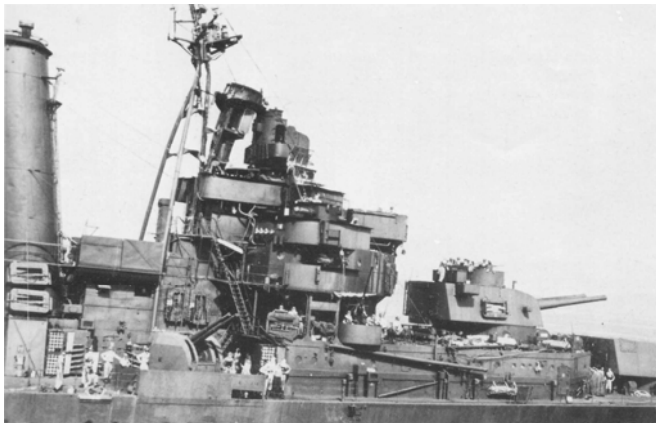


WARSHIP SURVIVABILITY

Something more than courage – know how – was required to conquer fires such as those that raged in [USS] Franklin. Neither she nor many of the other ships crashed by kamikazes...could have been saved but for the fire-fighting schools and improved techniques instituted by the [US] Navy in 1942-43.

Rear Admiral Samuel Eliot Morison, USN¹

For some reason a number of Defence commentators still maintain that surface warships, by their very nature, are excessively vulnerable.² This is simply not true. Survivability is an integral part of a warship's design, with the key elements in the equation recognised as susceptibility, vulnerability and recoverability.³ As such, warships are far more resilient to damage and much less mission sensitive in terms of defects than say airborne units. Unsurprisingly, wartime stories of ships surviving horrendous punishment yet still completing their operational tasking are legion. In the Australian context the staying power of HMAS *Australia* (II) during the brutal Philippines campaign in World War II comes immediately to mind, while in Vietnam in 1968 HMAS *Hobart* (II) was quickly repaired and returned to full service after damaging hits from three Sparrow missiles.⁴



During the invasion of Lingayen in January 1945, HMAS Australia (II) endured five kamikaze hits. Except for the casualties among her anti-aircraft gun's crews, her fighting efficiency was not impaired beyond the capacity of temporary repairs (RAN)

The complex process of warship design has always been undertaken by a dedicated but small number of professional naval practitioners, naval architects and marine engineers. Given the relatively limited spread of these professions, many of the decision-making processes are not well understood by those who are not closely involved. Nevertheless, it is essential that commentators have a good understanding of the issues if they are to provide a meaningful contribution to the debate - and some issues such as the relationship between ship size and vulnerability are not necessarily intuitive. Survivability is one which impacts greatly upon Australian Defence Force (ADF) capability development and operations, and closely involves the Defence Science and Technology Organisation (DSTO) and Australian defence industry.

Warships are designed to float, to move and to fight.

This fundamental truism of warship design has implications in almost every decision made concerning the planning of a warship's hull, structure, machinery, systems and equipment. Although designed to have maximum weapon and sensor power, combined with high speed, acceleration and manoeuvrability, a warship also needs the capacity to withstand damage within the limits imposed by its size and type. Commercial vessels, by contrast, even if fitted with sophisticated weapon systems are not intended to survive damage and still continue to float, move and fight. Moreover, unlike a merchant vessel, all members of a warship's crew are trained in damage control techniques, and dedicated damage control parties with access to portable fire pumps, breathing air compressors, and specialised repair equipment are expected to fight to save their ship whenever it is subject to flooding or fire.

Warships possess survivability through layered defence systems, signature management, structural robustness and system redundancy.

Every warship possesses a minimum level of self-defence, but it is the integration of warships into and within an umbrella of defence layers, as systems within systems, which achieves maximum survivability. Taking anti-air warfare as an example, point defence systems like the Phalanx Close-In Weapon System need to be supplemented by electronic countermeasures, such as the Nulka decoy; area defence systems such as the AEGIS combat system incorporating the Standard (SM-2) anti-air missile; and long range surveillance systems such as Airborne Early Warning & Control aircraft. Importantly, not all these systems need to be mounted in the same platform, and a fully networked force offers significant advantages by combining and enhancing the different sensor and weapon capabilities of individual units.

To fully exploit their sensors, weapons and countermeasure systems, warships incorporate signature reduction technologies. These include designing for stealth, the use of radar absorbent materials, as well as techniques to reduce acoustic, magnetic, infra-red, and other signatures. The point here is that an adversary can rarely expect a 'free hit' or perfect situational awareness in a combat situation. Even ignoring a warship's hard and soft kill responses to a threat, issues of detection, identification, and tracking will hamper an enemy's ability to build an accurate picture, and hence add significantly to their targeting problems.

Warships also have to be structurally robust, not only to minimise the extent of hull and structural damage if hit, but also to prevent the breaching of the vessel's watertight integrity. Watertight compartments help localise damage due to flooding and allow counterflooding techniques to be used to maintain ship stability. These techniques go far towards ensuring that a warship will stay afloat even after severe damage to the underwater hull. Indeed, critical systems below the waterline can continue to operate normally even in a flooded compartment.

When HMS *Nottingham* accidentally grounded on Wolf Rock near Lord Howe Island in 2002, five compartments were flooded. Nevertheless, her propulsion and power generation machinery continued functioning long enough to extricate the destroyer from danger and move her into sheltered waters. Meanwhile the determined efforts and training of her crew combined with the resilience of the warship ensured she kept afloat until more lasting repairs could be made.

Gastight compartments and citadels may also be used to ensure unrestricted operations when a warship transits through chemical, biological, radiological or nuclear environments, and to minimise the spread of smoke or toxic gases. Additional protection to vital areas such as magazines may be offered by blast protection and armour, while critical machinery and equipment, including pipe systems, control panels and instruments use resilient shock mounts to reduce the impact of forces transmitted through the hull. All such equipment is subjected to rigorous shock testing to verify that they are robust enough to operate after a nearby explosion. Trials and experiments to further improve warship resilience, such as DSTO's Ship Survivability Enhancement Program (SSEP), mean that each new generation of warship design incorporates additional advances.



Over 10 weeks in 1994 DSTO carried out SSEP trials on the former HMAS Derwent (II), all aimed at enhancing the combat survivability of RAN ships and their crews to a range of weapons and associated threat effects (RAN)

System redundancy is also an integral component of warship design. Critical systems and manning are duplicated to ensure that damage or casualties in one area of the ship will not lead to loss of the entire system. For example, warships often have two parallel main propulsion systems, incorporating power plants, gearboxes, shafts and propellers, which are located in separate compartments, so that even the loss of one machinery compartment will not prevent the ship from moving. Electrical power generation and distribution systems are likewise spread throughout a warship. Should a ship's main power be suddenly lost, then emergency supplies, for restart, lighting and essential command and control functions, immediately come into force.

The extent of system redundancy tends to increase dramatically with hull size. The larger the ship, the smaller proportion of her hull any given weapon is likely to destroy; furthermore, the easier it is to duplicate vital equipment while accommodating advances in technology and changes in mission requirements. Australia's three new *Hobart* Class Air Warfare Destroyers (AWDs) will displace around 6250 tonnes when fully loaded and will be just under 150 metres in length. Although they might

seem large when compared with previous RAN frigates and destroyers, the *Hobarts* are directly comparable in size with equivalent ships serving in other world navies. More importantly, they reflect the world's best practice in survivability design, with particular attention given to open architectures, redundancy, dispersion of vital systems around the hull and the use of especially hardened materials. In view of the uncertain world outlook and the likelihood of unexpected attacks – such as the 2000 bombing of the destroyer USS *Cole* during an ostensibly friendly port visit – this means 'that our ships should be able to take the first shot from an enemy', yet still be able to 'fire the last shot, which destroys that enemy'.⁵

Missiles are relatively inefficient in terms of explosive content and tend to produce only localised damage in a warship. In cases such as the loss of HMS *Sheffield* to an Exocet in 1982 it was not the warhead – which failed to detonate – but the subsequent fire and thick noxious smoke which sealed the destroyer's fate.⁶ Underwater weapons, by contrast, are inherently far more lethal, with the potential for even a single mine or torpedo to sink a quite large vessel. Yet even here, the situation is not always clear cut. During the 1991 Gulf War the amphibious ship USS *Tripoli* struck a contact mine which left a 7x10 metre hole in the ship's hull below the waterline. Notwithstanding this damage, effective control measures meant that for almost a week she remained on station, still serving as a command ship and floating base for the airborne mine countermeasures unit. Just hours after the *Tripoli* hit, the guided missile cruiser USS *Princeton* suffered two nearby mine explosions. Once again, despite severe damage which almost broke the ship in two, the crew brought *Princeton's* AEGIS combat system back online within 15 minutes, and she remained on anti-air duty for a further 30 hours. With respect to submarine launched torpedoes, early detection and sophisticated decoys are the warship's most effective response and both capabilities are slated for the AWD.

The very nature of warfare, and more particularly operations at sea, means that there will always be risks. More specifically, naval forces may be required to go into harms way, and may be severely damaged or lost in battle. This does not imply that ships and aircraft and their precious crews can be wasted, but navies which have proved themselves risk averse have never enjoyed any degree of success. The inherent survivability of modern warships ensures that these risks can be managed with some high degree of confidence and allows surface warships to maintain their position as some of the most relevant and flexible assets in the ADF inventory.

1. SE Morison, *Victory in the Pacific 1945*, History of USN Naval Operations in World War II, Vol XIV, Castle Books, Edison, 2001, p. 98.
2. See for example, A. Davis, *Asian military trends and their implications for Australia*, ASPI strategic Insights, Canberra, July 2008, p. 22.
3. L de Yong, 'Integrated ship survivability for the Royal Australian Navy', *Pacific 2008 International Maritime Conference Proceedings*, Sydney, 29-31 January 2008.
4. *Hobart* was a victim of friendly fire, one of several ships mistakenly attacked by jets of the US 7th Air Force.
5. N Friedman, *Seapower as Strategy: Navies and National Interests*, Naval Institute Press, Annapolis, 2001, p. 234.
6. *Sheffield's* survival was also compromised by poorly applied cost cutting during design and build, which saw fire fighting and damage control measures targeted for savings.

