F - Short fat Ships

MR OWEN

17 September 1985

SHORT FAT SHIPS

Thank you for showing me the attached note of 29 July to you from Mr Brown, the Deputy Chief Naval Architect, covering a loose minute dated 9 July from Mr Wall, the Chief Naval Architect. You passed them to me on 3 September on my return from holiday. I now have the correspondence referred to in the CNA's minute and the relevant portions, with my comments, are set out below.

First, Dr Garwin's note to me of 28 March, the document which provoked the CNA's minute. Here it is, in full:

> "That the Royal Navy has ignored the potential of short, fat ships is both certain and evident. This lack stems from an error by K J Rawson, who as Deputy Director of Naval Ship Design (Bath) wrote me that favourable results on a 1/25 scale model were irrelevant to the performance of a full-size ship because "lift increases as the square of the length scale (like the area), while displacement (weight) increases as the cube". Thus, a full-size ship would have 25 x 25 = 625 times the lift, and 25 x 25 x 25 = 15,625 times the weight.

"Mr Rawson forgot that model tests are done at speed scaled by the square root of length scale factor (so at 1/5 speed), and lift goes as speed squared. So full-size ship lift will be 625 times the model lift (area factor), multiplied by 5 x 5 = 25 times (speed-squared factor).

"That my analysis is correct was certified by a letter from Sir James Lighthill to D L Giles, all the more remarkable for replacing an earlier letter approving Mr Rawson's position.

It is this simple but not obvious error on the part of the Royal Navy which prevented consideration of short, fat frigates."

The correspondence between Garwin and Rawson arose because Garwin, a physicist with much experience in consultancy for the US Government on national security and defence, had been consulted by David Giles, the inventor of the Sirius short fat design. Rawson had written to Giles on 13 April 1981 as follows:

"You will remember at our meeting on 27 February I said that if there were any significant dynamic lift on the OSPREY form, it really would represent an important contradiction of traditional theory. Unhappily, the information you now supply does not show such evidence and it must be presumed that conventional wisdom is not to be denied. Such dynamic advantage is confined to quite small craft and is lost at OSPREY displacements - not surprisingly because displacement varies as the cube of the dimension and dynamic lift as the square. We are safe in assuming that ships of SIRIUS size will certainly obey normal laws."

After four exchanges of letters between Garwin (who challenged the above paragraph) and Rawson, beginning in July 1981, Rawson wrote at the end of September:

"Like other dynamic forces, the lift coefficient will be the same for geosims at the same Froude number. This, I believe, is what you are saying and, if so, we are in agreement.

"Significance of lift depends on the attitude of the boat which will be perturbed to a degree depending on its weight and inertia that do not scale simply. Characteristic length, used for Froude number, may also change with attitude so that the significance of lift in affecting the power requirements is not directly scalable. As a generality, lift and planing are important in small craft operating at Froude numbers much higher than are usual with large ships."

On October 6, Garwin replied:

"We agree that at the same Froude number (and attitude) the lift is as important in comparison with weight on a large ship as on a small ship. We agree that the significance of lift in affecting power requirements depends critically upon attitude.

"I believe therefore that we must also agree that if lift can be used to reduce drag significantly in small ships, then by careful attention to trim and attitude in a similar large ship (or by good luck) a similar beneficial effect may be obtained.

"Therefore the laws of physics (and in particular the "square-cube relation") in no way prohibit this happy result."

Game, set and match to Garwin. While this correspondence was in progress, Giles wrote to Professor R V Jones in Aberdeen, asking for his views. Jones recommended Sir James Lighthill, Provost of University College, London, and formerly Director of the Royal Aircraft Establishment and Lucasian Professor of Mathematics at Cambridge. Giles wrote to Lighthill, who replied on 13 July:

"Thank you for your letter of 8 July and its enclosures. I am afraid I remain sceptical of the ideas put forward in these. I see the disadvantages of 'larger lifting area' and 'wider form' (disadvantages arising from increased frictional resistance and wavemaking resistance) as likely to be substantially greater than any potential advantages of dynamic lift at these displacements. The square-cube law is at it again."

However, after seeing the full correspondence between Rawson and Giles, Lighthill wrote to Giles again on 9 November:

"Over the last few months I have much enjoyed the technological argument that has been in progress between Mr Rawson and Dr Garwin. I assure you that I have been reading every letter in the correspondence carefully even though I have not hitherto joined in. Now, however, I will just make the comment to you that, in my own carefully considered opinion, Dr Garwin's concluding letter of October 6 sums up the position perfectly correctly from the standpoint of hydrodynamic theory."

This is the letter which Garwin, in his note to me, describes as "all the more remarkable" for replacing the earlier letter approving Rawson's position.

On 5 March 1984, Garwin wrote to a Mr Hobbs, Projects Director of Marconi at Stanmore, making it clear that he in no way agreed with Rawson's original position:

"I was asked by a mutual friend some years ago to look into the controversy between Kenneth Rawson and David Giles, when Rawson maintained that model results were inapplicable to large-ship performance, because dynamic lift might be important for a model but could not be for a large ship. Rawson based his claim on the undisputed fact that the lifting area increased as the square of the linear scale factor, while the displacement of the ship (and hence the mass to be lifted) increased as the cube of the linear scale factor. What Rawson ignored (and what I pointed out to him in the enclosed letter) is that dynamic lift goes as the square of the speed, and the characteristic speed for a ship increases as the square root of the linear scale factor. Thus the dynamic lift, being the product of the area and the square of the speed, increases as the cube of the linear scale factor, just as is required to be equally important for a large ship as for a small ship of similar form.

"I have never wavered in this assertion, and I was supported, after some reflection, by Sir James Lighthill. I do not know whether Mr Rawson has explicitly recanted his incorrect judgement in this matter. If he has not, he is probably still confusing himself and certainly the community of those who are either unable to judge for themselves or who haven't exerted the very slight effort required to form an independent opinion."

With this lengthy but essential background of correspondence, we are ready to examine the Chief Naval Architect's loose minute. It is at once apparent that paragraph 5 is, to say the least, a most unfortunate misrepresentation of the positions of Garwin and Lighthill in relation to Rawson, casting doubt on the reliability of the remainder of the minute, and that paragraphs 1-3 are not relevant to the main point in Garwin's note to me, which is that Rawson made a simple but not obvious error, an error which led the Royal Navy not to consider the development of Giles' designs. The only paragraph relevant to this point is paragraph 4:

but they seem to have done so since

"4. The effects of dynamic lift raised by Dr Garwin in Reference 3 ((Garwin's note of 28 March 1985)) are irrelevant to the rejection of the S90. Dynamic lift would only be perceptable ((sic)) at speeds approaching 40 knots, a speed which is not required by the T23 and which could never be attained by the S90 with the engine fit proposed. Furthermore, any reduction in power due to dynamic lift at this very high speed would first have to offset the very substantial resistance penalty of the S90 form in the displacement mode. This higher resistance of the S90 form compared to a conventional form (such as LEANDER) is in fact implicit in Giles' own data presented as Figure 13 in the written discussion in Reference 3 ((actually Reference 2, Admiral Sir Lindsay Bryson's paper on The Procurement of a Warship, RINA, 1984)), and was exposed by Meek in the same Reference. Essentially, the value of V divided by the square root of L for the S90 at 28 knots would be about 1.75 of 1.45 for a LEANDER. The S90 resistance per ton would therefore be nearly twice that of the LEANDER at the same speed. The "benefit" claimed by Giles for the S90 at higher speeds shown in Fig 13 is an illusion - albeit cleverly presented."

I am not qualified in ship design and should, therefore, like to know the answers to the following questions:

1. How is it calculated that the effects of dynamic lift would only become perceptible at speeds approaching 40 knots on the S90 hull? If Garwin and Lighthill are right (and the correspondence indicates that they are), it ought to be the case that the lift effects, if any, come in much earlier, perhaps at speeds towards the upper end of the operational range rather than at the given figure of 40 knots. What is the evidence for the

assertion that "large ships would need to go very fast indeed to get into the region where lift was significant"? Also on the question of lift, what are the results of the Navy's measurements of the rise and fall of the "towpoint" (the point at which the longitudinal centre of gravity and the thrust line coincide), which, according to Garwin, can be used as a measurement of dynamic lift? If I remember rightly, such tests were originally done on the floats of flying-boats for the Schneider Trophy.

2. Does Reference 2, Figure 13, establish that a Sirius hull of the same length as a "Perry" class frigate, although having nearly twice the beam and operating at over twice the displacement, has a broadly similar resistance in terms of lb per ton of displacement up to a speed of V divided by square root of L of 1.4, and offers less resistance at higher speeds? It would be helpful to see the Navy's estimates of a) resistance, b) efficiency of the propellers, c) horsepower requirements for speeds from, say, 20 knots to the 40 knots mentioned by Mr Brown, both for the Leander and for an S90 of the same displacement. In particular, what propulsive coefficient would be obtained by relating the Leander resistance given by Admiral Bryson in Reference 2, Figure 16, to trials results of a full-scale Leander in a similar condition, at a speed of 28 knots?

3. Admiral Sir Lindsay Bryson, presenting his paper on the procurement of a warship to the Royal Institution of Naval Architects on 7 June 1984, states in his reply to Giles' written response that he "fully accepts the test data produced by BHC and NMI Ltd" for the S90. However, there appears to be a considerable discrepancy between the test results produced by these two companies and YARD Ltd. NMI estimated that at 28 knots and a displacement of 2,600 tonnes, the power required for the S90 would be 35,000 kilowatts, while YARD Ltd estimated that the S90, at a mere 200 tonnes more in displacement, would require 70% more power - about 59,500 kilowatts. I should have thought that an increase in power to about 38,000 kilowatts would have been more than enough to compensate for the 200 tonnies increase in displacement. Which is right, YARD Ltd or NMI? What increased power would a Leander class frigate require for the same increase in displacement and making allowance for the fitting of a sonar dome, fins and fouling?

Turning to the remainder of Mr Brown's minute, there are one or two other questions which, although not germane to Garwin's original note, ought to be answered. In paragraph 2, the CNA states that minimum length will be defined by a number of factors - but he does not include speed as one of these factors. I should have thought that speed would have been one of the more important considerations in arriving at the specification, particularly in view of the dramatically increased speed capability of recent Russian warships.

In paragraph 3, the CNA refers to the discussion of Admiral Bryson's paper and says that the paper contained the reasons why the S90 proposal was rejected. It is clear from reading Bryson's comments on the S90 that the fundamental objection to the design was indeed the objection that it would require more power than the designer and the tank tests at NMI suggested. And this error arose at least in part from Rawson's mistake.

and what part? — to extent that lift offsets the broadside beam.

The CNA goes on to say that Giles' views were not supported by the majority of those present. Fortunately, this assertion can be tested because the full written and spoken responses to Bryson's paper were minuted and published by the RINA. I now have a copy. I have read the document through with some interest and I can find only two comments on the author's paper which appear to disagree with Giles' position. One, from Bryson himself, has already been mentioned. The other, to which the CNA refers in his minute, is that from Mr M Meek. Like Bryson's comment, Meek's contribution concentrates on the resistance which the hull form would offer, and appears to have been based on Rawson's error and the other errors which appear to have flowed from it subsequently. In any case, Meek is not an impartial witness. He was Chief Naval Architect of British

Shipbuilders, who are the first defendants in the litigation which Giles has initiated, claiming that they stole his designs. At the same time, Meek acted as Chairman of the DSAC Hull Committee which recommended rejection of Giles' estimates for the S90, based on the BHC and NMI tank tests, and acceptance of the YARD computer predictions instead. Since then, Meek has become Director of NMI Ltd and has refused to endorse the sea-keeping resistance and propulsion tests which the organisation had produced.

Conclusion

1. It is clear from reading the correspondence between Rawson and Garwin that Rawson had indeed made the mistake which Garwin mentions in his note to me, and that Rawson has been unwilling to admit his mistake publicly, though the correspondence makes it clear that he recognises his error.

2. On the basis of this mistake, further errors have been made and it is evident that the design of the S90 has not been seriously evaluated by the Royal Navy.

3. I understand that Giles himself is now working with MITI in Japan on the further development of his idea, which Japanese naval architects have recognised as one with some potential. Furthermore, an Australian millionaire has recently ordered a 55 metre S90 hull

for his personal yacht, and the yachting world is now buzzing with rumours of further orders, including one for a ship to attempt the Blue Riband, perhaps as early as 1987.

4. Giles is, of course, quite prepared to accept that the Navy may wish to have nothing further to do with him or his designs, but he has discovered some evidence that the Navy has been quietly advising other navies, including that of New Zealand, not to have anything to do with his designs. It seems that their reluctance to allow other navies access to his designs is based, in essence, on Rawson's mistake.

5. A committee under Lord Hill-Norton, a former First Sea Lord, is now looking into the whole question of how it was that the S90 form came to be rejected and of the appropriateness of that form for warship design. Preliminary indications from that committee indicate that the mistake made by Rawson and others derived from it will be exposed, with sufficient accompanying facts and figures to establish the nature of the mistake beyond doubt.

Furthermore, the committee is likely to recommend that the design is viable and that the designer is in most respects right in his claims for what it will achieve. Lord Hill-Norton is likely to ask for access to the

Prime Minister in order to present his report to her, since he believes that it contains material of sufficient merit to warrant her personal attention. At this point, we shall, of course, have to give her a briefing. In order to prepare for it, I suggest that you and I should discuss the matter of the S90 with the Ministry of Defence in order to obtain answers to the questions I have raised in this note.

CM.

<u>CHRISTOPHER MONCKTON</u>

FROM: D K Brown M.Eng., C.Eng., FRINA, RCNC

CM
You will be interested to see. There seems to be more to this than I, at least, imagined. Could we agree on what we do next?
N.O. 3/9

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D/SSC/DCNA/101/6/7

29 July 1985

Nicholas Owen Esq
Policy Unit
Cabinet Office
Whitehall
London SW1

Dear Mr Owen,

SHORT FAT SHIPS

The Chief Naval Architect has asked me to draw your attention to the attached minute which bears on the arguments over the hydrodynamics of the Osprey form. I hope you will find it useful.

Yours sincerely,

David K. Brown

Deputy Chief Naval Architect

Defence Scientific Advisory Council (Secretary: MB ~~1372~~ 0333 A.L. Oliver

or CNs secretary

Marine Tech Report on S90

F - Short fat ships

LOOSE MINUTE

D/SSC/CNA/1884
9 July 1985

Sec/C of N

Copy to: DCW
~~DCNA~~ ✓ 101/6/7.
AD/FPSS

HULL DESIGN FOR RN FRIGATE

Reference:
1. C of N's 614/79 of 5 July 1985.
2. The Procurement of a Warship - Admiral Sir Lindsay Bryson, RINA 1984.
3. 2700/12 from C Monckton to 1SL, covering note from R Garwin of 28 March 1985.
4. Letter from R Garwin to K J Rawson of 6 October 1981.
5. Letter from Sir James Lighthill to D Giles of 9 November 1981.

The selection of the appropriate hull form for RN Frigates (or other classes of ships) does not begin with any preconceived ideas on length/beam ratio. The length, beam and other form parameters are an output derived from the Staff Requirements and not the input. In consequence, there are in the RN ships with a wide range of L/B ratio and even more extreme values, in both directions have been used in the past. (Examples are given in the Table I attached.)

2. A minimum length will be defined by the physical clearances required by weapons, for helicopter operation and for the electronic clearances required by radios, radars etc. Stability considerations will lead to a minimum value of the beam while the product of these dimensions and the depth must define a hull with sufficient internal space to meet the requirements and sufficient buoyancy to support the weights. A number of design options will be produced around these minimum values and evaluated for maximum effectiveness and minimum through life cost.

3. The Type 23 was designed in this way and after lengthy discussion the present form was accepted as the best compromise. The reasons why the S90 proposal was rejected are given in detail in Admiral Bryson's paper (Reference 2). Mr Giles gave his views during the discussion and these were not supported by the majority of those present and were answered in full by Admiral Bryson.

4. The effects of dynamic lift raised by Dr Garwin in Reference 3 are irrelevant to the rejection of the S90. Dynamic lift would only be perceptable at speeds approaching 40 knots, a speed which is not required by the T23 and which could never be attained by the S90 with

04.4.

the engine fit proposed. Furthermore, any reduction in power due to dynamic lift at this very high speed would first have to offset the very substantial resistance penalty of the S90 form in the displacement mode. This higher resistance of the S90 form compared to a conventional form (such as LEANDER) is in fact implicit in Giles' own data presented as Figure 13 in the written discussion in Reference 3, and was exposed by Meek in the same Reference. Essentially, the value of $\frac{V}{\sqrt{L}}$ for the S90 at 28 Knots would be about 1.75 cf 1.45 for a LEANDER. The S90 resistance per ton would therefore be nearly twice that of the LEANDER at the same speed. The "benefit" claimed by Giles for the S90 at higher speeds shown in Figure 13 is an illusion - albeit cleverly presented.

5. Dr Garwin's note of 28 March 1985 (Reference 3) is somewhat unexpected, coming as it does some 3½ years after his letter to Mr Rawson of 5 October 1981 (Reference 4, copy attached) which noted their complete agreement on the physics of dynamic lift and this agreement was endorsed by Sir James Lighthill in Reference 5. The fact is, however, that large ships would need to go very fast indeed to get into the region where lift was significant.

6. It is suggested that Mr Monckton might reply to Dr Garwin on the following lines:

> "Thank you for your note of 28 March 1985. As you observed in your letter to Mr Rawson in October 1981 there appears to be a general agreement in regard to the physics of dynamic lift. You will of course be aware that this particular consideration, which in large vessels only becomes significant at very high speeds, was not a major factor in determining the hull form for the Type 23 frigate. The rationale for that design is given at some length in a paper given by Admiral Sir Lindsay Bryson entitled "The Procurement of a Warship" to the Royal Institute of Naval Architects in 1984."

Why then Did Rawson consider the physics at all?

B O WALL
Chief Naval Architect

Annex to D/SSC/CNA/1884
Dated 9 July 1985

TABLE I

Ship Type	Length/Beam Ratio
14" Gun Monitors (1914)	3.5
Lord Nelson (1904)	5
PRINCE OF WALES	8.3
FEARLESS	6.3
HUNTs	5.7
CASTLEs	7.0
Type 22 (B1)	8.5
Type 23	7.6
S90	5.2

24/10

Christopher:

Herewith a Memo which I have prepared on the NOLL situation. Also, some more information on the S90/Leander power comparison. I found the enclosed Rolls Royce speed/power graph for a '2500 tonne SD (standard displacement) frigate; it must be something very close to the Leander. I have modified your 'graph 1' accordingly. You can see how it is now consistent with the 'Sirius' vs 'Perry' Class comparison in the famous 'figure 13' of Brown's paper. At 31 knots, the Leander power curve is going up at a progressively faster rate than the S90's.

Also the transcript of the Leach/Hennessy 'gaffe' - pp 8+9. Yo friend Sikes

24 Lapman Rd
SW18
29th October '88

Dear Christopher,

In answer to your points dated 25 Oct:

1. AMI & BAe Tests: Yes, models run at 1/25th (also 1/43rd & 1/20th scale) in the tanks. They were run at the correct scaled speed for the relevant Froude No. of a full scale version. That's the tanks' job!

2. R.A.S.: I expect Bath will say that refuelling is necessary every 3-5 days. I would be interested to know how often replenishment of stores etc is necessary. We claim that refuelling need not be done so frequently if the ship's stability does not necessitate it.

3. Silent Running: We would expect that hull-radiated noise is critical from 0-12 knots; propeller cavitation becoming critical above 12-15 knots. Bath's reply would be interesting.

4. Life of a frigate: I did not entirely disagree with Ramsay's figures on 'Newsnight'; it was the way in which he presented them. The total through-life running cost of a frigate (according to D.K. Brown's Naval Review article of July '84) is:

Operating Cost: (at £105,000 per day for 150 days p.a. over 20 years)

£315,000,000

Investment Cost (at £150 million first cost over 20 years at 8%):

£162,000,000

Total Cost: £477 million. Of this, we would hope to save a great deal more than the £5-7 million extra fuel cost incurred by the short fast ship. If inflation is taken into account, our percentage (1.9%) of Operating cost reduces. The All-North Committee is (I think) 'addressing' this question.

5. <u>Cost of Extra Length</u>. Ask Bath what the stretched Type 42 ~~carries~~ (HMS Manchester onwards) carries in addition to the earlier (HMS Sheffield) type. Very little, to judge by 'Jane's'. They will tell you 'better seakeeping'; but this is problematical. Jane's states that the cost of HMS 'Coventry ('short') (ordered 1972) was £37.9 m.; the cost of the ships ordered in 1980 (all stretched) had risen to £85 m. (i.e. × 2.24). Why? The equipment hardly changed at all. This is way above inflation.

6. <u>Hull characteristics</u>: HKPC Length (waterline) is 60 m.; Skeandhu is 80 m. LWL. The sea trials of ~~the~~ HKPC were about 2 knots above estimates, we understand from Porter & other reports. Some say they were up to 5 knots faster. We have ~~the~~ some trial results but I cannot disclose them!

7. <u>Blue Riband</u>: My views are all contained in the letter I gave you, dated 9th September, in which I gave my view that Bath would go for a 500 ft ship. In 1838 the 700 ton ship 'Sirius' (!) just took ~~the~~ Blue Riband – carrying 400 tons of coal & averaging 8.6 knots. We shall use about 220 tons of fuel & average about 7 times the speed – there's progress! We shall start at about 700 tons displacement, too.