy is gone, gravity takes effect.

Soooo the Titanic's displacement in lbs was 119,414,400. Divided by the weight of the water coming in per minute (968,016) gives you 123.35 minutes, or roughly 2 hours.

Now it's not exact on the time, since the ship didn't flood evenly, and it didn't have to be totally filled with water to sink. It was well constructed and considering the numbers, held on pretty well.

I know this will get buried in this sub, I just thought it was cool, especially since these are probably similar to the calculations Andrews did, though probably much more quickly by him. The ship sank 16 feet in the time it took me to calculate this.

APPENDIX 3 – TITANIC LIFEBOAT DETAILS – WIKIPEDIA

Number and types of lifeboats

Titanic's wooden lifeboats in New York Harbor following the disaster. This particular image has been doctored[to add the words "R.M.S. Titanic". In fact the lifeboats bore the name "S.S. *Titanic*" on a plaque mounted at the other end of the boat[1]

Titanic had 20 lifeboats of three different types:

- 14 clinker-built wooden lifeboats, measuring 30 feet (9.1 m) long by 9 feet 1 inch (2.77 m) wide by 4 feet (1.2 m) deep. Each had a capacity of 655.2 cubic feet (18.55 m^3) and was designed to carry 65 people. The rudders were made of elm – selected because it resisted splitting – and were 1.75 inches (4.4 cm) thick. The exterior of the boats were fitted with "grablines" for people in the water to hold on to.[2][3] They were fitted with a variety of equipment to aid the occupants, comprising 10 oars, a sea anchor, two bailers, a painter (effectively a tow-rope) 150 feet (46 m) long, two boat-hooks, two 10 imperial gallons (45 l) tanks of fresh water, a mast and sail, a compass, a lantern and watertight metal provision tanks which contained biscuits.[4] This equipment was not kept in the boats for fear of theft, but in locked boxes on the deck. In many cases, the equipment was not transferred to the boats when they were launched on 15 April and ended up going down with the ship.[3] Blankets and a spare lifebelt could also be found in the boats. Apparently unknown to many officers and crew, these boats were reinforced with steel beams in their keels to prevent buckling in the davits under a full load.

- 2 wooden cutters intended to be used as emergency boats. They were kept ready to be launched quickly in the event of an incident requiring a boat in the water, such as a man overboard. The cutters were swung out at all times when the ship was underway, uncovered and with all their equipment, including a lighted oil lantern placed in the boat every evening. The cutters were of a similar design to the main lifeboats, but smaller, measuring 25 feet 2 inches (7.67 m) long by about 7 feet (2.1 m) wide by 3 feet (0.91 m) deep. They had a capacity of 322 cubic feet (9.1 m^3) and could carry 40 people.[5] They were equipped similarly to the main lifeboats but with only one boat-hook, one water container, one bailer and six oars each.[6]

- 4 "collapsible" Engelhardt lifeboats. These were effectively boat-shaped unsinkable rafts of kapok and cork, with heavy canvas sides that could be raised to form a boat. They measured 27 feet 5 inches (8.36 m) long by 8 feet (2.4 m) wide by 3 feet (0.91 m) deep. Their capacity was 376.6 cubic feet (10.66 m^3) and each could carry 47 people.[5] The Engelhardts, built to a Danish design,[7] were built by the boat-builders McAlister & Son of Dumbarton, Scotland.[8] Their equipment was similar to that of the cutters, but they had no mast or sail, had eight oars apiece and were steered using a steering oar rather than a rudder.[6]

The main lifeboats and cutters were built by Harland and Wolff at Queen's Island, Belfast at the same time that *Titanic* and her sister ship *Olympic* were constructed. They were designed for maximum seaworthiness, with a double-ended design (effectively having two bows). This reduced the risk that they would be flooded by a following sea (i.e. having waves breaking over the stern). If a lifeboat had to be beached, the design would also resist the incoming surf. Another safety feature consisted of airtight copper tanks within the boats' sides to provide extra buoyancy.[2]

APPENDIX 4 – CANOE TENT

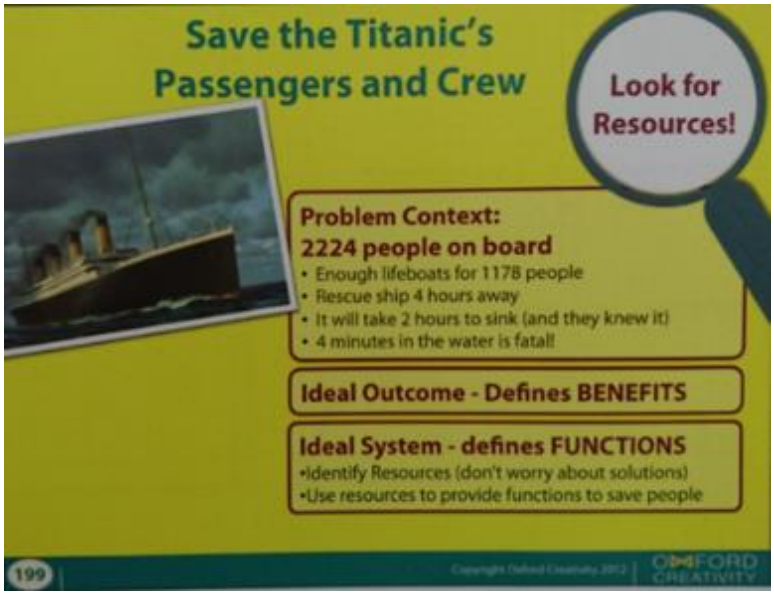
Dorothy refers to a ‘Canoe tent’ project. This was/is a known Scout project

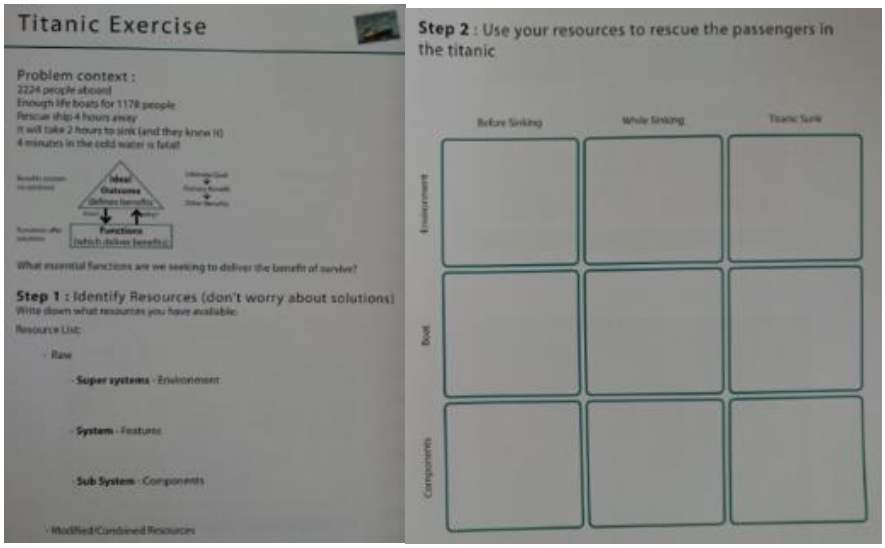
https://www.pinterest.com/pin/82472236916716306/



APPENDIX 5 – SOLUTION ORIGINS

The original Triz exercise that inspired this solution and the possibility of saving everyone on board





APPENDIX 6 – LINKS AND BACKGROUND

Documentaries
https://www.youtube.com/watch?v=TvwUxquqRFQ&ab_channel=malisaraha
https://www.youtube.com/watch?v=yzHZJcyU9g8&ab_channel=hazardsandcatastrophes
https://www.youtube.com/watch?v=T2NFMzbt0FE&ab_channel=FreeDocumentary-History
https://www.youtube.com/watch?v=FSGeskFzE0s&ab_channel=NationalGeographic

https://en.wikipedia.org/wiki/Lifeboats_of_the_Titanic

https://titanicdatabase.fandom.com/wiki/Passengers_of_the_RMS_Titanic
https://en.m.wikipedia.org/wiki/Girlguiding
https://en.m.wikipedia.org/wiki/Lifeboats_of_the_Titanic
The two boats were lashed together for the rest of the night until they separated to meet the RMS Carpathia.[37]

Answer to How far did the boats from the Titanic get from the Titanic? by Dave Nitzer
https://www.quora.com/How-far-did-the-boats-from-the-Titanic-get-from-the-Titanic/answer/Dave-Nitzer?ch=3&share=226b3a52&srid=hx8Hc

https://images.app.goo.gl/VTfG94eyJqvn6auY9 Overloaded ferry

http://www.drdavidkowalski.com.au/contact.html Titanic alternative history book
https://girlwithherheadinabook.co.uk/2012/08/the-company-of-dead-david-j-kowalski.html

https://titanicfacts.net/titanic-timeline/
http://www.paullee.com/titanic/everybodysaved.php

https://www.quora.com/If-you-are-on-the-Titanic-and-the-ship-sinks-what-will-you-do-to-delay-the-sinking
https://www.quora.com/Would-a-large-sinking-ship-like-the-Titanic-pull-a-person-under-water-if-the-person-was-in-the-water

https://www.goodreads.com/topic/show/1024476-could-all-of-titanic-s-passengers-have-been-saved

https://www.debate.org/opinions/could-the-titanic-have-been-saved
https://www.encyclopedia-titanica.org/the-average-lifeboat.html
http://www.titanic-cad-plans.com/wp-content/uploads/2019/06/Titanics-Lifeboat-Capacity.pdf

APPENDIX 7 – THE LOSS OF THE TITANIC – BACKGROUND INFORMATION