15 November 1985

RECORD OF A DISCUSSION ON SHIP DESIGN HELD AT SHIP DEPARTMENT, BATH ON WEDNESDAY 6 NOVEMBER 1985

Present

Rear Admiral Hugh L O Thompson, Director-General, Surface Ships

Mr Brian O Wall, Chief Naval Architect

Mr Simon Webb, Director of Resources and Programmes (Warships)

Mr John Cox, Assistant Director, Warship Secretariat

Mr Nicholas Owen, Policy Unit

Mr Christopher Monckton, Policy Unit

Rear Admiral Thompson said that there had been an approach to the office of the Controller of the Navy in August, on behalf of Lord Hill-Norton's committee enquiring into the Thorneycroft, Giles S90 design. During September, the Controller's office had asked on several occasions what the standing of the committee was and what its security clearance was. There had been no response on this point. In a letter to the Controller fairly recently, Lord Hill-Norton had said he was disappointed, but that the information he had been asking for was not important and would not affect his conclusion.

Mr Webb said that Bath would be quite happy to help if they knew the committee's questions and if the information requested was not confidential.

<u>The Requirement for the T23</u>

Rear Admiral Thompson said that Bath's job, in a Nato and national context, against the threats which were perceived and in the light of what the Government wanted to do, was to give the Naval Staff options on what might be done to meet their needs and what it would cost. That work was not done uniquely at Bath, because the procurement industry was deeply involved. Y-ARD Ltd, for instance, had proficiency in many matters. Bath also did design work and, although export potential was borne in mind, the first consideration was the defence requirement of this country.

Mr Webb said that because Admiral Sir Lindsay Bryson's paper on the procurement of the Type 23 Frigate was unclassified, it had not made clear one of the major requirements of the T23, namely, that it should be exceptionally quiet so that ship-noise would not interfere with the towed-array sonar devices used in the detection of Soviet submarines.

Rear Admiral Thompson said that at any given time there was an inventory of ships which existed to fill particular needs. Bath's function, in support of Nato, was the deterrent (supporting the SSBN fleet); the defence of the UK base; and the free and easy passage of reinforcements by sea in the event of war with the Soviet Union. Therefore the anti-submarine capability was important. The other side were working hard to quieten their submarines, which had been notoriously noisy in the 1960s and 1970s.

The Type 42 destroyer, of which the Sheffield and Coventry had been examples, had come into service in the 1970s; and the Type 22 was coming into service now: the "Cornwall" had been commissioned the previous week. The Nato Frigate, now being planned, would not come into service until the 1990s, by which time the present ships would be getting long in the tooth. Among the new considerations which had to be borne in mind were long-rang missiles from over the horizon and layered defence, from the Sea Harrier at long range to the Goalkeeper system at short range.

It was, therefore, a moving picture. When the T23 had been conceived, the need was for anti-submarine warfare, with detection as the essential first step. The advent of the towed array had been a significant step, but its success depended totally on successful reduction of the noise the towing ship itself made.

Much work had been done on noise attenuation. For instance, diesel engines could now be mounted on rafts inside acoustic hoods. The towed array could run at up to 15 or 16 knots, so the aim had been to find the quietest suitable propulsion system. CODOG was the answer, combining the low-speed capability, fuel efficiency and absence of gearbox noise in a diesel-electric engine with the high acceleration and maximum speed of 29 knots in a gas turbine. The diesel engines in the T23 had been mounted in two blocks, one of which was well above the waterline and was used when hunting to take advantage of the inverse square law. Furthermore, air-conditioning and other devices on the ship had had to be designed for silent running.

There had also been a requirement for the T23 to be able to go through the ocean at about three knots in "listening mode", hunting very silently. A gas turbine on its own would have drunk fuel at these low speeds; and a diesel engine alone would have made too much gearbox noise: hence the diesel-electric engines.

A brief discussion of the relative merits of fixed-pitch and controllable-pitch propellers followed. Fixed-pitch propellers were quieter.

Mr Webb said that the key point was that the type of ship was dictated by a gap in the existing inventory to detect Soviet submarines which were quieter now than formerly. The Soviet Union had more than 100 submarines in the North Atlantic at ay one time. Detection at several hundred miles would be possible with new towed arrays. The ship also had to be able to carry a big helicopter.

Rear Admiral Thompson said that the T23 also had to be able to go out on patrol for 30 days at a time, so Bath had also had to consider the need for AOR supply ships, which also had to have a helicopter maintenance capability and two helicopters to help in submarine detection and in vertical replenishment of the frigates. The T23 could run for 5,000 miles at 16 knots. But no defence force commander would let his ship run low on fuel unless he had to, so replenishment at sea normally took place every three to five days, when fuel had run down to 60 or 70% of capacity.

Costings

Rear Admiral Thompson, in answer to a question about the cost of the Type 23, said that the average cost would be bout £110 million, excluding £30 million for helicopter, missiles, fuel and other supplies; that one T23 had been ordered and three more had been put out to tender. Yarrows were working on the design of the first frigate, which was basically, but not yet totally complete. Before the contract had been let, Bath had agreed a price of about £60 million for the ship with Yarrow's, excluding weapons-fit.

Mr Wall said that the hull, engines, generators, steering and everything that was not weapons accounted for about one-third of the cost of a frigate; labour, including the labour for the weapons-fit, was about another third; and the cost of buying-in the weapons was the remaining third.

Looked at another way, 60% of the cost of the ship derived solely from the requirement to carry weapons, with the hull and machinery accounting for about 20% each. To put to sea with all the kit required solely to float and to move would, therefore, cost £45 million. The original planned cost had been £70 million; now the cost was £110 million. There had been about 15% real growth since original conception in 1981.

Rear Admiral Thompson said that the T23 as an anti-submarine warfare ship with a general-purpose frigate capability, equipped with a gun and Harpoon surface-to-surface guided weapons.

Mr Wall, in answer to a question about an article in the previous Saturday's Daily Telegraph, said that he had thought the article had said that the Government was contemplating reducing the number of frigates to fewer than the present plans, a suggestion which implied a departure from the current thinking. The notion of offshore patrol vessels to replace the T23 was not credible.

Mr Webb said the Navy had gone to tender on the remaining three of the first four T23s and had asked for option prices on another four.

There was a brief discussion of the radar image of the T23 and its suitability as a helicopter platform.

Mr Wall said that measures to reduce intrinsic machinery noise had already been discussed, but that there were additional measures that could be taken, such as air emission round the propellers to reduce cavitation and a girth of air round the hull to reduce hull noise. Rubber tiles with air cavities in them were also being evaluated for use in surrounding the machinery spaces.

Mr Wall said that Bath, when designing a ship, did not start off with a hull form and then try to fit a ship into it. On the upper deck, for instance, funnels, masts, aerials, the helicopter and its hangar and weapons with suitable arcs of fire had to be fitted. Electronic systems had to be fitted in such a way as not to interfere with each other.

Rear Admiral Thompson said that the whole ship emerged as a result of compromises. Changing any one part sent out ripples that affected other systems in the ship.

Mr Wall said that below the upper deck and outside the machinery area it was necessary to accommodate the crew and the maintenance facilities and offices. The layout of the next couple of decks was determined more by area than by volume. Below that, one had really got to find enough volume for fresh water, fuel, stores and so on. Starting with the requirement of the weapons system, it was possible to sketch out an arrangement of the upper deck, second deck and so on, which yielded a design regarded as viable. Deck height was determined by the height of a man and the size of the equipment. Then the stability of the ship had to be checked.

If the beam of the hull were increased, more area would be generated, but, depending on the sort of vessel, the geometry that would emerge could be quite different. The Ton class minesweepers had a length-beam ratio of 5:1, the Hunt class rather more. A typical destroyer had a length-beam ratio of 7 or 8:1, an assault ship rather less.

In response to a question about the major factor which made destroyers and frigates longer than most other types of ship, Mr Wall said there was no major factor in determining the fact that a ship was long and thin. There were a variety of factors, such as weapons disposition.

The Type 42 had been stretched because there had been no spare space for additional systems or stores which might be required in the future. Batch 3 of the T42 had been stretched by some 40 ft in length and 2 ft in beam. One bonus had been an extra knot on the maximum speed.

The optimum monohull length-beam ratio from the point of view of speed was 9 or 10:1. Above that, factors such as skin friction came into play. Generally speaking, the longer a ship the better its sea-keeping, in terms of pitch.

Having looked at the layout of the ship, and having looked at the hull cocoon which fitted that, a length-beam ratio of 7 or 8:1 came out as natural. Most destroyers and frigates had the ability to operate at speeds in the high 20s.

Rear Admiral Thompson said that the Naval Staff believed one paid a lot of penalty in horse-power for driving up the speed above 28-29 knots. History and experience said that 28 or 29 knots was about the right sort of level. Russian submarines were thought to be capable of 40-45 knots, and Russian surface ships could achieve 33 knots.

Mr Wall said that there were many constraints on using a warship. For instance, speed was limited in any severe sea by sea-keeping factors. If the Navy had needed to compromise on the hull form to achieve higher speed, it would have done so, because the penalties of shuffling around with length-beam ratios of 6.5 to 8.5 were not all that great.

<u>The S90</u>

Mr Wall said that there was no doubt that the resistance per ton of displacement was greater than a conventional warship form. The S90 offered a reduction in resistance at very high speeds because its shape allowed for greater hydrodynamic lift than a normal ship. Within the usual speed régime, however, which was up to 30 knots, the superiority that the S90 might ultimately achieve by way of increased lift was not relevant, because lift did not begin until about 40 knots. Thorneycroft, Giles had measured the sinkage and rise of the towpoint. This only rose above the centre of gravity at 38 or 39 knots.

In answer to a question about whether the hydrodynamic lift might have an effect within the usual speed range, not by raising the towpoint above the centre of gravity but by raising it above where it would be at a comparable speed on a normal hull, Mr Wall said that in the Thorneycroft, Giles design, there was an element of this. Its significance in terms of reducing the rate at which resistance would otherwise increase was not too relevant. Thorneycroft, Giles had produced their own curves on the measured resistance of the hull, which they had compared with the Perry curve, which was not the Navy's curve, but which Bath had no reason for disputing. If one took the curves and analysed them on the basis of speed, rather than speed divided by the square root of the length, one found that, speed for speed, the resistance per ton on the Sirius form at the speed range Bath were talking about was twice as great as that of a conventional hull form. There was a crossover point, but at a very high speed.

In answer to a question about whether there was a straight trade-off between resistance and installed horse-power, Mr Wall said that it was not quite a straight trade-off: one would be going up to 90,000-100,000 shaft horsepower to push a 2,800-ton Sirius form at speeds approaching 30-35 knots. After that, although the power increment needed was less than the power increment to push a T23, it remained very considerable. These calculations were derived from TGA's own submission.

There followed a discussion of the correspondence between Mr Rawson, the Chief Naval Architect at the time of the evaluation of the Thorneycroft, Giles design by the Defence Scientific Advisory Committee, and Dr Richard Garwin, a scientific consultant to the US Government, on the question of hydrodynamic lift. Mr Wall said that Mr Rawson, in his original letter to Mr Giles on the subject, had not perhaps expressed himself as well as he might have, but the fact that Dr Garwin had expressed it rather more accurately and succinctly was not important because it did not affect the argument on the grounds that a) the speed-range at which lfit became effective was beyond normal operating requirements; b) the question of lift had not been the main reason for the rejection of the design. There was no argument about the position as Dr Garwin had stated it: but in the Staff Requirement speed-range of 0-28 knots, the S90's tendency to use hydrodynamic lift did not affect the issue. Moreover, whatever hydrodynamic lift is afforded by the S90 at these speeds, would be reflected in TGA's resistance curves.

Mr Wall said that the Ministry of Defence, as far as Bath were aware, had done no tests on the Giles hull form.

Rear Admiral Thompson said that there was a court case between British Shipbuilders and Thorneycroft, Giles.

Mr Wall said that there had been an allegation that British Shipbuilders had tested a model of the Giles ship without the previous permission of the designers. Giles' own tests had been done by the British Hovercraft Corporation.

Mr Cox said that the tests had also been done at St Albans with the agreement of Giles, and then, it was alleged, used for other purposes. It was not something that the Ministry of Defence had had any formal part in, although it would be difficult to say that none of the results had filtered through to Bath informally.

Rear Admiral Thompson said that the Navy had done no trials, but that some information might have come Bath's way on a personal basis. There was no reason for the Government to be implicated.

Mr Wall said that the MoD had no wish to become involved. They had no reason to doubt the competence of BHC. And the results of the BHC tests had been broadly what Bath would expect. Marshall Meek, who had chaired the DSAC Hull Committee, had pointed out that a family of high-speed displacement forms had been tested at the National Physical Laboratory in the mid-1970s, and that the family of curves produced gave results which accorded very closely with those which Giles had produced for the S90. Bath had no reason to suppose that the basic resistance curve for the S90 was incorrect.

In answer to a question about the meaning of the phrase "standard methodical series", Mr Wall said that this term applied particularly to a series of tests done at Haslar on propellers. It would not normally be applied to a series of models of hull-forms, with the same basic design shape but with varying dimensions. The terms was usually used only in the context of open-water propeller tests.

In answer to a question on Fig 14 submitted in response to Admiral Bryson's paper, which showed that Osprey hull-forms (a smaller and earlier variant of the S90) had performed considerably better in full scale than the tank-tests had predicted, Mr Wall said that one could work out the power requirement to propel a ship by towing it and measuring its resistance. From this, the effective horse-power to propel the bare hull could be determined: but the installed horse-power was greater because allowance had to be made for the efficiency of the hull (usually 0.95), of the shaft transmission (0.97), the relative rotative efficiency (0.97) (these three multiplied together yielded the quasi-propulsive coefficient), and the correlation factor to adjust for differences between models and full-size geometrically similar vessels. There was some evidence that with a wide-beamed ship, the correlation factor could be lower than for a conventional form. The amount of evidence was scanty, but Bath believed that the correlation factor, or (1+x) factor, could be as low as 0.9 for the short, fat ship.

Mr Wall said that the propulsive coefficient of the S90 was about 0.6. Mr Monckton said that the propulsive coefficient of the Leander class frigate, based on the Leander resistance-curve published as Fig 16 of Admiral Bryson's paper, worked out at only 0.467, unless the curve was wrong, but Mr Wall pointed out that, since the maximum speed of the Leander was not 28 but 30 knots, the propulsive efficiency of the Leander was also 0.6. The 28-knot figure was merely being used as an illustration, because that was the germane to the design of the T23.

Mr Wall said that the results from the Marwood and Bailey series at the National Physical Laboratory were much the same as for the S90, which was generally similar in performance. He had not compared the hull-form of the S90 with the Marwood and Bailey hull-forms, but they were not dissimilar.

In answer to a question about the hull-form of the S90, Mr Wall said that, as far as he knew, there was no particular distinguishing characteristic which marked out the S90 design family from other short, fat hulls. He was not aware of the claim that there was a feature under the hull which might add to hydrodynamic lift.

Rear Admiral Thompson, in answer to a question about the absolute maximum speed achieved by the Hong Kong Patrol Craft on trials, said that he thought the top speed was 24-25 knots, but that he would check this figure and report back.

Mr Wall discussed damage stability and roll stability of the S90 form. He said that a warship had to be able to remain afloat despite a 20 m hole below the waterline. On a long, thin ship, the amount of water in a compartment was comparatively small because the compartment was narrow: hence, on a short, fat ship, the choice was between putting in more compartments, where possible (which still entailed the danger that several adjacent compartments would flood, sinking the ship because the weight of water was greater than for a conventional form) or putting in longitudinal compartments (which would cause the ship to heel, since the water would enter only one half of the ship).

On roll stability, Mr Wall said that the roll period of the S90 would coincide with the frequency of North Atlantic waves and that the roll period was too quick, at 7 seconds rather than the 10-12 seconds for the Leander frigate. Even though the roll period on the 1/10 scale model tests of the S90 against the Leander appeared to favour the S90 , this was because very large fins had been fitted to the S90 model in order to stabilise it. Such fins would impose a resistance penalty, and would add to the noise of the ship through the water. The metacentric height of the S90, at 5 metres, was too high to allow sharp turns without an unacceptable angle of heel.

Mr Monckton pointed out that the metacentric height on the S90 design as finally submitted with the validation report, only a few months after the DSAC committee had considered the design, had a metacentric height of 3.5 metres. This was, in his opinion, a problem with the DSAC report: the hull committee had considered a design which was a) far from complete; and b) only intended as an outline. Furthermore, the designers had not been told in advance that the hull committee would be considering their design in such detail. Many of the points of detail in the report went beyond what the Minister had originally requested Thorneycroft, Giles to consider.

Mr Wall said that it was possible to build a T23 short, fat ship, but one might not be able to accommodate all that was required without electrical interference between weapons systems.

Rear Admiral Thompson said that, even then, it depended on whether the designers' claims for the S90 were valid.

Mr Wall said that if one were to assume that the equipment as necessary for the Naval Staff Requirement were fitted, then the scope for reducing the cost depended solely on whether putting the package in a different-shaped cocoon yielded any savings in cost. Bath had speculated that the savings on the hull-form would be in single-figure millions, but Mr Wall's guess was that the disadvantages outweighed the small potential for reducing costs.

Mr Owen and Mr Monckton thanked all the representatives of Ship Department, Bath for their kindness in giving up so much of their time to clarify the position. It was agreed that any further points would be addressed to Mr Cox.

Rear Admiral Thompson said that Bath would be willing to give any further help that might be necessary.

CHRISTOPHER MONCKTON

File
- Short fat
ships

10 DOWNING STREET

Rear Admiral H L O Thompson
Director-General
Surface Ships
Procurement Executive
Ministry of Defence
Block G
Foxhill
BATH
BA1 5AB

15 November 1985

Dear Admiral Thompson

I am most grateful to you and your colleagues for sparing the time last week to discuss ship design with Christopher Monckton and myself. The meeting was most helpful from our point of view.

In view of the technical nature of the discussions, which we may not have fully understood, I enclose a draft note of the discussion, prepared by Mr Monckton, which you may care to have looked at and corrected, if necessary.

You were kind enough to offer to deal with any further points. Having read through the note, there are some which are not quite clear to us, and I enclose a list of these. Would it also be possible to have the transposed versions of diagram 13 in the discussion of Admiral Bryson's paper which you presented to us?

Yours sincerely

Nicholas Owen

NICHOLAS OWEN
Policy Unit

FRIGATE HULL DESIGN

Cost of the Type 23: Would it be possible to provide an itemised breakdown of the £110 million + £30 million cost of the Type 23, showing the cost of labour, steel for the hull, engines, equipment, weapons etc.

Performance: Fig 14 in the RINA proceedings (7 June 1984) claims that Osprey hull-forms had performed considerably better in full scale than the tank-tests had predicted. To what extent might this factor offset the resistance penalty of the S90 suggested by the transformed versions of figure 13? Likewise, does the unusually low correlation factor of the S90 tend to offset the resistance penalty?

Powering: NMI Ltd estimated that at 28 knots and a displacement of 2,600 tonnes, the power required for the Thornycroft Giles hull would be about 35 Mw, while YARD's figure for a hull of only 200 tonnes more displacement was about 70% higher - about 59.5 Mw. Why is there such a discrepancy, and which is judged to be right, YARD Ltd or NMI?

Fuel: What percentage of the average daily running cost of a frigate is represented by the extra fuel which an S90 would require? What would be the total through-life cost of this extra fuel?

Speed: is it possible to judge the minimum displacement and powering requirement of a warship carrying a normal payload and travelling 3,000 nautical miles at an average speed of 40 knots without refuelling?

Displacement: Various displacement figures have been mentioned. What was the original planned displacement of the T23? What was the displacement to which TGA were asked to design their hull form?

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From: J C Cox, Assistant Director Warship Secretariat

Procurement Executive Ministry of Defence Room 31
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F-Short

Fast Ships.

Mr N Owen
Policy Unit
10 Downing Street
London

Your reference

Our reference
D/SSC/RW310/1920/1

Date
19 December 1985

Dear Mr Owen,

1. Further to my letter of 4 December 1985, I now attach answers to the six questions you posed in your letter of 15 November 1985. I hope you will find that these answer your queries adequately but if you require any further information, please do not hesitate to let me know. Also attached are the "transposed versions of diagram 13" referred to in the last paragraph of your letter.

2. Finally, page 11 of my letter of 4 December contains an error in line 25, "45 metres" should read "4 to 5 metres" and I would be grateful if you would make this amendment.

Yours sincerely,

John Cox

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Question 4 - Fuel

Fuel represents about 10% of the predicted running costs of a Type 23 frigate, about £1M per annum at current prices. Fuel usage obviously depends on the ship's required operating pattern (speed and frequency of operations) but it is estimated that the S90 could use up to twice the fuel of the Type 23.

Question 5 - Speed

Since the RN has no requirement for ships capable of 40 Knots, MOD has not undertaken detailed work in this area. However it may be helpful to observe that, using Figure 13 of the RINA paper, the S90 form at 2800 Tonnes could be expected to require between 95 and 100 MW shaft power to propel it at 40 Knots. (S90 installed power is 32.5 MW.) To achieve 3,000 miles endurance at this speed it would require about five times as much fuel as the current S90 design. It would be necessary to increase the size of the ship very substantially in order to accommodate the 3-fold increase in propulsive power and the extra fuel; such a design would as a consequence not then be capable of 40 Knots without a yet further increase in power and fuel, giving a still bigger ship, and so on. Since the first iteration indicated a displacement approaching 6000 Tonnes we felt further calculations would be unrewarding!

Question 6 - Displacement

The deep displacement of the Type 23 reported at Ministerial endorsement in October 1983 was 3770 Tonnes. Displacement is not a pre-requisite of any particular ship but an output of designing to meet the operational requirement. TGA were not given a displacement but worked to the operational requirement.

NO 10 POLICY UNIT - ANSWER TO QUESTIONS ON FRIGATE HULL DESIGN

Question 1 - Cost Breakdown of Type 23

a. The cost breakdown under the headings requested is broadly as follows:

	%
Shipyard labour (incl overheads etc)	34
Steel	1
Engines, machinery and fittings	26
Weapons (delivered to the shipyard)	35
Shipbuilders profit	4

However, this is not a good indication of the split between Hull and Weapons as some of the shipyard labour is used to instal weapons and some of the machinery and fittings are provided to support weapons (cooling, electronic power, etc). The above breakdown can consequently be re-allocated approximately as follows:

	%
Hull	12
Outfitting and Machinery	28
Weapons	60

b. The cost of items carried on board (£33M) is split as follows:

	%
Torpedoes	22
Missiles	29
Helicopter	46
Other ammunition, spares, tools	3

Question 2 - Performance

MOD is not in a position to comment definitively on the validity of Figure 14 of the June 1984 RINA paper since we have no knowledge of the data on which the diagram is based, nor of its origins. However the curve given in Figure 14 for the "tank estimates" is significantly higher than the predictions quoted in the YARD report and which are stated by YARD to be drawn from tank estimates data given by NMI in a report analysing the results of the "HAVORNEN" sea trials. These NMI predictions indicate a (1+x) factor of just over 1.0, when corrected for the actual sea trials displacement which was a little less than that on which tank estimates were based. A value of (1+x) of around unity would not seem to us to be unreasonable for the speed range concerned.

Interestingly, the figures quoted by YARD (from NMI data) for the actual powers for HAVORNEN at sea are consistent with those given in Fig 14 for "Sea Trials (4 ships)".

Question 3 - Powering

The NMI figure relates to a clean, bare hull at 2600 Tonnes. The YARD figure includes allowances for the additional resistance of appendages, fouling, higher displacement; it also includes some correction for propeller geometry and uses a different (1+x) factor. We would judge the YARD figure to be somewhat pessimistic, and believe a realistic figure to be somewhere between the two.

CM

I did not question your accuracy. I questioned whether a verbatim note is acceptable in all details as a record. Either side can ask for some matters not to be recorded in the minutes, and for others to be clarified or expressed differently. That is why we gave Bath this opportunity. I will reflect on your points, taking the latest developments into account, too. I am not sure we want a correspondence about minutes running in parallel with a separate investigation which the P.U. is expressly excluded from.

N. O.
19/12

MR. ~~OWEN~~
cc BRIAN GRIFFITHS

SHORT, FAT SHIPS

Sorry to be boring about this, but I should be grateful if you would either send to Bath my list of corrections to their redraft of the minutes of our meeting or ask Bath to remove my name from the bottom on all copies which they may have circulated.

As you know, I took a shorthand note of the entire proceedings. You have suggested that my note was not verbatim. In fact, all the passages I took down were indeed verbatim, and I am certified in shorthand at 100wpm and 100% accuracy. The transcript produced from my notes is not a complete record of every word that was said, but it is so close to a full record that Bath at first suspected the undeclared use of a recording device.

I have listed for correction only those passages where the changes Bath made are significant; and I have explained the significance in the accompanying brief for you. I have listed only passages where there is no doubt about what was said: in cases of any doubt, I have given Bath the benefit of it.

I should be grateful if either you or Brian could find out whether a warning has yet been given to Ministers about the Navy's involvement in the court case. This should not be kept from them any longer.

CM.

CHRISTOPHER MONCKTON
12 December, 1985.

From: J C COX, ASSISTANT DIRECTOR WARSHIP SECRETARIAT

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Procurement Executive Ministry of Defence
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F-Short Fat Ships

Your reference

Mr N Owen
Policy Unit
10 Downing Street

Our reference
D/SSC/ADWS/1920/1

Date
4th December 1985

Dear Mr Owen,

1. Admiral Thompson has asked me to thank you for your letter of 15 November and has asked me to collect together the comments of those who attended the meeting on the draft note prepared by Mr Monckton. We have made some changes which I hope will aid understanding and help the reader.

2. The briefing which we gave you was intended to provide some background against which you would be able to brief the Prime Minister when Admiral Hill-Norton presents his report. Mr Monckton raised questions about matters which are currently the subject of litigation between TGA and BS. The answers which we gave you were based on our recollections of reports of events which are alleged to have taken place several years ago. The remarks which were made are confidential between those present at the meeting as a basis for advice to Ministers.

3. I have set work in hand on the six questions which you raised and I will let you have the answers as soon as we have assembled the information.

4. This is a complex technical area and I understand from John Ledlie (MOD's Chief of Public Relations) that your visit may not have produced all the information which you require. If any of the answers which we gave were not immediately comprehensible or were otherwise unsatisfactory for your purposes, do please let me know.

Yours sincerely,

John Cox

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Manuscript alterations by CM

15 November 1985

RECORD OF A DISCUSSION ON SHIP DESIGN HELD AT WARSHIP DEPARTMENT, BATH ON WEDNESDAY 6 NOVEMBER 1985

Present

Rear Admiral Hugh L O Thompson, Director-General, Surface Ships
Mr Brian Wall, Chief Naval Architect
Mr Simon Webb, Director of Resources and Programmes (Warships)
Mr John Cox, Assistant Director, Warship Secretariat
Mr Nicholas Owen, Policy Unit
Mr Christopher Monckton, Policy Unit

Rear Admiral Thompson said that there had been an approach to the office of the Controller of the Navy in August, on behalf of Lord Hill-Norton's committee enquiring into the Thornycroft, Giles S90 design. During September, the Controller's office had asked on several occasions what the standing of the committee was and what its security clearance was. There had been no response on this point. In a letter to the Controller fairly recently, Lord Hill-Norton had said he was disappointed; ~~it no~~ but it longer mattered ~~as he and his colleagues had enough information for their purpose~~ as the information was unimportant and would not affect his conclusion.

Mr Webb said that the Warship Department would be quite happy to help if they knew the committee's questions and if the information requested was not confidential.

The Requirement for the T23

Rear Admiral Thompson said that the Sea Systems Controllerate's (SSC) task, in a Nato and national context, against the threats which were perceived and in the light of what the Government wanted to do, was to give the Naval Staff options on what might be done to meet their needs and what it would cost. That work was not done uniquely at Bath, because industry was deeply involved. Y-ARD Ltd, for instance, had proficiency in many matters. The SSC did concept and feasibility work, the design subsequently being undertaken by industry. Although export potential was borne in mind, the first consideration was the defence requirement of this country.

✓

Mr Webb said that because Admiral Sir Lindsay Bryson's paper on the procurement of the Type 23 Frigate was unclassified, it was important to emphasise one of the major requirements of the T23, namely, that it should be exceptionally quiet so that ship-noise would not interfere with the towed-array sonar devices used in the detection of Soviet submarines.

Rear Admiral Thompson said that the Royal Navy's function, in support of NATO, was the deterrent (supporting the SSBN fleet); the defence of the UK base; and the free and easy passage of reinforcements by sea in the event of war with the Soviet Union. Therefore the anti-submarine capability was important. The other side were working hard to quieten their submarines, which has been notoriously noisy in the 1960s and 1970s.

At any given time there was in inventory of ships which had been designed to meet particular requirements. For example, the Type 42 AAW destroyer, of which the Sheffield and Coventry had been examples, had begun to come into service in the 1970s; the Type 22 ASW Frigate was coming into service now: the first of class, "Broadsword" was accepted into service in 1979; the "Cornwall" had been launched the previous week and the last, 22.14 would not be accepted from the builder until 1989. L So far as Air Defence was concerned, among the new considerations which had to be borne in mind were threats such as long-range missiles from over the horizon and to meet these threats a concept of layered defence had been developed, ~~with~~ which ranged from the Sea Harrier at long range to the Goalkeeper system at short range. ~~Consideration was now being given to the possibility of a NATO Frigate, which would enter service in the mid 1990's~~.

It was, therefore, a moving picture. The T23 had been conceived to meet the need for an anti-submarine warfare vessel with detection as the essential requirement. The advent of the towed array had been a significant step, but its success depended totally on successful reduction of the noise the towing ship itself made.

L Warship Dept. were now thinking in the context of the NATO Frigate of the '90s; on that timescale the Type 42s would be getting long in the tooth.

Much work had been done on noise attenuation. For instance, diesel engines would now be mounted on rafts inside acoustic hoods. The towed array could run at up to 15 or 16 knots, so the aim had been to find the quietest suitable propulsion system. CODLAG was the answer, combining the low-speed capability, fuel efficiency and absence of gearbox noise in a diesel-electric drive with the high acceleration and maximum speed of ~~28~~ 29 knots with gas turbines. The diesel engines in the T23 had been mounted in two blocks, one of which was well above the waterline to reduce noise and was used when hunting. Furthermore, air-conditioning and other devices on the ship had had to be designed for silent running.

There had also been a requirement for the T23 to be able to go through the ocean at about three knots in "listening mode", hunting very silently. A gas turbine on its own would have drunk fuel at these low speeds; and a diesel engine alone would have made too much gearbox noise: hence the diesel-electric drive.

A brief discussion of the relative merits of fixed-pitch and controllable-pitch propellers to control speed followed. In the Type 23 fixed-pitch propellers were better suited and were inherently quieter.

Mr Webb said that the key point was that the type of ship was dictated by a gap in the existing inventory to detect Soviet submarines which were quieter now than formerly. The Soviet Union had the capability to deploy more than 100 submarines in the North Atlantic at any time. Detection at over one hundred miles would be possible with new towed arrays. The ship also had to be able to carry a big helicopter.

Rear Admiral Thompson said that the T23 was designed to go out on patrol for 30 days at a time. The MOD also had to consider the need for AOR supply ships to support this task and the Fleet in general. The AOR is to have a helicopter maintenance capability and will carry helicopters to help in submarine detection and in vertical replenishment of the frigates. Whilst the T23 could run for over 5,000 miles at 16 knots, no defence force commander would let his ship run low on fuel unless he had to, so replenishment at sea normally took place every three to five days, when fuel had run down to 60 or 70% of capacity.

Costings

Rear Admiral Thompson, in answer to a question about the cost of the Type 23, said that the average cost would be about £110 million, excluding about £30 million for helicopter, missiles, fuel and other supplies. The First of Class, HMS NORFOLK had been ordered in October 1984 with delivery planned for 1989 and tenders for three more had been invited. Yarrow Shipbuilders(YSL) were working on the detailed design of the first of class. This work was nearing completion. Before the build contract for 23.01 had been let, a price of about £60 million for the ship had been negotiated with YSL, excluding the cost of the weapons-fit.

Mr Wall said that the hull steel, engines, generators, steering and other equipments and fittings which were not weapons accounted for about one-third of the cost of a frigate; labour, including the labour for the weapons-fit, was about another third; and the cost of buying-in the weapons was the remaining third.

Looked at another way, 60% of the cost of the ship derived solely from the requirement to carry weapons systems and associated equipment, ie to FIGHT. Some 16-17% was required to FLOAT and the remaining 23% to MOVE. These were typical figures, each Class of Ship would be slightly different. For the Type 23 the figures were about £45m to "float and move" and about £65m to "fight".

The original target cost of the Type 23 had been £70 million at 1980 prices. The cost was now £110 million at 1984-85 prices. There had been about 15% real growth since original conception in 1981, due entirely to the addition of a number of features to the design, such as the gun, Sea Wolf, the helicopter hanger and the incorporation of lessons learned from the Falklands.

Rear Admiral Thompson said that the T23 was now a very capable anti-submarine warfare ship with a general-purpose frigate capability, equipped with a gun and Harpoon surface-to-surface guided weapons.

Mr Wall, in answer to a question about an article in the previous Saturday's Daily Telegraph, said that he had thought the article had said that the Government was contemplating reducing the number of frigates to fewer than the present plans. The notion of offshore patrol vessels to replace the T23 was not credible. MOD was not however able to comment on what was a speculative article. He knew of no such activity.

Mr Webb said MOD had recently invited tenders for three further type T23s and had asked for option prices for another four.

There was a brief discussion of the radar image of the T23 and its suitability as a helicopter platform.

Mr Wall said that measures to reduce intrinsic machinery noise had already been discussed, but that there were additional measures that could be taken, such as air emission round the propellers to reduce cavitation noise and round the hull girth to reduce machinery noise. Rubber tiles with air cavities in them were also being evaluated for use in surrounding the machinery spaces.

Mr Wall said that when designing a ship, one did not start off with a hull form and then try to fit a ship into it. On the upper deck, for instance, funnels, masts, aerials, the helicopter and its hangar and weapons with suitable arcs of fire had to be fitted. Electronic systems etc had to be fitted in such a way as not to interfere with each other.

Rear Admiral Thompson said that the whole ship emerged as a result of compromises. Changing any one part sent out ripples that affected other systems in the ship.

Mr Wall said that below the upper deck and outside the machinery area it was necessary to accommodate the crew and the maintenance facilities and offices. The layout of the next couple of decks was determined more by area than by volume. Below that, one had really got to find enough volume for fresh water, fuel, stores and so on. Starting with the requirement of the weapons system, it was possible to sketch out an arrangement of the upper deck, second deck and so on, which yielded a design regarded as viable. Deck height was determined by such factors as the height of a man and the size of the equipment. Then the stability and strength of the ship had to be checked. ~~and an overall geometry would emerge~~. If the beam were increased, more area would be generated, but, depending on the sort of vessel, the geometry that would emerge could be quite different.

In the case of destroyers and frigates, the length/beam ratio would typically lie in the range 7.5:1 to 9:1. For smaller, slower vessels such as minesweepers L/B ratios of 5 or 6 to 1 were not unusual, while one of the old monitors had had a ratio of under 4:1. The Assault Ships (Fearless and Intrepid) were just over 6:1.

In response to a question about the major factor which made destroyers and frigates more slender than other types of ship, Mr Wall said that there was no major factor in determining the L/B ratio. There were a variety of factors which in most cases led fairly naturally to an acceptable solution, but one which was a compromise between various requirements. The early Type 42 destroyers were in fact shorter and fatter than the optimum from purely hydrodynamic considerations. The subsequent lengthening of later vessels in the class by 40 feet (with a 2 foot increase in beam) was to provide space for future weapon systems. One bonus had been improved seakeeping and an extra knot in maximum speed.

The optimum practical monohull length-beam ratio from the point of view of speed was 9 or 10:1. Above that, factors such as skin friction came increasingly into play and stability would be an increasing problem. Generally speaking, the longer a ship the better its sea-keeping, in terms of pitch.

Rear Admiral Thompson said that most destroyers had the ability to operate in speeds in the high 20s. The Naval Staff believed one paid a lot of penalty in horse-power for driving up the speed above 28-29 knots. History and experience said that 28 or 29 knots was about the right sort of compromise for meeting the present Naval concepts of operations cost-effectively. In answer to a question, Rear Admiral Thompson said that some Russian submarines were thought to be capable of 40-45 knots, and that some Russian surface ships could achieve 33 knots.

Mr Wall observed that the extent to which any ship would be capable of operating at its maximum speed depended on many factors, of which sea state was clearly important. The value of squeezing some extra speed from a design by deliberately going for a more slender hull form than that which emerged from the normal design process depended on the particular ship and the operational requirements which it was being designed to meet. Speed itself was of little value unless it could be sustained in adverse sea conditions.

Mr. Wall said that there were many constraints on using a warship. For instance, speed was limited in any severe sea by sea-keeping factors.

The S90

Mr Wall said that there was no doubt that the resistance per ton of displacement was greater than a conventional warship form. The S90 offered a lower rate of increase in resistance at very high speeds because its shape is likely to generate greater hydrodynamic lift than a normal hull form. Within the usual speed regime, however, which was up to 30 knots, the superiority that an S90 hull form might ultimately achieve by way of increased lift was not relevant, because [significant benefits from] dynamic lift would not ~~occur~~ begin in a frigate size ship until speeds approaching about 40 knots had been reached. [However, the S90 design did not have sufficient engine power to achieve these speeds.]

In answer to a question about how the 40-knot figure had been arrived at, Mr. Wall

~~Mr Monckton~~ said that Thornycroft, Giles had measured the sinkage and rise of the tow point. This only rose above the static position ~~above~~ at about ~~37~~ 38-39 knots. In answer to a further question about whether the hydrodynamic lift might have an effect within the usual speed range, not by raising the towpoint above the static position but by raising it above where it would be at a comparable speed on a normal hull, Mr Wall said that in the Thornycroft, Giles design, there might be an element of this. Its significance in terms of reducing the rate at which resistance would otherwise increase was not too relevant. Thornycroft, Giles had produced their own curves on the measured resistance of the model hull, which MOD had no reason for disputing and which must, since they were derived from actual measured values on model tests, include any effects of dynamic lift. Comparing the TGA curves which those for the US Perry Class frigate (again taken from a TGA diagram, but which Warship Dept had no reason to dispute) and plotting resistance per ton against speed rather than $\frac{V}{\sqrt{L}}$, one found that speed for speed, the resistance per ton on the Sirius form at the speed range MOD were talking about was about twice as great as that of a conventional hull form. There was a crossover point, but at a very high speed.

In answer to a question about whether there was a trade-off between resistance and installed horse-power, Mr Wall said that it was not a straight trade-off, power was proportional to resistance times speed: one would be going to around 90,000-100,000 shaft horsepower to push a 2,800-ton Sirius form at speeds of around 35 knots. This would require a considerable increase in displacement to accommodate the extra propulsion machinery needed and the bigger ship would, again, need extra power because of this, requiring further increases in size. Although at very high speeds the power increment needed for a given speed increase would be less than the power increment for a normal hull form, it remained very considerable. These calculations were derived from TGA's own submission. On being asked for a copy of the replotted Fig. B, Mr. Wall said that it should not be shown to Mr. Giles, who was sensitive about the use of his data by others.

There followed a discussion of the correspondence between Mr Rawson, the Chief Naval Architect at the time of the evaluation of the Thornycroft, Giles design by the Defence Scientific Advisory Committee, and Dr Richard Garwin, a scientific consultant to the US Government, on the question of hydrodynamic lift. Mr Wall said that Mr Rawson, in his original letter to Mr Giles on the subject, had not perhaps expressed himself as well as he might have, but the fact that Dr Garwin had expressed it rather more accurately and succinctly was not important because it did not affect the argument on the grounds that a) the speed-range at which lift became effective was beyond normal operating requirements; b) the question of lift had not been ~~a significant factor in~~ the main reason for the rejection of the design. There was no argument about the position as Dr Garwin had stated it: but in the Staff Requirement speed-range of 0-28 knots, the S90's tendency to use hydrodynamic lift did not affect the issue. Moreover, whatever hydrodynamic lift is afforded by the S90 at these speeds, would be reflected in TGA's resistance curves, [which were derived from actual model tests.] ~~On being asked for a copy of the replotted Fig. B, Mr. Wall said that it should not be shown to Mr. Giles, who was sensitive about the use of his data by others.~~

In answer to a question Mr Wall said that the Ministry of Defence, had done no tests on the Giles hull form.

Rear Admiral Thompson said that there was a court case between British Shipbuilders and Thornycroft, Giles. ~~Mr Monckton and Mr Owen should be careful about using publicly any of the material on designs that had been discussed.~~

Mr Wall said that there had been an allegation that British Shipbuilders had tested a model of the Giles ship without the previous permission of the designers. Giles' own tests had been done by the British Hovercraft Corporation [and NMI.]

Mr Cox said that [he thought that] the allegation was that tank tests had been done at St Albans with the agreement of Giles, and then, it was alleged, used for other purposes. It was not something that the Ministry of Defence had had any formal part in, although it would be difficult to say that none of the results had filtered through to Bath

Rear Admiral Thompson said that the Navy had done no trials, although some information might have come Bath's way on a personal basis? informally. There was no reason for the Government to be implicated.

Mr Wall said that the MOD had no wish to become involved. They had no reason to doubt the competence of BHC [or NMI.] And the results of the BHC [and NMI] tests had been broadly what MOD would expect. Marshall Meek, who had chaired the Defence Scientific Advisory Committee (DSAC) Hull Committee, had pointed out that a family of high-speed displacement forms had been tested at the National Physical Laboratory in the mid-1970s, and that the family of curves produced gave results which accorded very closely with those which Giles had produced for the S90. Both were round bilge hull forms. MOD had no reason to suppose that the basic resistance curve for the S90 was incorrect.

In answer to a question about the meaning of the phrase "standard methodical series", Mr Wall said that in his experience this term applied particularly to a series of tests done at Haslar on propellers, to represent the best efficiency one could get in open water. In his experience the term was used only in the context of open-water propeller tests. ~~though in principle it could apply to any systematic series on propellor of hull geometry~~. ~~The term was however, more commonly used in the context or open-water propeller tests.~~ In answer to a question about whether the term could be applied to a series of models of hull-forms, with the same basic design shape but with varying dimensions, Mr. Wall said the term would not normally be used in this context.

In answer to a question on Fig 14 submitted in response to Admiral Bryson's paper, which showed that Osprey hull-forms (a smaller and earlier variant of the S90) had performed considerably better in full scale than the tank-tests had predicted, Mr Wall said that one could work out the power requirement to propel a ship by towing a model and measuring its resistance. From this, the effective horse-power to propel the clean, bare hull can be determined. The installed horse-power would need to be significantly greater than this because allowance had to be made for the effects of fouling, the resistance of appendages, the propeller efficiency, (typically between 0.6 and 0.7 for moderate speed ranges where cavitation loss is small), the hull efficiency (typically 0.95), the relative rotative efficiency (typically 0.97), the shaft transmission efficiency (typically 0.97), and finally an additional factor necessary to adjust for other small differences between models and full-size geometrically similar vessels. It is common practice for this latter factor, and the shaft transmission efficiency, to be combined into one correlation factor or (1+x) factor, which is the ratio of the shaft power delivered in the actual ship to that predicted from model experiments (after allowing for the various effects listed above). There was some evidence that with a wide-beamed ship, the correlation factor could be lower than for a conventional form. The amount of evidence was scanty, but there was some indication that ~~at low speeds~~ the correlation factor, or (1+x) factor, could be as low as 0.9 for a short fat ship. ~~For higher speeds the evidence suggested that the value of (1+x) would probably be of the same order as a conventional form~~. [[DSAC assumed 1.04]]

Mr Wall said that the propulsive coefficient of the S90 might be expected to be of the order of about 0.6. Mr Monckton said that the propulsive coefficient of the Leander class frigate, based on the Leander resistance-curve published as Fig 16 of Admiral Bryson's paper, worked out as only 0.467, unless the curve was wrong, but Mr Wall pointed out that, since the maximum speed of the Leander was not 28 but about 30 knots, the propulsive efficiency of the Leander was also about 0.6. The 28-knot figure was merely being used as an illustration, because that was the germane to the design of the T23.

Mr Wall said that the results from the Marwood and Bailey series of tests at the National Physical Laboratory were understood to be much the same as for the S90, which was generally similar in performance. He had not personally compared the hull-form of the S90 with the Marwood and Bailey hull forms but they were believed to be generally similar.

In answer to a question about the hull-form of the S90, Mr Wall said that, as far as he knew, there was no particular distinguishing characteristic which marked out the S90 design family from other short, fat hulls. He was not aware of any claim that there was a feature under the hull which might add to hydrodynamic lift.

Rear Admiral Thompson, in answer to a question about the absolute maximum speed achieved by the Hong Kong Patrol Craft on trials, said that he thought the top speed was 24-25 knots, but that he would check this figure and report back.
(Note: now confirmed as 25 knots, achieved during acceptance trials). X

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28 knots plus on trials.

Mr Wall discussed damaged stability and roll characteristics of the S90 form. He said that a warship had to be able to remain afloat despite a 20m hole below the waterline. On a long, thin ship, the amount of water in a compartment was comparatively small because the compartment was narrow: hence, on a short, fat ship, the choice was between putting in more compartments, where possible (which still entailed the danger that several adjacent compartments would flood, sinking the ship because the weight of water was greater than for a conventional form) or putting in longitudinal compartments (which would cause the ship to heel and perhaps capsize, since the water would enter only one side of the ship).

On roll stability, Mr Wall said the DSAC had concluded that the roll period of the S90 as designed would be close to the modal frequency for Atlantic waves so that there would be a high probability of resonant rolling. The roll period was too quick, at 7 seconds rather than about 12 seconds for the Leander frigate. Although the 1/10 scale model tests of the S90 showed a roll period somewhat higher than 7 seconds; this was probably because the model had been ballasted to produce a longer period. The S90 model had a better roll amplitude than the Leander model under the test conditions, but there was some evidence that the S90 model had been fitted with large fins, which would have tended to reduce roll motion. If fitted, such fins would impose a resistance penalty, and would add to the noise of the ship through the water. The accelerations induced by short roll periods would impose more difficult conditions high in the ship.Whilst the large metacentric height of the S90 (of the order of 45 metres) should pose no problems in regard to heel in sharp turns, attempts to reduce the metacentric height (to produce a more acceptable roll period) by raising the centre of gravity could result in high angles of heel on a turn.

Mr Monckton pointed out that the metacentric height on the S90 design as finally submitted with the validation report, only a few months after the DSAC committee had considered the design, had a metacentric height of 3.5 metres. This was, in his opinion; a problem with the DSAC report: the hull committee had considered a design which was a) far from complete; and b) only intended as an outline. Furthermore, the designers had not been told in advance that the hull committee would be considering their design in such detail.

Many of the points of detail in the report went beyond what the Minister had originally requested Thornycroft, Giles to consider. [Mr Cox said that the then Minister DP had asked TGA to produce proposals which could be evaluated against the Naval Staff Requirement (NSR) to see if it offered advantages over the Type 23 design. DSAC, Y-ARD and MOD had each independently assessed the outline produced by TGA and had concluded that the S90 design submitted failed to meet MOD's requirements because it would not be large enough to contain the weapons needed, did not have sufficient engine power to achieve the required speed; nor would it achieve the required endurance unless it carried substantially more fuel than envisaged, fell far short of the under-water noise target (ie would have degraded the performance of towed array by an unacceptable margin), would roll rapidly (eg. to an unacceptable degree for safe helicopter operations) and could not survive action damage adequately, would not be in service until long after required and, finally, because the (unproven) cost advantages claimed would be so small as not to compensate for these major shortcomings.]

Mr Wall added that whilst it might be possible to build a T23 short, fat ship, it might not be able to accommodate all that was required without electrical interference between weapons systems.

Rear Admiral Thompson said that, even then success depended on whether the designers' claims for the S90 were valid.

Mr Wall said that if one were to assume that the equipment necessary to meet the Naval Staff Requirement had to be fitted, then the scope for reducing the cost depended solely on whether putting the package in a different-shaped cocoon yielded any savings in cost. MOD had speculated that the savings postulated by TGA on the hull-form would be in single-figure millions, but Mr Wall's assessment was that the disadvantages outweighed the small potential for reducing costs.

Mr Cox added that MOD's public comments on the suitability or otherwise of the S90 for service with the Royal Navy had been muted because, as with all other UK equipment suppliers who produced items which might not be what the RN wanted, MOD did not wish to prejudice their chances of achieving sales elsewhere, eg overseas.

Mr Owen and Mr Monckton thanked all the representatives of Ship Department, Bath for their kindness in giving up so much of their time to clarify the position. It was agreed that any further points would be addressed to Mr Cox.

Rear Admiral Thompson said that the MOD would be willing to give any further help that might be necessary.

CHRISTOPHER MONCKTON