MV Derbyshire - theories and factual evidence

Part 1

Public scrutiny

> *5.10 The purpose of a public inquiry is thus to carry out a full, fair and fearless investigation into the relevant events and to expose the facts to* ***public scrutiny****. That is or should be the purpose of every public inquiry.*
>
> ***Lord Justice Clarke,*** *THAMES SAFETY INQUIRY*

Courtesy of http://johnfenzel.vox.com/library/posts/tags/supertanker/

Bulk Carriers and the Derbyshire

The above two images show a panamax sized[1] (*60,000 - 80,000 tonnes deadweight*) bulk carrier in a storm. They have been shot from the bridge, looking forward, and show

[1] The Derbyshire was much larger than the vessel shown, able to carry up to 173000 tonnes deadweight

general deck wetness and 'green sea' loading on the number 4 and 5 cargo hold hatch covers.

The Derbyshire was lost in typhoon Orchid off the coast of Okinawa in darkness, during the night of 9th/10th September in 1980. A formal investigation into her loss was carried out in 1989, which concluded that the Derbyshire had probably been overwhelmed by the forces of nature.

Following the discovery in 1994 of her wreckage, some 2½ miles below the sea surface and the detailed underwater surveys of 1996 and 1997, the Formal Investigation was re-opened on 5 April 2000 under Mr Justice Colman. The report of the Admiralty Court hearings was published in November of that year.

In brief, the court's findings were that heavy weather damage to a number of ventilators and air-pipes at the fore end of the vessel had allowed seawater to enter the hull's forward spaces and cause the vessel to trim by the bow. It was also concluded that this forward trim had enabled heavy seas to break on and over the number 1 cargo hold hatch covers and subject them to significant 'green sea' loading. This 'green sea' loading was deemed to have exceeded their collapse strength (equal to about 4 metres head of seawater) causing them to fail, and leading to the flooding of number 1 cargo hold and yet more trim. The process was repeated on the number 2 and then the number 3 cargo holds hatch covers causing them to fail in a similar manner. As further flooding took place, the vessel sank.

While these findings are very plausible and align with much of the evidence from the underwater surveys, the model tests and expert testimony given during the 2000 Derbyshire Re-opened Formal Investigation (RFI) court hearings, Justice Colman's final conclusions do not lead to an 'Eureka' moment, neither do they have that unquestionable ring of authenticity about them, and something of substance still appears to be missing.

Discussion

For the Derbyshire to have sunk, it is obvious that some extraordinary or **unusual event** must have taken place, otherwise similar vessels[2] in similar weather conditions around the world would, over the years, have reported serious hatch cover failures and/or been lost in a similar manner.

In the Derbyshire case, the court concluded that the **unusual event** that had led to hatch cover failure and the vessel's loss was the forward trim (brought about by flooding of the stores spaces, chain lockers and forepeak). But was this forward trim so significant?

While the evidence indicating that the Derbyshire's hatch covers had failed due to seawater loading is conclusive, it is suggested that the court was unable to demonstrate in a wholly satisfactory manner, that the vessel's forward trim, due to the flooding of forward spaces, was causative of their failure.

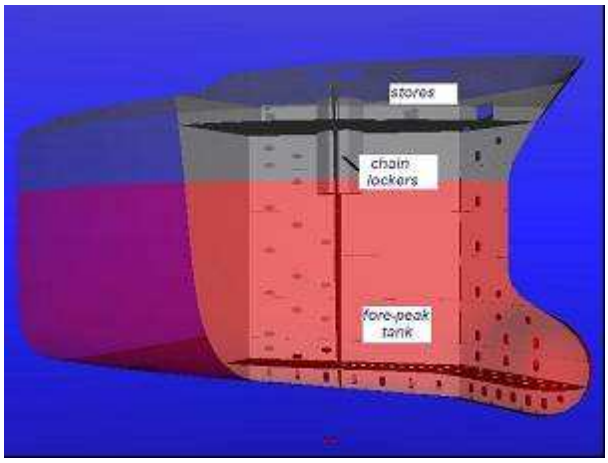
A reduction in forward freeboard due to trim would obviously increase the frequency and severity of seawater loading on the forward hatch covers, and therefore the probability of their failure, but by how much?

The MARIN model tests and the subsequent calculations that were carried out by the RFI's experts were able to show that, when the fore end was flooded and when the vessel's pitching motions, its speed and the storm wave's length, maximum amplitude

[2] While there have been a large number of bulk carrier losses in the past 30 years, an analysis of the underlying causes of their loss has shown that hatch cover failure was not a significant factor.

and frequency were adversely in phase, this small difference in trim could mean the difference between the vessel's survival and its loss[3]. Essentially this was confirmation that, in a limited number of circumstances, the adverse forward trim could lead to hatch cover overload and failure.

However, the MARIN model tests, which indicated that hatch failure was a realistic possibility, were carried out for two principal conditions only – with the vessel in undamaged and fully damaged conditions. In the fully damaged condition, in addition to the store spaces and the ballast tank, the forward fuel oil deep tank was also assumed flooded[4] - i.e. with some 3000 tonnes of seawater in addition to the 2000 tonnes of fuel oil it initially contained. In this condition the vessel's trim would have been approximately double that of when the stores and forepeak ballast tank only were flooded.



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Bearing in mind that the fuel tank was not flooded prior to hatch cover failure, it would have been more appropriate if the MARIN model tests had been carried out with the model in a condition that reflected that situation. The fact that these MARIN results were subsequently used in a process of statistical analysis and extrapolation does not automatically give confidence in the final outcome of this whole modeling process.

Was this forward trim so significant?

The loss of forward freeboard due to flooding and trim, about 1.3m only (excluding flooding of the Fuel Oil Deep tank), was not of a magnitude that could significantly alter the 'ballpark' hatch cover loads expected to arise from the large waves and ship motions generated by typhoon Orchid. The hatch covers in this trimmed condition would still be about 8.9m above the sea surface and only about 630 mm below their position, with the ship in an undamaged but fully laden condition[5]

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[3] When the vessel was undamaged the tests showed that the hatch covers would retain their integrity. However, when the vessel's fore end was fully flooded (including the forward fuel deep tank), the tests showed that the hatch covers would fail.

[4] The RFI concluded that this tank was **not flooded** prior to hatch failure

[5] i) Maximum laden condition - Centre of no 1 hold hatch cover = 9.5m above summer load waterline
ii) Assumed sailing condition - Centre of no 1 hold hatch cover = 10.165m above waterline
iii) Assumed sailing condition with stores and chain lockers flooded - Centre of no 1 hold hatch cover = 9.756m above waterline
iv) Assumed sailing condition with stores, chain lockers and fore peak tank flooded - Centre of no 1 hold hatch cover = 8.868m above waterline

Most importantly, there is evidence that over the past 35 years, many vessels of a similar size to the Derbyshire, having similar draughts and freeboards, have sailed in more severe conditions than those presented by Typhoon Orchid - i.e. bigger waves and more severe vessel motions - without a significant number of recorded hatch cover failures. Of course, some vessels were lost without trace and which may have been due to hatch failure, but there are many other reasons why the hulls of old single hulled vessels could have failed.

In conclusion

It is suggested that regardless of Justice Colman's statements:

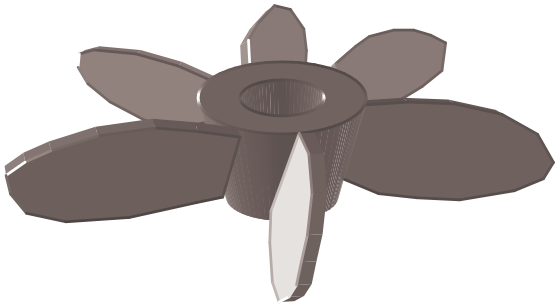
> *"it can be concluded with reasonable confidence* ***that the initiating cause of the loss was the destruction of some or all of the ventilators and air pipes located on the foredeck*** *by sustained green water loading over many hours in the course of 8th and more probably 9th September 1980"*
>
> ***"there is no room for any further unidentified factor"***

we should not necessarily blindly accept the conclusion that the flooding of the forward spaces/ FP Tank and resulting bow trim were the **unusual events** that led to the failure of the cargo hold hatch covers and the Derbyshire's loss.

Part 2

A different theory

An old newspaper article, published more than 100 years ago in the New York Times, and which is copied below may be able to give us a lateral view of what might possibly have happened onboard the MV Derbyshire that day in September 1980.



The Derbyshire carried a spare propeller that was strapped to the upper deck plating on the starboard side of the vessel (between and outboard of the number two and number three cargo hold hatches).

This six bladed propeller was made of nickel alloy, had a diameter of 7.6 metres and weighed **41 metric tonnes**.

If this propeller had broken loose in bad weather it would have been capable of inflicting serious damage to any deckhouse, small hatch, hatch coaming, vent or deck fitting which got in its way

A RUNAWAY PROPELLER.

IT SMASHES A HOLE IN THE STEAMER ELSIE'S PLATES.

The fifteen-hundred-ton steamer Elsie, from St. Vincent, lies at anchor off Liberty Island with a hole through her sides bigger than a big barrel, as an example of the mischief a ponderous mass of metal which slips its leash at sea can work. Out of the jagged hole hangs the blade of a propeller.

The Elsie sailed from St. Vincent on Dec. 27 with a spare propeller lashed aft between decks. It was a four-bladed affair, weighing something over two tons, and molded all in one piece. Keeping it company was a four-ton cylindrical tail shaft.

On Jan. 11 a gale came up out of the west and the vessel pitched heavily. Early in the morning Capt. Creeden, the skipper of the Elsie, was alarmed by a great din coming from the interior of his vessel. There he found that three of the blades of the propeller had broken off. The men were kept on a continual hop-skip-and-jump to dodge the ponderous masses of metal thrown about by every pitch of the ship. To make bad worse, the huge tail shaft gave indications that it, too, was about to break loose. To secure the shaft was the main object, and it was attained after many narrow escapes in dodging the propeller blades.

The propeller put itself out of harm's way at last by jabbing a hole clear through the plates of the starboard side, and sticking there. The rest of the hole was filled up with burlap, and, the wind lulling, the Elsie, thanks to her good engines and her freedom from cargo, got into this port safely.

The "jamboree," as the Captain called it, of the propeller lasted half an hour, but it will cost the owners considerably over $4,000 to repair damages.

The following paragraph, taken from the publication 'Steamboats and Sailors of the Great Lakes', puts forward a possible scenario for the mysterious loss of the great lakes bulk carrier the 'Edmund Fitzgerald'

> **"What if, however, something had broken loose on deck and was battering the hatches and vents on the deck? The only objects on the deck heavy enough to do serious damage were the hatch crane and the spare propeller blade. The hatch crane would have been secured at the after end of the deck, while the spare propeller blade was bolted down in the midship area. Could the propeller blade have broken loose from its mounting and started battering up against the hatch coamings, smashing them in and allowing great quantities of water to cascade into the cargo hold?"**

The first question to be asked is: why did the RFI's experts not consider this possible scenario?

The experts considered 14 separate loss scenarios:

1. **Deck Cracking at Frame 65.**
2. **Deck Cracking at Mid-Sections.**
3. **Torsional Weakness.**
4. **Hatch Cover Collapse.**
5. **Hatch Cover Attachment Failure.**
6. **Fore Deck Corrosion and Fracture.**
7. **Flooding of Forward Spaces.**
8. **Cargo Shift/Liquefaction.**
9. **Loss of Propulsion.**
10. **Rudder Loss/Steering Failure.**
11. **Explosion and/or Fire in the Engine Room.**
12. **Pooping – from Forward Waves.**
13. **Pooping – Running with the Sea.**
14. **An Unforeseen Cause**

The RFI Judge was able to discount 11 of these on the basis of the evidence collected from the underwater surveys. Of the three scenarios that remained, number 4 and 7 were strongly supported by the evidence from the underwater surveys. Although number 14 should have been a little more difficult to pass over, Justice Colman was nonetheless able to tie up the loose ends in the RFI in such a way that all possibilities, other than the favoured loss scenario were eliminated:

Transcripts of evidence 3 May 2000

> **"Q. Finally, then, on scenarios, the unforeseen scenario, you are the only man who leaves it open, but I am going to ask you a difficult question now: can you give us any idea of what might be another scenario as yet unforeseen?**
> **A. Well, my Lord, the experts did not have wide-ranging discussions about all possible scenarios. It seemed to me that at least there was the possibility, even if remote, of some other factors coming into play. I mean, for instance, one thing we have not mentioned, and we have no evidence for, is the status of hatch coamings, and whether or not there could have been some ingress of water through damage to a hatch coaming; or perhaps, as we discussed earlier today, the possibility of damage to a hatch cover which allowed water ingress before a sudden failure. That was the initiating event in as much as --**
> **MR JUSTICE COLMAN: Is that not part of the overall process of hatch cover failure as the initiating exercise?**
> **A. That would be, my Lord, yes, yes.**
> **MR JUSTICE COLMAN: I think it would be.**
> **A. That would be.**
> **MR MORAN: Mr Squire, is it the case that if you sat down for long enough, you could think of all sorts of things for which there is no evidence in the wreckage or the facts that have been deployed before this investigation?**
> **A. Yes. I would agree that I have no alternatives in mind, my Lord."**

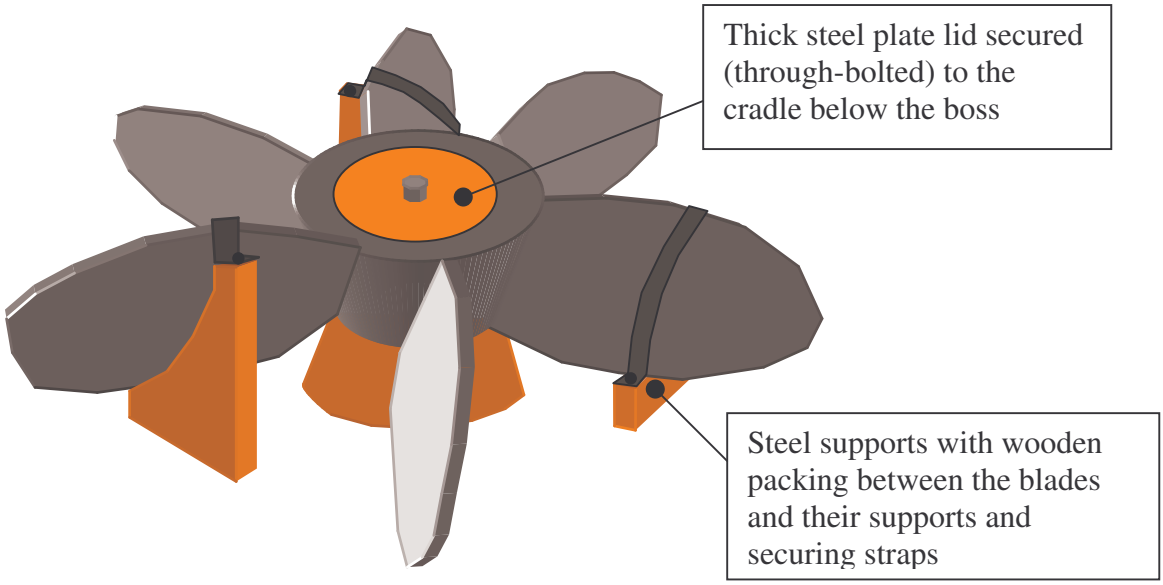
Report of the Re-opened Formal Investigation (page 141)

> "9.12 Finally, a fourteenth scenario – some unknown cause - was added but rejected by the majority of experts. This Report accepts that conclusion. **The evidence in support of the initiating cause of the loss being ingress of seawater into the bow spaces due to damage to ventilators and airpipes is so compelling that as a matter of probability there is no room for any further unidentified factor."**

The spare propeller

On the Derbyshire, the spare propeller was secured in a cradle on the upper deck, between and outboard of hatch numbers 2 and 3.

The means for securing the propeller were typical of that in contemporary shipbuilding practice: i.e. a steel cradle under the boss with additional tailored supports under three of the propeller blades, all welded to the upper deck with wooden blocks used as chocking materials between the propeller and cradle, and between the propeller blades and their supports and securing straps:

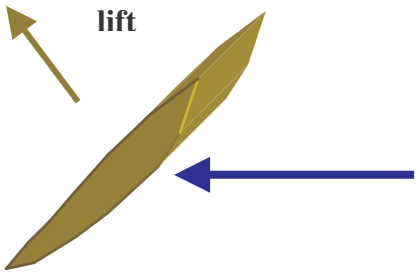


Although the above arrangement is typical and utilised onboard many ships, there were two factors in the arrangements on the Derbyshire that may not have been fully considered at the time of her design and construction:

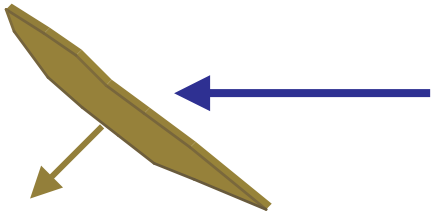
1. The spare propeller was stowed in the forward region of the upper deck and thus would be liable to the effects of waves breaking over the foredeck (on many vessels, spare propellers are stowed in the midship area or even at the after end).
2. The propeller was stowed on the starboard side of the vessel, with the pitch angle of the outboard blades facing forward; if the propeller had been stowed on the port side of the vessel the pitch angle of the outboard blades would have faced aft

The combination of these two factors could mean that, in heavy seas, as a wave broke over the foredeck and travelled aft, the hydrodynamic forces from the wave would act upon the outboard propeller blades and tend to cause the propeller to lift and rotate. Thus instead of the propeller being pushed more deeply into its support cradle, which was of substantial construction, it would tend to lift and bear against the three relatively flimsy steel securing straps.

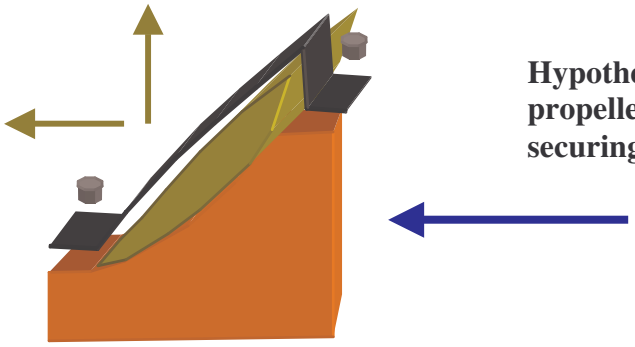
Sections though the propeller blade in way of the support and strap:



A breaking wave on the upper deck, travelling down the deck, would act upon the outer blades and cause the propeller to rotate and lift against the securing straps. (The arrangement as fitted on Derbyshire)



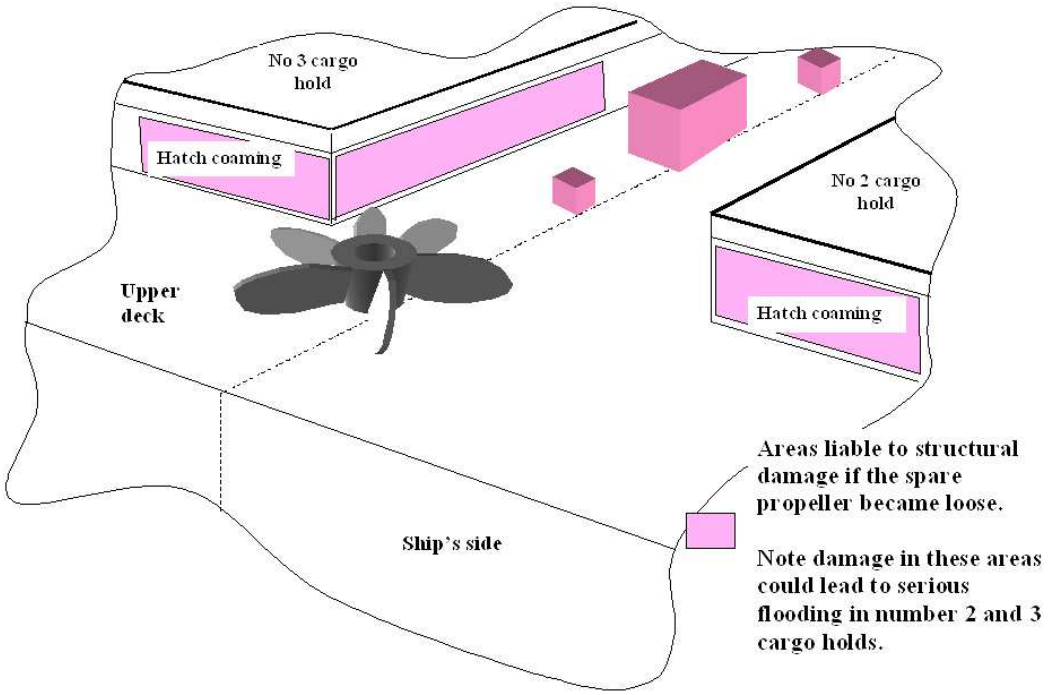
However, if the propeller had been stowed on the port side of the vessel, a breaking wave on the upper deck, travelling down the deck, would tend to push the propeller down and firmly onto its support bed



Hypothesis: Sea loading causes the propeller to rotate and lift and the securing straps to fail

A possible loss scenario

If the spare propeller became detached from its supports, apart from the possibility of it sliding overboard, there would also be the possibility of it travelling inboard as well as fore and aft, due to the vessel's pitch and roll motions and the actions of storm force waves breaking over the fore deck.



If the spare propeller *did* travel inboard, the hatch coamings, which were nearby, together with several small access hatches and the companion house, which led to the number 2 and 3 holds, would be liable to serious damage. The 41 tonne propeller would find little resistance, should it come up against any of these small deck structures; similarly, the

blades of the propeller would be able to punch through and gash holes into the hatch coamings with relative ease

A 14th Scenario

1. The spare propeller becomes detached from its deck supports due to waves breaking over the starboard foredeck.
2. The loose propeller then collides with the hatch coaming to number 3 hold and leaves a tear in the hatch coaming plating.
3. The vessel then rolls to port and the propeller, helped by another breaking wave, follows suit destroying the small access hatches and companionway on its way
4. The vessel rolls to starboard, the propeller reverses its tracks, slides over the deck to starboard and then drops over the ship's side and is lost.
5. Seawater is then able to enter the number 2 and 3 cargo holds due to the holes in the coaming and the damaged access hatches and companionway. The high degree of deck wetness means that water ingress is significant
6. The partial flooding of these two forward cargo holds causes the vessel to sit lower in the water and to trim by the bow.
7. The resulting loss of forward freeboard puts increased sea loading on the ventilators at the bow and a number of ventilator heads are lost, then the bosun's store spaces, the chain lockers and fore peak tank become flooded.
8. Due to the flooding in number 2 and 3 cargo holds and in the forward spaces the vessel is now trimming significantly by the bow
9. The hatch covers to number 1 cargo hold are overloaded by breaking waves, they collapse and water floods into the number 1 hold.
10. The additional trim means that the hatch covers to the partially flooded number 2 hold are then overloaded by breaking waves and they collapse in a similar manner to number 1 hold.
11. The starboard windlass on the foredeck is torn from its seating, damaging the hatch to the bosun's store on its way.
12. Number 3 hatch covers also fail, and the vessel sinks.
13. All partially filled or empty tanks (including the partially filled forward fuel deep tank in way of bulkhead 339) implode/explode as the sinking hull makes its way to the seabed

Evidence

The above theory is supported by the following facts:

- The scenario cannot be discounted on the basis of the evidence observed on the seabed
- If strength calculations were carried out, they could show that the support arrangements for the spare propeller were inadequate in view of anticipated loads from waves breaking on the fore deck
- The spare propeller was not found within the wreckage field, which is consistent with the propeller having become detached from its mountings and falling over the side before the vessel foundered. (The RFI also considered the possibility of the spare propeller detaching itself from its supports and damaging the starboard windlass
- Heavy weather damage to the securing arrangements of the spare propeller on the *Kowloon Bridge* (a sister vessel to Derbyshire) was observed before she foundered (see images on the following pages)

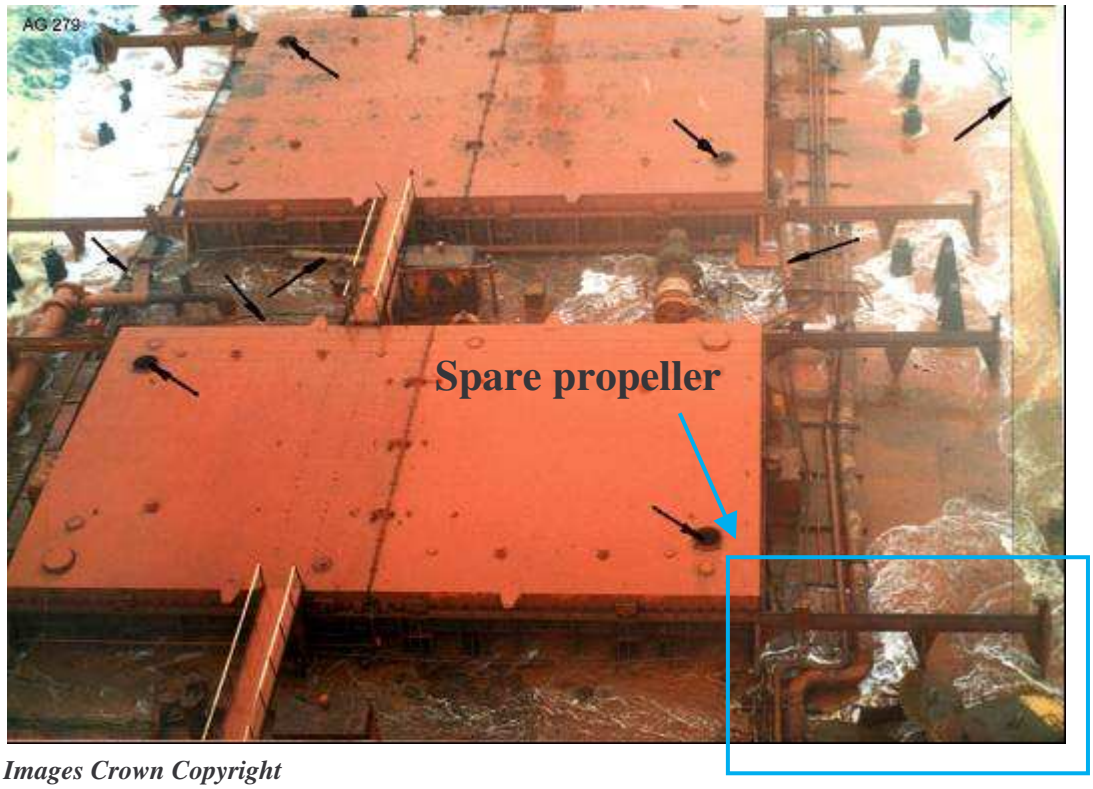
Conclusion

Given the above arguments, can Justice Colman's assertion that **"as a matter of probability there is no room for any further unidentified factor"** still be logically sustained?

The fore deck of the Kowloon Bridge (ex English Bridge and sister ship to the Derbyshire) in the afternoon of 23 November 1986
- just prior to the vessel foundering on the Stags rocks in Irish waters

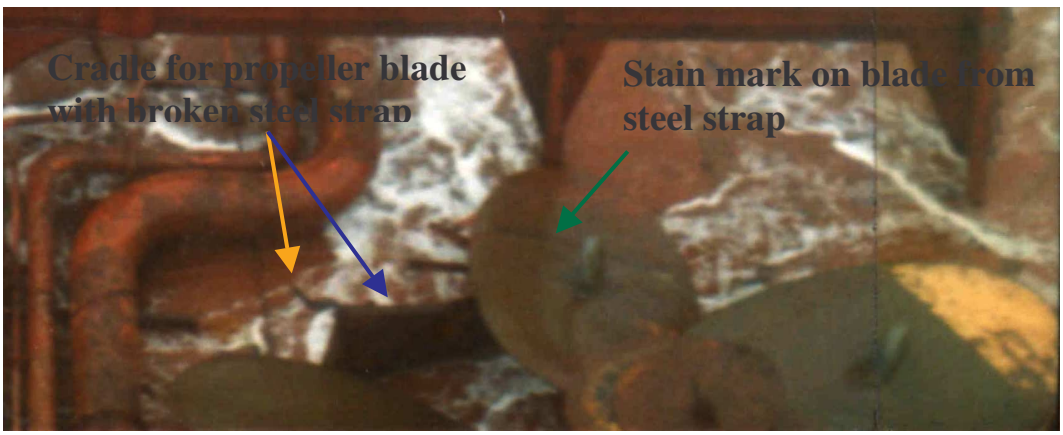
Note the condition of the spare propeller

The securing arrangements for the spare propeller can be seen to have been damaged – at least two out of the three propeller blade support straps are broken. Additionally the propeller has rotated slightly and moved off its support cradle. The broken strap can be seen more clearly in the images on the following page.



Images Crown Copyright

In the image below, the object (**arrowed**) is one of the support cradles for the blades of the spare propeller, a broken steel strap also **arrowed** can be seen attached to left hand side of this cradle. The propeller has obviously rotated on its supports and the strap has been broken. The dark linear **indication** that can be seen on the surface of the propeller blade is a stain mark, which shows where the steel retaining strap would have normally sat



The thick steel securing lid and the through-bolt on the propeller boss have been displaced to the right, the circular rust stain on the boss shows the original location of the lid.