'SUBDIVISION, STABILITY & SURVIVABILITY'

—A BOOK?

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ABSTRACT

MOD(PE) is launching a new BR series aimed at providing ship stability and survivability information. The background to the requirement is presented and the first book of the series—for the CASTLE Class Offshore Patrol Vessels—is introduced.

Introduction

To Float . . . to Move . . . to Fight. These are the familiar operational priorities for warship recovery following damage. The loss of mobility and loss of fighting effectiveness after damage are routinely exercised, so that their effects and the recovery action to take are likely to become second nature in operational warships. But the essential prerequisite, to *float*, is perhaps not understood quite so well and it is certainly much more difficult to exercise.

HMS *Phoenix* teaches the basic principles of what happens to a ship when she floods, or when stability is reduced for other reasons. This is reinforced in part in the NBCD Book, *BR 2170*. It is not too arrogant to say however that the only person who really has a chance of understanding what is likely to happen to a given ship under damage conditions is her original designer, the naval architect. Looking at the traditional NBCD Book one has to admit that this knowledge has not been transmitted to the Command very effectively.

This state of affairs does not follow from lack of interest in the Navy, however. Far from it. There has long been a demand for more information, spurring a debate about what is operationally relevant to the Command. His ship has been designed to be survivable so does he need to know the practical effects of damage? Does he need to know the consequences of loss of stability and so forth? Should he be aware of which is more likely, capsize or sinking? More fundamentally, and to use a common misquotation, is a little knowledge a dangerous thing?

These questions will remain alive (and will not be revisited in this article); however the debate will perhaps be fuelled by the launch of a new series of BR—*BR 8971, The Class Subdivision, Stability and Survivability Book*. It aims to provide warships with practical advice on the way a ship will respond to varying extents of damage.

Background

British warship design philosophy aims to ensure that a warship is as survivable as possible. But not only that, survivability should be such that counterflooding is not required as an immediate response; a ship's actions should focus first on securing watertight boundaries and clearing any free surface. Only then may pumping begin.

The ability to sustain damage from even one small hit below the waterline (in the worst case at a transverse bulkhead), gives rise to a one, two, or three-compartment damage standard, depending on ship size. This standard is the

basic minimum for UK warship design. It requires subdivision by fully watertight bulkheads and often drives compromises of layout. This subdivision does, of course, provide important benefits to other aspects of damage control, firefighting and smoke confinement.

In a similar way, the standards of intact (undamaged) stability aim to remove the need for constant consideration of vessel loading. The exceptions to this are the liquid and fuel usage restrictions which are mandatory for many ship classes. Although these restrictions may sometimes seem onerous they are intended to assure safety.

It is perhaps worth noting at this point that MOD philosophy is different to that of the merchant marine. Here, not only are survivability standards generally much lower (or even non-existent), but Masters naturally have significant responsibility for the loading and stability of their vessels. It may come as a surprise to some that it is legally correct for large cargo ships to have no capacity to survive any damage whatsoever.

For a warship, the current design philosophy is to ensure that the vessel is inherently capable of surviving a wide range of operational loadings and circumstances; of which damage is one. This philosophy extends to providing reassurance to the Command that he need take little part in understanding such an inherent capability.

Operation CORPORATE sadly reminded us that ships can be lost due to operational damage (FIG. 1). Of lower profile, the grounding of HMS *Guernsey* in 1987 demonstrated that vessels can come close to sinking but, through a combination of good design and correct reaction on board, can remain safe and be recovered. HMS *Bristol*'s fire of 1974 brought home the different lesson of the adverse effect of firefighting water on decks. In that incident the implication of her loll from port to starboard was not fully realized until after the event.

It was CORPORATE that forced MOD(PE) to re-examine the way stability information was provided to the Command. The Sea Systems Controllerate formally took onto its Action Grid the investigation of improving the usefulness of stability information it provides to ships.

FIG. 1—HMS 'COVENTRY', 25 MAY 1982

Investigation

The formal investigation was led by the then Chief Naval Architect's department (now reformed under a new Directorate) in a consultative process with Commodore Naval Ship Acceptance (who is the Controllerate's seamanship and NBCD advisor), the Directorate of Naval Warfare, and C-in-C Fleet.

Quite independently of this the Controllerate's Design Authority for 'Large Auxiliary Vessels' was examining the same problem from a different viewpoint. In the four years from 1985 to 1988 several of their vessels had accidents which showed that stability and survivability information was virtually useless when it was most needed—at the time of the accidents. In particular, HMS *Endurance* was holed by ice and HMS *Guernsey* ran aground. Neither ship had any information on survivability; even if they had, the conventional information in Class NBCD Books would not have helped. It was clear from these incidents, from a review of losses in the Falklands and from an appraisal of damage and loss in World War II that we were simply not giving advice that the Command could easily recall and interpret when under stress. There was no guidance to judge whether a ship was about to sink or not, above all there was no guidance to judge if a ship was at risk of capsizing.

The thrust for the Large Auxiliaries Group, fuelled by discussion with serving Marine Engineering and Commanding Officers, was to prepare a book of practical examples of damage, its consequences and advice on actions to take. In early 1988 the 'HMS *Endurance* Subdivision, Stability and Survivability Book' was published. It was followed a year later by a similar book for HMS *Herald*.

Meanwhile the Chief Naval Architect's more formal investigation had developed a different approach. This sought to give a wide audience a deeper theoretical understanding of survivability together with the tools to calculate the consequences of damage. In collaboration with the Type 22 Frigate Design Authority a draft 'Type 22 Stability Pocketbook' was issued for comment in 1989.

From their different stables the emphases and styles were quite different. There was more than a little internal rivalry within the Naval Architecture community between the two formats; however both attracted positive, constructive comment from the users and their representatives, CNSA and C-in-C Fleet.

In particular, the question of using both computer-aided information recall and computer-aided survivability assessment was raised. This served to focus on the real objecive of presenting effective information which is intended to be used in times of stress. It must be easily understood, easily remembered *before* the event and reliably available for reference *during* the incident if circumstances permit.

A healthy internal debate about style and format continued but, to curtail the story, the finally agreed way forward was an inevitable convergence of the more effective aspects of each of the published books.

By the time this article appears the 'Large Auxiliaries' Group will have published *BR 8971(1)* for the CASTLE Class offshore patrol vessels. Following this lead and taking any other relevant reaction and comment, Class Books for the majority of the White Ensign Fleet are planned. These will be sponsored by the relevant design authority sections.

The Book—Style

The book aims to give the Command practical advice on the extent of flooding which is likely to cause loss; whether loss will be sudden and unpredictable rather than progressive; and whether loss will be by capsize or sinking. It aims to equip him with means of judging if loss is likely in the

circumstances prevailing and describes in straightforward, easily recollected terms:

- the design standards and features of the Class;
- the qualities of stability and survivability that the Class possesses;
- how to maintain and test watertight integrity in service;
- the general extent of damage where loss is not likely;
- how the ship physically responds to damage or accumulation of firefighting water on deck;
- how to detect and improve a hazardous situation such as imminent capsize or sinking.

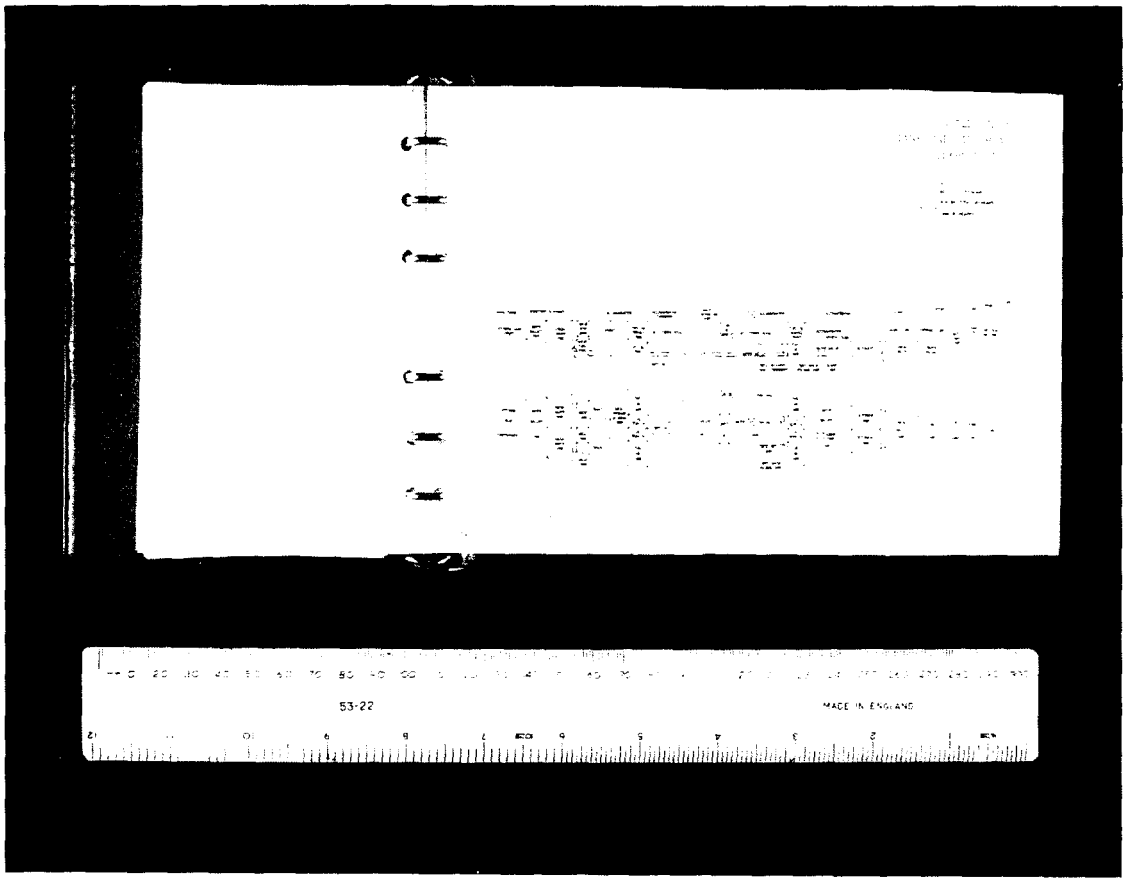

FIG. 2—THE BOOK, BR 8971(1)

Perhaps surprisingly, comments during the investigation reinforced the original proposal for the book to have a 'pocketbook' format (FIG. 2). It is therefore slightly smaller than a Filofax and can fit coverall pockets. This author believes that the arguments for and against this approach are far from over. However, in these days of 'space-conscious' documentation and the pressures of microform, perhaps all BRs should go this way?

The style is not too far removed from the Submarine Service 'Training Aid Books'. In a similar way to the TAB the presentation keeps the words to a minimum (there is no background theory) and presents as much information as possible using coloured diagrams. Water resistant paper is used to improve durability.

The book is therefore not exhaustive on the subject but does aim to include everything pertinent to the Ship Class. This includes the 'Stability Statement' with which every ship is issued and previously was the only formal disclosure made.

The Book—Content

This article aims only to introduce the book while avoiding the danger of reprinting the entire pilot issue here! It is however worthwhile commenting on the content, as it appears in the book, and providing examples of the fundamental diagrams.

- *Introduction*—includes the Authority, Validity and Precedence of the document.
- *Design Standards*—describes the standards employed for intact and damaged stability and the survivability after damage.
- *Scheme of Watertight Subdivision*—supported by diagrams of the Profile and Deck Plans of the ship, describes the key features of the ship construction, the watertight boundaries and the openings in them, together with their NBCD risk and control marking.
- *Watertight Integrity*—emphasises the importance of correct testing and maintenance of watertight boundaries and openings. It describes the effectiveness of decks in contributing to survivability.
- *Testing Watertight Boundaries and Compartments*—is a reminder of testing and survey requirements, referring to the relevant authoritative documents.
- *Response to Flooding*—comments on the types of transient behaviour which may be encountered (for example due to rapid flooding or the spray plume from an underwater explosion) and then introduces the more important 'post-transient' behaviour. This is particularly illustrated by Appendices showing quick reference Carpet Plots (described below) and 17 survivable cases to illustrate the response of the ship to damage (also described below).
- *Modes of Loss*—presents the symptoms likely to lead to loss by capsize and compares with the symptoms likely to lead to loss by bodily sinking.
- *Stability During Firefighting*—describes the effect on stability of firefighting water build-up on internal decks. This is supported by two examples in similar fashion to those presented for Flooding.
- *Measures to Correct Heel*—Compares the two different causes of heel: List and Loll. A sequence of actions to reduce the angle of heel in each case is presented and is supported by a tabular Jettison Bill. It is worth noting here that background research for this booklet examined historical warship losses since 1939. There was no direct evidence of any ship having been lost due to the theoretically possible 'lurching' from side to side, when in a state of loll. This does not mean that free surface is not hazardous; it means that ships do not capsize unpredictably after damage, providing they have survived the first traumatic three minutes.
- *Docking and Grounding*—presents general advice on stability during docking and the different effects of grounding on a 'pinnacle' as opposed to a flat bottom.
- *Stability with Ice*—presents the mandatory requirement to apply fluid usage restrictions under icing conditions.
- *Permissible Cargo Loaded on Upper Deck*—gives the maximum static weight which may be carried.
- *Number of Personnel Carried in Emergency*—gives the maximum number of people which may be carried in, for example, evacuation operations.
- *Stability after Damage Carpet Plots*—support the statements made in the Response to Flooding section. FIG. 3 is one example, of four *quick* reference plots, showing an example case. The plots give an indication of

the survivability of the ship given the extent of longitudinal flooding. The four plots are derived by considering two different initial loading conditions of the ship (the 'deep' and 'worst seagoing'), and by considering flooding to be either restricted or unrestricted by the horizontal boundary of No. 2 Deck. This latter condition will be determined by whether the damage has breached No. 2 Deck or whether there are any watertight hatches remaining open. For the CASTLE Class, the significance of this deck is clearly demonstrated by a marked improvement in survivability if the deck remains watertight. Having obtained a rapid impression of survivability from the plots, the next step is to observe the immersion and behaviour of the damaged ship, for that is the ultimate indicator of sinking or capsize.

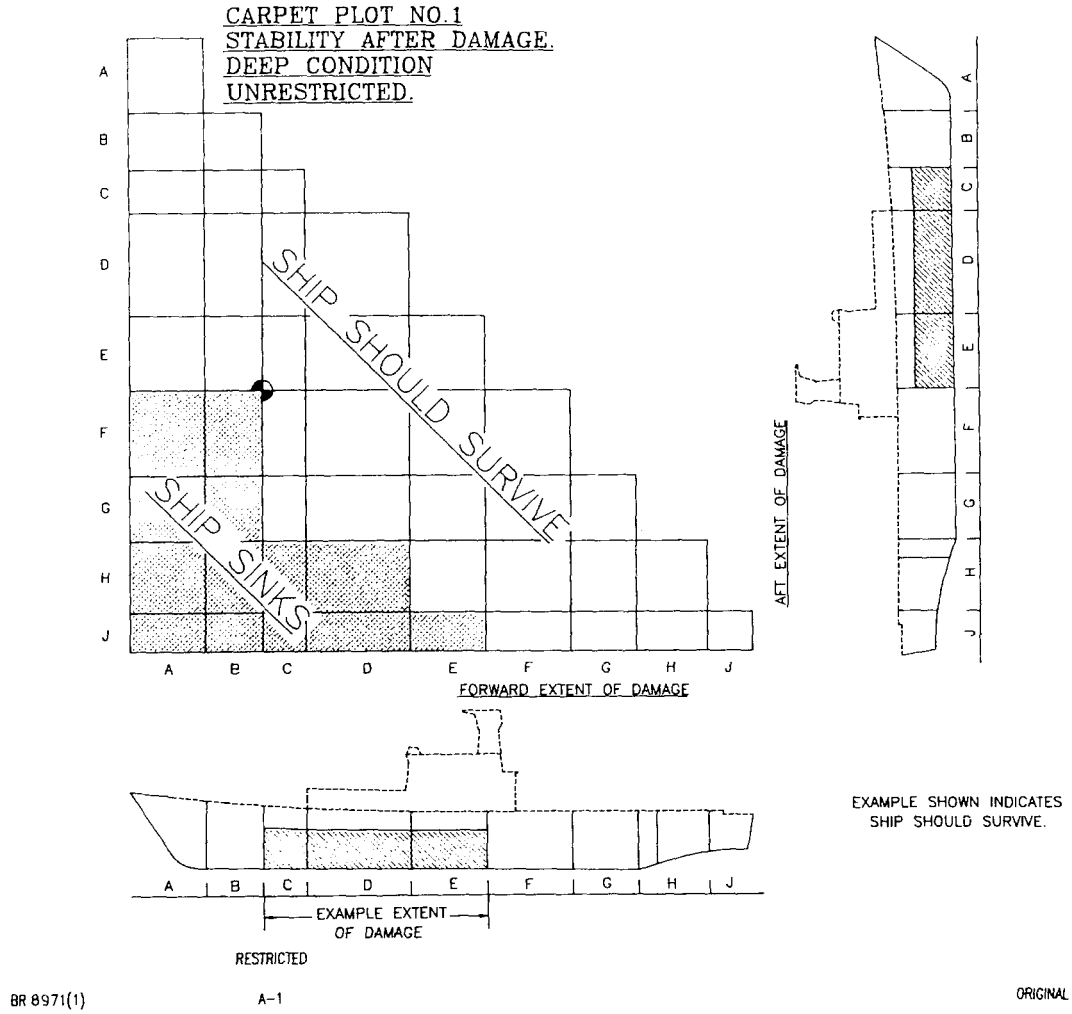

FIG. 3—EXAMPLE CARPET PLOT

- *Current Stability Statement*—is presented complete. This includes mandatory liquid loading restrictions and Curves of Statical Stability reproduced in colour.
- *Jettison Bill*—lists items which may be easily removed and which have a significant effect on improving stability. The location of the items is stated together with their individual effect on improving stability. For example, removable items include the anchors and cables, upper deck guardrails and a wide range of items which can be carried off, unbolted or burned off.

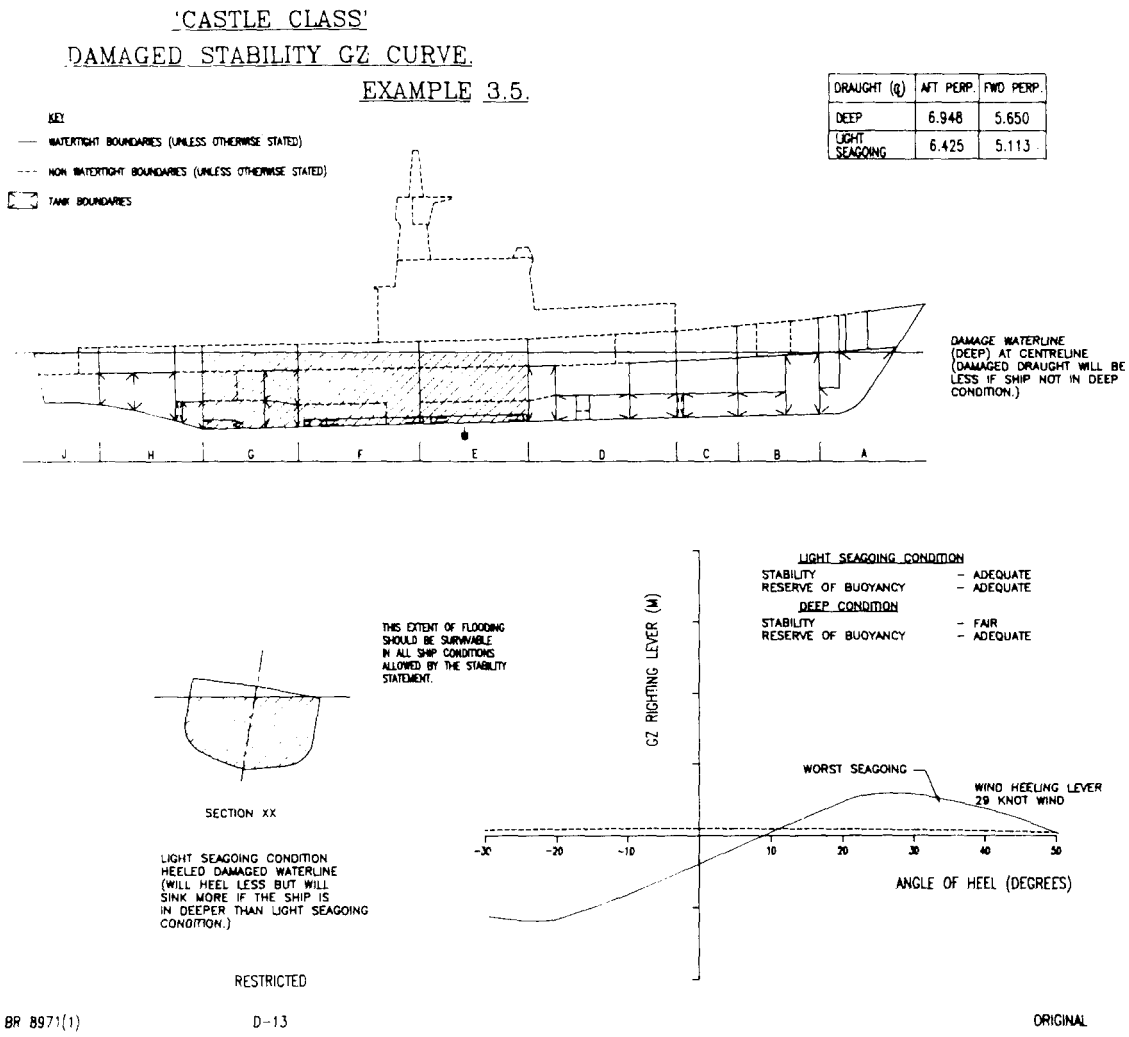

FIG. 4—EXAMPLE DAMAGED CASE

- *Damaged Examples*—show the most important information for those conditions which are survivable. A typical case is shown in FIG. 4. Each example shows the following information:
  - The flooded compartments.
  - Profile of ship with waterline and angle of trim.
  - Section of ship with waterline and angle of heel.
  - Table showing draughts for two loading conditions.
  - The Stability Curve indicating also the additional effect of wind, particularly in increasing angle of heel.
  - Qualitative descriptions of the two essential factors for survivability—Stability and Reserve of Buoyancy.
  - A summary statement on the overall survivability with any advice relevant to this particular condition.

  The examples have been derived by computer modelling using GODDESS, the MOD(PE)'s own design and analysis system.
- *Firefighting Examples*—are presented in identical fashion to the Damaged Examples. These show the effects of water build-up due to firefighting and boundary cooling for fires in the superstructure, machinery spaces and magazine.

- *Tank Capacity Plan*—a profile and plan of tank disposition is reproduced together with tabulated capacities, centres of gravity and free surface moments.
- *Watertight Subdivision Plan*—deck plans and profile showing watertight boundaries and openings.
- *Ventilation Plan*—deck plans and profile showing main ventilation runs and watertight closures.
- *Salvage Schematic Plan*—showing bilge system, ballast system and cross connections with other sea water systems. Location and capacities of pumps are also shown.

In summary, the book has 15 pages of text, 2 tables and 33 colour diagrams—and it fits in the pocket.

Conclusion

This short article has aired some of the arguments surrounding stability information and has introduced the Sea Systems Controllerate's intentions for *BR8971*. It is believed that a very positive step forward is now being made to service operational needs.

There is no doubt that the early issues of the book will attract further comment and proposals for enhancement. As the series develops over the next few years not only can improvements be incorporated in later issues but the subject will remain very much alive.

Acknowledgements

The author particularly acknowledges the contribution of his predecessor in post, Mr Euan Haig, RCNC, who listened to many 'drips' from the Navy and generated the concept resulting in the books for HMS *Endurance* and HMS *Herald*.