THE AUSTRALIAN NAVAL ARCHITECT

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HMAS *Parramatta* ready for undocking in April after her Anti-Ship Missile Defence upgrade at BAE Systems, Henderson Shipyard, Western Australia.
(RAN photograph)

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Cover Photo:

The 72 m high-speed support vessel RNOV *Al Mubshir*, built by Austal for the Royal Navy of Oman, during sea trials off Western Australia in March (Photo courtesy Austal)

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From the Division President

As this is my first column as re-elected Division President I would like to begin by thanking my predecessor, Dr Tony Armstrong, for doing such a wonderful job. I know that he has put an enormous effort into this role and it will be very difficult for me to follow in his footsteps; however, I will do my best.

I would like to thank my fellow Council members who voted for me as President. I appreciate their faith in me and hope that I won't let them down.

My thanks go to the retiring Council members who have served on Council so well, and I look forward to them returning to Council at some stage in the future.

I would also like to welcome the new Council members and, in particular, Jesse Millar, who has taken on the role of Vice President.

During Tony Armstrong's tenure he worked with the Division Council to develop a list of main activities for the future, as noted in the February 2015 edition of *The Australian Naval Architect*. These are all useful initiatives and I think that it is important to continue to work on these.

The overarching theme of many of these initiatives is to raise the public awareness of the Institution, so that we are seen as the authority of choice on matters relating to ship and boat design and production. However, I believe that it is also very important that we do not become a lobby group for any particular part of the maritime industry.

As Tony Armstrong noted, this can be achieved by quality submissions to Government and a greater involvement by members in the activities of their local sections. He also raised the importance of working with the academic institutions, contributing to the relevant courses, and encouraging students to join the Institution.

I look forward to working with the new Council on these important matters.

One of the things that I want to achieve during my term as President is to visit as many of the section technical meetings as possible. I have already attended section meetings in the ACT, NSW, and Victoria this year. These have been very interesting and I have enjoyed them all. It has also been great meeting with section committee members, and others, at these gatherings. I am struck by how differently the various sections operate and run their technical meetings. Of course there is no reason why they should all be the same — whatever suits that particular section. It is also interesting to compare the way the sections are run here in Australia with my recent experiences at the Southern Joint Branch in the UK, and the UAE Branch.

I'm looking forward to attending section meetings in the other states in the future.

I believe that now is a very interesting time to be working in the maritime industry in Australia — particularly in defence-related activities. Although there is much talk about SEA 1000 — the new submarine — we mustn't forget about the other major purchases, including the new frigates, the new offshore combatant vessel and the new patrol boats. It seems that the Government has, at last, learned the importance of avoiding the "valley of death" in naval shipbuilding that we, and others, have been warning about for many years.

Martin Renilson

With all this maritime activity in the country, there is quite a demand for education. Of course, this is not only for traditional undergraduate degrees, but also for a range of industry-related short courses, particularly those specialising in defence-related technologies. It is important that the Institution is in a position to provide advice to those running these courses, in particular where accreditation/certification is involved.

I also note that the Defence White Paper refers to the generation of a Centre for Defence Industry Capability, and a Defence Innovation Hub. These could be potentially interesting developments and I hope that, if appropriate, the Institution will be able to contribute. We have already written to the Defence Minister asking for further information and offering to assist.

Internationally, I welcome the appointment of Tom Boardley as President, and look forward to meeting with him again in due course. Also, I understand that RINA's International Council is settling down into its new role as the reporting point for Technical Committees, with organisational management and governance being handled by the Board of Trustees.

I would like to encourage all members to update their areas of interest on "my RINA" so that they can contribute to the workings of the new Technical Committee structure. This is important as it will enable the Committees to tap the expertise of members worldwide, and will be an opportunity for us to contribute from Australia.

For example, the method of analysing inclining experiments developed by Richard Dunworth has now generated quite a bit of discussion. Personally, I think that this is a great step forward, and am actually quite amazed that nobody thought of this before! If you're not already aware of it, we published a good paper on his approach in the *International Journal of Small Craft Technology*, to which all members will have access (Dunworth, 2014).

I know that this has also attracted quite a bit of interest within the SNAME SD-3 Stability Panel.

I would therefore like to encourage all members to get as involved with the Technical Committees as they feel able.

Martin Renilson

Dunworth, R.J., (2014) "Back Against the Wall", *Transactions* RINA, Vol 156, Part B2, *International Journal of Small Craft Technology*, Jul-Dec 2014.

Editorial

After what has seemed to many observers a very long wait, the Government has announced that Australia's new submarines will be built in Australia to a French design in partnership with DCNS, designers and builders of the French Navy's nuclear submarines and designers of conventional submarines which have been built around the world for other navies. This welcome decision sets in place a relationship with France which will last for decades and, along with plans for offshore patrol vessels and future frigates, will provide the greatest continuity in Australian naval shipbuilding since the two decades immediately after World War II.

It is almost forty years since a project definition study was completed which resulted in the choice of the last, and only previous, French-designed ship for the RAN. That ship, built in Sydney, was the fleet underway replenishment ship HMAS *Success*. HMAS *Success* recently celebrated the thirtieth anniversary of her commissioning with a gathering of her ship's company attended by previous commanding officers, representatives of her builders and the Navy project team. I was very pleased to be there and to once more inspect the ship which it had been my privilege to hand over to the Navy, on behalf of her builders, at sea on 16 April 1986. It seems like only yesterday — how time flies.

The construction of HMAS *Success* was a challenging task for everyone involved. Taking an overseas design and adapting it for Australian service, in this case with 41 design changes and 140 material substitutions, and building it in a different shipbuilding culture and a different language is not a trivial task. It was made more difficult by the fact that the shipyard had not built a major ship for some years and had to re-establish that capability. They were challenges which would be familiar to today's builders of our air-warfare destroyers.

The last thirty years have been very busy for HMAS *Success*, as reported later in this edition of *The ANA*. Part of every shipbuilder goes with every new ship, and it is very rewarding to see a ship which you have helped to build provide good service for so long. The rewards with *Success* began when we first took her to sea. Her trials quickly proved that the choice of the design for the RAN had been the right one, and her shipbuilder and the project team were full of admiration for the French naval architects and engineers who had designed her. Today she looks in great form and ready to serve another five or six years until replaced by one of the new replenishment ships which are to be to be built in Spain.

French-designed ships, in this case submarines, will now continue to be part of the RAN for decades into the future. It is right to build all the submarines in Australia and the program of naval shipbuilding now announced will provide much-needed continuity for new generations of shipbuilders.

Speaking of time flying, this is the 72nd edition of *The Australian Naval Architect* since Phil Helmore and I took over in July 1998 from the team who started the journal in Western Australia early in the previous year. I don't think we had any idea then that we would still be producing the journal eighteen years later. The Western Australian pioneers really started something. Today *The ANA* is larger, and produced in colour for publication on the RINA website, where it is available to all. This would not have been possible without the continuing support of members in Australia and those organisations who have supported the Institution through advertisements in *The ANA*. Thank you all.

John Jeremy

Awash with memories — John Jeremy and HMAS *Success*, 22 April 2016
(Photo CAPT Alison Norris RAN)

LETTERS TO THE EDITOR

Dear Sir,

A colleague of mine has asked me to comment on the letter by Martin Grimm in the February 2016 edition of *The ANA*, principally with respect to aluminium in shipbuilding. Aluminium design and fabrication is a very mature industry. I have been designing aluminium high-speed vessels for almost 30 years and I agree with Martin's assessment and conclusions and agree that is it not aluminium, *per se*, that is the problem, although an appreciation of the metallurgy is now a prerequisite.

Attention to Detail

In the late 1980s, at my former company FBM Marine, we designed and built the world's fastest SWATH MV *Patria*, which is still the fastest SWATH. She is of all-aluminium construction to guarantee the light weight required to achieve the high-speed requirement at the time. Within several weeks of entering service, cracks started to appear in various locations around the vessel. It was exacerbated by a global structure resonant behaviour. This was the first introduction to the "beauty" of aluminium, in that just because it shines doesn't mean all is gold! Our other vessels which reinforced the issues encountered in *Patria* were *RedJet 1* and *RedJet 2*. These are two high-speed ferries which used to run across the Solent from near our shipyard in Cowes (which built them) to Southampton. The waterjets were constantly cracking.

Whilst, at the time, both these vessels caused severe problems for the company, they proved, with hindsight, to be the best lessons we ever learnt — that of attention to detail and, for me personally, a lifelong interest in such causes and effects that spawned many technical papers which I have authored, magazine articles and even a book which I am currently writing on this very subject.

In Martin's letter, he lists Items 4.9 to 4.18 from the book *Ship Design and Construction*. All these were eventually found to be the sources of cracking coupled with poor fabrication practice. However, fabrication ended up being responsible for a majority of the issues owing to poor information/practice. In the late 1980s, whilst aluminium was not a new material for construction, it was still relatively "new" in its understanding and longevity in the high-speed vessel market. As such, it was common for welders to adopt typical steel work practices. Aluminium is a metal like steel and can be welded, why shouldn't it be treated the same? was the methodology at the time. This attitude proved to be an additional source of cracking. Aluminium is not steel and should never be addressed in the same way — new procedures and thinking were required.

Lessons Learnt

Any engineer, when faced with a problem, must first establish the mechanisms which caused the failure, for example cracking, before arriving at a solution — a solution which is a permanent one, rather than an instant and immediate cure which is often the wish of the operator to get the vessel back into service.

I spent many years gathering as much data as I could on the metallurgy of aluminium, structural load paths and their influences using FEA and strain gauging, effects of small changes in shapes and radii and detailing of them along with the influence of welding and welded-joint quality relating to misalignments etc. with regard to fatigue life, and devoting a lot of time on the shop floor understanding how and why the welders fabricated in a particular way and experimented further with in-house testing of joints to failure. Donning the welder's very heavy leather overalls and cumbersome masks and totally inflexible gloves, which offered no real dexterity, was even more illuminating. The experience left me with a feeling of awe at how these fabricators could work in such challenging conditions. This was the final key to understanding — an appreciation for the lack of mobility and space for the fabricators. If the fabricator cannot gain real access to the joint, how on earth can they be expected to produce high-quality welds? Sitting down with the fabricators and asking them can XX or YY be built proved to be an extremely valuable experience for both parties along with seminars — a real two-way conversation to improve design detailing and fabrication.

I instituted a series of design measures, with respect to detail and structural methodology, and provided technical seminars for the shop floor of the dos and don'ts of aluminium to ensure that the changes required were not in one department only. A successful vessel is one which is a blend of good design and good construction, acting in harmony — it cannot occur in isolation. If the naval architect does not know how the fabricator will build the structure, how can the naval architect design a fatigue-resistant structure for longevity beyond the computer screen? Suffice it to say that some of the measures I required to be implemented on the shop floor did not go down well with the production manager — change is often seen as a bad thing by those with an eye on costs.

Evidence Based Results

All the measures we adopted and implemented have since proven to be totally effective. For example, there are currently 13 Tricat-class high-speed 45 kn passenger ferries running in Hong Kong. These have been operating for about 12–18 hours every day for almost 20 years. Not one has experienced any cracking, to the best of my knowledge. The company which ran these vessels for the first 10 years of their service life was also the company that owned FBM Marine at the time, so any issues would be immediately reported. We also designed and built two further SWATHs for the UK MoD. It was reported by the MCA that the annual survey of these vessels proved that the MCA could decide to survey biannually, even possibly tri-annually, because of the lack of any cracking and quality of fabrication. The same was true for the other vessels from patrol boats to crew boats which we designed and built. Of all the vessels in which I have had total control over the design and implementation of fabrication practices to ensure that the design intent is maintained, not one vessel has cracked, to the best of my knowledge. All the above can simply be summarised as quality control. Quality control which must be strictly adhered to, no exceptions — it is the glue which holds the success of these vessels together.

Of course it came at a cost, for which my former company paid the ultimate price. Our vessels were considered too expensive by many operators and orders dried up from competition from others who offered vessels which were much quicker and cheaper to build. This is not to say being 'cheap' is not good quality or that quality control cannot be achieved by offering less-expensive vessels or improved speed of building, as it can. This requires knowledge and the courage to implement such changes to production. However one wishes to view it, crack-free vessels come at a cost. Whether the operator pays for it at the beginning or during the service life with constant maintenance is a choice left to the operator alone and those advising them. Nothing in life is for free.

John Kecsmar
Naval Architect
Ad Hoc Marine Designs Ltd

Dear Sir,

My latest discovery in naval architecture is the quadrimaran. This four-hull concept could be a revolution in naval architecture and solution for some maritime transport problems. The project was first put into practice by Daniel Tollet in France in the 1990s. Then his son, Alexandre Tollet, developed the concept and created Tera-4 in 2014. This young French company, based in Aix-en-Provence, proposes a range of eight quadrimaran versions.

The main revolutionary idea behind the quadrimaran is that the hulls create three air-flow channels under the vessel, offering an innovative airborne ride. This QU4DRI® technology provides new hydrostatic and hydrodynamic performance. The technology also combines extreme stability and excellent manoeuvrability. These vessels are designed with a draught of 50 cm, irrespective of the size of the craft, allowing them all to operate in shallow water and to be easily used for beaching. Another advantage of the quadrimaran is that its fuel consumption is reduced by up to 50%. Hence, the quadrimaran could provide support for innovative renewable-energy-powered engines. The hull complies with the International Maritime Organization and has been approved by most of the classification societies as a high-speed vessel.

Built in Arcachon in October 2014, *T-9Prime* was the first prototype. Made of aluminium alloy, this 9 m long × 4 m beam vessel can reach a top speed of 60 kn with its 3 t displacement powered by two 200 kW engines. Trials began in February and have shown positive results, especially in navigation comfort over a large range of speeds.

Finally, this new hull concept could find potential applications in coastal survey, crew transport, firefighting,and even military applications.

For further information, check out the Tera-4 website at www.tera-4.com.

Adrien Parpinel
UNSW Student

Dear Sir,

I am writing to express my excitement at the latest addition to the Royal Caribbean International fleet. Royal Caribbean International is a cruise-ship operator transporting its customers on fun-filled journeys to different ports around the world.

The latest ship, *Ovation of the Seas*, has a length of 347.8 m, a. gross tonnage of 168 700, and is the third ship in the Quantum-class series, the second-largest passenger vessels in the world. With a maximum beam of 41.4 m, basketball courts of 28.7 m length can be fitted sideways on some decks. The Quantum class was originally announced on 11 February 2011 as part of a new class of ships under "Project Sunshine".

Built by Meyer Weft in Papenburg, Germany, *Ovation of the Seas* was floated out for the first time on 20 June and completed on 8 April 2016. The ship's registered port is Nassau in the Bahamas and she has a passenger capacity of 4905 people. However, with such large ships, the logistics and services for the passengers can often be challenging. Indeed, on some of RCI's other ships in the Oasis-class (the world's largest passenger-ship class), the passenger-to-facilities ratio was not good and it was reported to be a very poor experience compared to that on some of the smaller ships. In the customers' eyes, larger may no longer be better. RCI has continued to order more of these large ships, so perhaps these problems have been resolved.

Ovation of the Seas also packs in new features, such as the first-ever sky-diving simulator at sea, so expect queues every day!

An interesting feature of the ship's propulsion is the fact that 20.5 MW azipods are used. These are different from traditional drive shafts and propellers, and are placed further from the main hull to propel the ship through the water with less vibration transmitted to the ship. The location places the units in less turbulent water, reducing hydrodynamic losses too. The diesel-electric system and the pod structure allow the pods to rotate 360 degrees, providing more manoeuvring capabilities for docking and tight turns.

Unlike an ocean liner which aims to transport passengers from one port to another on a schedule, cruise ships often go on round trips and around the same continent. Since ocean liners are designed for more-frequent operation in rough seas, they sit lower in the water and have sharper bows to cut through water (for faster speed and efficiency). Cruise ships are designed for more luxury and hence more cabins are situated higher up and are fitted with balconies. This makes cruise ships appear to have a high centre of gravity. To address this issue, much of the upper superstructure is manufactured from lighter material such as aluminium whilst the heavy equipment, such as the engines and tanks, all remain low to maintain a lower centre of gravity. Furthermore, cruise ships generally have a wider beam which provides more transverse moment of inertia and increases transverse stability. The Quantum class does not have any ice classification and, hence, is confined to ice-free seas.

More information can be found on the RCI website; however, this is quite tourism oriented and the technical specifications are brief. If you have any questions, please do not hesitate to get in touch. I will keep an eye on the Sydney Ports cruise schedule, as news outlets have reported that *Ovation of the Seas* will homeport in Sydney in the winter of 2016–17. If so, then this will be the biggest ship to homeport in Sydney!

[*The Cruise Schedule shows that* Ovation of the Seas *is due in Sydney on 30 December 2016, then on 9 and 23 January 2017, and starts making regular visits on 12 December 2019* —Ed.]

Yun Cho
UNSW Student

NEWS FROM THE SECTIONS

ACT

Annual General Meeting

The AGM was held on 15 March 2016 at Campbell Park Offices. In addition to the agenda items, some discussion in relation to a strategic plan or mission statement for the ACT Section included potential interaction with Defence and government on issues relating to the shipbuilding and maritime industry; professional development of current and future resources, considering imminent demand in defence and decline in offshore; and the running of a RINA Warship Conference in Canberra. It was agreed that the ACT Section would contribute, where possible, to the development of the RINA Australian Division Council strategic plan, under the direction of the new President.

Technical Meetings

Two technical meetings were held during first quarter of the year.

On 24 February the Section benefitted from a very interesting presentation by Amin Rashid, Chief Engineer at the Pacific Patrol Boat System Program Office on *The Tongan Landing Craft*. Amin gave both a technical and project-management overview of the Landing Craft Medium (LCM) built in Australia, and donated to the Government of Tonga. He detailed the LCM project from requirements development, tender, tender evaluation and selection, to design, build, trial and handover to Tonga. Amin shared his considerable professional insight from over 30 years' experience, double degrees in Naval Architecture and Ocean Engineering, and a master's degree in Project Management. The Section was grateful for such an interesting presentation.

On 5 April Rob Gehling gave a presentation on *High-speed Craft Codes — Considerations for Naval Operations*. Rob detailed the background development of the IMO Code of Safety for High-speed Craft from 1994, sharing his highly-informed perspective as Chair of the relevant working and correspondence groups from that time. The presentation delved into the philosophy of that Code and its successors, and the engineering basis of the relevant classification society rules, particularly DNV GL's High Speed and Light Craft Rules, and sought to examine current developments in relation to present and future naval ships. Experience with the Armidale-class patrol vessels, from the perspective of Rob's outsider's view to both the building and operation of these vessels, was touched upon, leading to interesting conversation and conjecture.

Jason Steward

Victoria

Visit by Chief Executive

The Chief Executive of RINA, Trevor Blakeley, visited Melbourne on Monday 29 February, following his visit to the Australian Oil and Gas Conference in Western Australia. Albeit a shorter trip than usual, Trevor visited several companies within the Melbourne CBD and surrounds. The meetings were very informative, and he was able to discuss current happenings within the Institution, as well as issues facing current members. Non-members were also present at these meetings, and were able to learn more about the benefits of membership through RINA. Trevor regarded his visit as being very successful.

A big thankyou to representatives of Jacobs, BMT Design & Technology, ThyssenKrupp Marine Systems Australia, DST Group and AMOG Consulting for their attendance.

Future Ship and Offshore Research

Dr Bas Buchner, President, Maritime Research Institute Netherlands (MARIN), gave a presentation on *Future Ship and Offshore Research: Bridging the Gap Between Design and Operations* to a joint meeting with the IMarEST attended by thirty on 4 February in in the Auditorium at Jacobs, 452 Flinders St, Melbourne.

Developing safe, smart and clean ships and offshore structures is the challenge of the maritime industry. Research should be focussed on supporting this challenge. What should be our focus in this research? What interesting physics need to be studied? What will be the tools of the future? What is the role of the human factor in this? Dr Buchner's presentation focussed on these questions and he highlighted MARIN's research results in support of his discussion.

One thing is certain: we need to bridge the gaps between knowledge and application, and between engineering and operations. We should not just develop knowledge for interest's sake. Rather, knowledge should be focussed on making ships and offshore structures cleaner, safer and smarter, and we should apply it to bridge the gap between knowledge and application. Furthermore, in our efforts to make ships and offshore structures cleaner, safer and smarter, we should also try to bridge other gaps in the maritime industry: those between shipbuilders and ship operators, between the office staff and the fleet crew, and between designers and operators. Who isn't familiar with complaints in both directions?

Using MARIN's vast experience in model testing, simulations, full-scale trials and simulator studies, Dr Buchner shared MARIN's vision on this topic.

Dr Buchner studied at the Delft University of Technology and graduated in 1991. He joined MARIN as a Project Manager and was responsible for many model test and simulation projects related to mooring, platform response, offloading analysis and wave-impact loading. He specialised in the topics of extreme waves, green-water loading and wave impacts. He completed his PhD on *Green Water Loading on Ship Type Offshore Structures* in 2002. He was Manager of the MARIN Offshore Department from 2000 to 2010; a Visiting Professor at the University of Newcastle-upon-Tyne, and has authored more than 50 papers in the field of offshore hydrodynamics. Since 2011 he has been President of MARIN.

Hyperbaric Evacuation

Ben Healy, Managing Director, Thrust Maritime, gave a presentation on *Hyperbaric Evacuation with a Focus on Naval Architecture* to a joint meeting with the IMarEST attended by twenty-nine on 21 April in the Auditorium at Jacobs, 452 Flinders St, Melbourne.

Hyperbaric evacuation technology is often used to support saturation (deep-sea) diving activities in the oil and gas sector. Recent developments have vastly increased the evacuation and recovery options available for diving contractors. Thrust Maritime (see www.thrustm.com), a small Melbourne-based company, is leading the world in this field and has developed highly-specialised equipment to achieve this challenging task.

Ben began his presentation by providing an introduction and background to the requirement for hyperbaric evacuation, and went on to discuss a typical project (specifically focussing on naval architectural elements), general project highlights, challenges and lessons learned regarding manufacture and design and, in particular, finite-element analysis (FEA) and welding of extremely high-strength steel (700 MPa yield strength).

The presentation highlighted some interesting facets of the naval architecture, fabrication and operations being completed by Thrust Maritime.

Ben studied engineering at the Australian Maritime College, business at Monash University and, in earlier days, graduated from the Royal Military College, Duntroon, and then operated as an Infantry Officer in the Australian Army. He is now an Engineer/Naval Architect and Managing Director of Thrust Maritime. His background includes significant experience in subsea operations from the practical, project-management and engineering sides. Notably, he has led the development of a fleet of recovery systems for SPHLs and HRCs which are now widely used in Asia and Australia with demand growing globally.

Martin Renilson, President of the Australian Division of RINA, flew in from his home in Tasmania to attend, and he and Ben Healey were guests at the informal dinner hosted by the Victorian Section Committee following the presentation.

Andrew Mickan

New South Wales

Annual General Meeting

The NSW Section held its eighteenth AGM on the evening of 2 March, following the Australian Division AGM and the March technical presentation in the Harricks Auditorium at Engineers Australia, Chatswood, attended by 10 with Alan Taylor in the chair.

Alan, in his fourth Chair's Report, touched on some of the highlights of 2015, which included eight joint technical meetings with the IMarEST (Sydney Branch), with attendances varying between thirteen for Raymond Fagerli's presentation on *Resistance Prediction for Trimarans*, and fifty-four for Peter Little's presentation on *The Dry-dock Challenge: Docking a Cruise Ship in Australia*. Interestingly, the average attendance at meetings for the year of 33 was significantly higher than our long-term average of 26 at the Chatswood venue. SMIX Bash 2015 was successful and was attended by almost 200, including a number of interstate guests.

Adrian Broadbent presented the Treasurer's Report. The EA venue at Chatswood had, as usual, been our major cost for the year. However, with a close watch on the outgoings, we had managed to operate within our budget and have a small amount in the Section account at 11 February 2016. SMIX Bash is funded separately through the Social account which currently has a healthy balance, although there are accounts still to be paid, but projections are for a sufficient surplus to enable preliminary arrangements for SMIX Bash 2016.

There is a number of changes to the NSW Committee for 2016. Graham Taylor has resigned from the Committee after a record service of fourteen years, including five years as Chair, four as Deputy Chair, and most of the fourteen on the SMIX Bash Committee; sterling service indeed! Dov Sobel submitted the only nomination for the vacancy on the Committee and, as a result, has been elected unopposed. The committee for 2016 is therefore as follows:

Chair	Alan Taylor
Deputy Chair	Valerio Corniani
Treasurer	Adrian Broadbent
Secretary	Anne Simpson
Assistant Secretary)	Nate Gale
Chair SMIX Bash Cttee)	
AD Council Nominee)	Sue-Ellen Jahshan
Auditor)	
TM Program Coordinator	Phil Helmore
Members	Craig Boulton
	Dov Sobel
	Rob Tulk

Committee Meetings

The NSW Section Committee met on 11 February and, other than routine matters, discussed:

- SMIX Bash 2015: Some sponsors still to pay, and accounts to be finalised; delivery of hampers to prize winners worked well.
- SMIX Bash 2016: *James Craig* venue booked for Thursday 1 December; Nate Gale to continue as Chair of the SMIX Bash Committee.
- Nominee to AD Council: Adrian Broadbent has competed his two-year term as NSW Section Nominee, and Sue-Ellen Jahshan appointed to take over.
- Webcasts of TM Presentations: Discussed and decided to continue with recording selected presentations.

The NSW Section Committee also met on 22 March and, other than routine matters, discussed:

- SMIX Bash: Some sponsors still to pay, and accounts to be finalised; attendance down marginally last year.
- Venue for Technical Meetings: Meeting held with Engineers Australia to discuss arrangements for technical meetings; current arrangements to continue.
- Webcasts of TM Presentations: EA no longer recording presentations via Mediavisionsz; recording has to be arranged and paid for by us; costs are being investigated.
- Finance: Accounts for 2015 have been audited and passed to the Australian Division; budget for 2016 forwarded to the Australian Division.

The next meeting of the NSW Section Committee is scheduled for Tuesday 17 May.

Submarine Diesel Engine Development

Geoff Goodwin, Specialist Marine Propulsion and Failure Investigation, AADI Defence, gave a presentation on *Diesel Engine Development for Ocean-going Submarines* to a joint meeting with the IMarEST attended by thirty-nine on 3 February in the Harricks Auditorium at Engineers Australia, Chatswood.

Introduction

Geoff began his presentation by saying that he became interested in diesel engines for submarines in his PhD project in the UK. The Oberon-class submarines were in their mid-life refits, and their engines had serious lubrication problems—submarine engines live in a difficult environment.

The presentation gave an introduction to the issues experienced in using turbocharged diesel engines in submarines, especially those destined for blue-water operation, and referred to some submarine-specific historical aspects from Lyle Cummins's 2007 book, *Diesels for the First Stealth Weapon: Submarine Power 1902–45*.

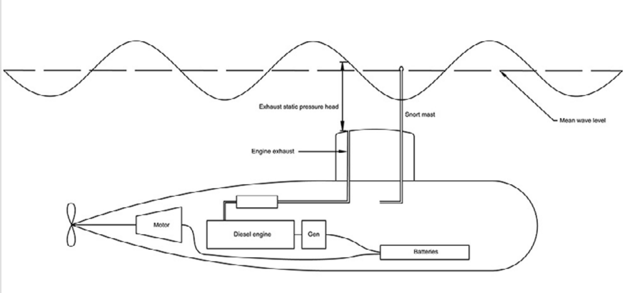
The Collins-class submarines are each powered by three Hedemora turbocharged V18 engines. Kockums had designed and built boats with similar engines before, but these operated largely in the Baltic, which mostly provides somewhat more benign sea states than the Indian and Pacific Oceans in which the Collins-class vessels live. They were V12 engines of smaller bore.

The Collins-class vessels have experienced significant problems when snorting in rough seas. With underwater exhaust at the fin top, exhaust back pressure varies considerably and, if a wave washes over the snort mast and closes the induction valve, then the crew and engine both suffer discomfort. This led to some reliability issues, hopefully now considerably improved by careful management.

Diesel Engines Breathing in a Snorting Environment

Diesel engines, turbocharged or not, need a lot of air. The three engines in the Collins-class vessels each breathe in several cubic metres of air per second. When the snort mast dips below the water, a valve closes and the engines breathe from the engine room, reducing the pressure uncomfortably quickly. If the pressure drops to an extent hazardous to the crew, then the engines stop, disrupting the battery charge. Waves over the subsurface exhausts also cause trouble, varying the exhaust back pressure and, hence, affecting turbocharger speed and boost pressure.

In Sea State 3, the significant wave height is less than 1 m; however, in Sea State 6, the significant wave height is 5 m, varying the exhaust back pressure by 50 kPa (half an atmosphere). In practice, snorting in Sea State 6 is something to avoid, short of desperately flat batteries!



How a submarine engine sees the sea state when snorting
(Drawing Phil Helmore)

Other ideas have been suggested and tried. The K-boats in WWI used steam turbines for performance, which gave the best-available power/weight ratio at the time, and there were big air intakes and two funnels to close off when submerged. However, they were a disaster, and six of the seventeen sank as a result accidents, not enemy action! Crews seem to have regarded a posting to one of them as a suicide mission!

Gas turbines have also been suggested, with very high power/weight ratio, relatively quiet but not efficient at sea level; back pressure makes this much worse, and they need enormous amounts of air, for both combustion and cooling. No practical arrangement has emerged.

So the diesels have it, in terms of heat engines at least.

The snorkel had been around from a Dutch innovation in the early 1930s, and had been found on a couple of Dutch submarines impounded by the Germans early in the war. Likewise, a couple of these boats had also made it to Allied havens, but the significance of the snorkel gear, which was used for ventilation, not necessarily to run main engines, was apparently not realised for several years. The snorkel (what we know as a snort mast), seems not to have come into service for running engines until later in WWII.

Common-rail Fuel Systems — New or Not?

Diesel was clearly preferred for submarines before WWI. The fuel was less volatile than petrol or other available fuels, so the vapour was less dangerous in the event of leaks. Fuel was supplied to all cylinders from a common pump, and each injector was operated by compressed air, known as 'air blast injection'. So early systems were effectively 'common rail', but not using the extremely high pressures used in modern engines. Air at around 70 bar (7 MPa) was used, and fuel was also supplied at high pressure. These systems were energy intensive and quite dangerous in the event of a leak. Rudolf Diesel is understood to have tried to produce a fuel-injection system not assisted by compressed air, without success. Brandstetter had a 1905 UK patent for an airless injector, using a spring-loaded accumulator. L'Orange designed a mechanical injection system for Deutz, with a patent dated 1908. Vickers made the real breakthrough in 1910 with a patent for a hydraulic injection system, the first to be known as 'solid injection'.

E-class Submarines for the RAN

HMA Ships *AE1* and *AE2* were E-class submarines for the Royal Australian Navy (the "A" indicating Australia) and were delivered just before World War I. The E-class boats were submersibles, designed to spend most of their time on the surface. To charge batteries, the boat was surfaced and the hatches opened. This was the usual mode of operation until well into WWII.

The engines were large, taking up most of the hull cross-section in the machinery space, and each drove a generator to charge batteries, but also a shaft to the propellers. This arrangement, as opposed to the diesel-electric mode we expect now, also persisted well into WWII.

The Bosch Injection Pump

In 1922, Robert Bosch entered the fuel injection business. He designed a 'solid injection' pump, with camshaft-driven pressure and timing, which was designed to be supplied with fuel at low pressure. The pump and injector were separate

Vickers engines in submarine E23 around the beginning of WWI
Note lots of exposed moving parts and pipework joints
(Photo courtesy DST Group)

items, one high-pressure pump per cylinder, and volume production began in 1927. It was so successful that it became a standard for more than 50 years. Almost everyone used Bosch's 'solid injection' system under licence, or copied it with variations to evade patents. Vickers, however, persisted with their own designs until they built their last engines in 1943. From this point on, there were few high pressure 'common rail' fuel systems in volume production until the evolution of electronically-controlled systems in the 1990s.

Performance of Turbocharged Diesel Engines in a Snorting Environment

Turbocharged engines have been accepted best practice for all kinds of shipping, for many decades. They are the most economical power source in both power/weight ratio (at least among piston engines) and in fuel consumption. However, they present problems for submarines because they don't respond well to dramatic changes in pressure, especially exhaust back pressure.

Turbocharged engines for submarines appear to have been introduced by Gustav Pielstick, chief designer at MAN, in the Type IX U-boat for the Kriegsmarine (the Navy of Nazi Germany). Those boats did not snorkel, but even on the surface they experienced a phenomenon known as "the following sea problem". When waves rolled over the casing, the exhaust was submerged, the back pressure went up, the turbines slowed down, the pressure in the hull fluctuated wildly, and sooty exhaust leaked into the boat, causing discomfort at best for the crew. This was a problem for all the boats, but much worse when they tried turbochargers. The exercise was repeated in the Type XXI U-boats with limited success, once again beaten by varying pressures.

The MAN M9V 40/46 of 1939

This diesel engine was a 9-cylinder version of the MAN 40/46, having a bore of 40 cm and stroke of 46 cm, giving 58 L per cylinder (522 L total — i.e. a big engine) and an output of 1640 kW at 520 rpm. At the time, Pielstick was also working on a higher-powered version, with a gear-driven supercharger prior to the turbocharger, which was supposed to be good for over 2.2 MW. This may not sound all that impressive today for an engine of over 500 L, but it was at fairly low speed. Interestingly, the OKM (Oberkomando der Marine–German Navy High Command) couldn't see any need for that much power and the "supercharged and turbocharged" project was cancelled. For the turbocharged engine, the valve timing was changed to reduce the valve overlap, so that any water in the exhaust could be blown out during starting and help to cope with the fluctuating back pressure. Boost pressure was not very high because of the back pressure — the turbocharger would have needed plenty of margin to cope with the variable pressures. However, the reduced valve overlap caused the scavenging to be poor and exhaust temperatures unusually high for a moderately-powered engine. The turbocharger was fairly quickly replaced by a gear-driven mechanical supercharger.

The MAN M9V 40/46 of 1941

The MAN M9V 40/46 of 1941 had the gear-driven mechanical supercharger fitted to resolve the "following sea" problem. This produced a successful submarine engine that coped with the conditions, but a price must have been paid in fuel consumption and therefore range. However, at this stage of the war the submarine could safely sit on the surface to charge batteries and could transit on the surface, only having to submerge if something appeared over the horizon.

A U-boat was small enough that it could escape detection unless an aircraft happened upon it and, even then, given the speed of the aircraft around, if they were keeping a sharp lookout, the boat would have had time to dive with minimal risk. The German Navy kept the submarines at sea for longer periods using the 'milch-kuh' (milk cow) submarine tankers, much as we extend the range of fighter aircraft today.

All these vessels seem to have lived on the surface, only submerging to hide from reconnaissance aircraft or to prepare for a stealth attack.

Royal Navy Supercharger Philosophy

The Royal Navy also adopted the supercharger solution for all of its submarines, both for diesel-electric submarine power and later for emergency gen-sets in nuclear boats, right up to and including the Upholder class, built in the 1980s.

As a result, for the Upholder class, they took the turbocharged Paxman Valenta minehunter engine, which also powers other vessels and was one of the commoner railway locomotive engines (the HST/XPT had these, though they have now been re-engined with MTU engines), but specified supercharging instead of turbocharging. They now have a unique engine in their submarines (there are about ten in the world!), something that seems to happen to many of us in the submarine community…

Closed-cycle Diesel Engines

The first closed-cycle diesel (CCD) seems to have been proposed at Stuttgart University in 1940, and the idea was sufficiently developed for a complete system to be installed in U798 in 1941. This was an exquisite Daimler-Benz V20 engine of 1.1 MW. It used high-pressure oxygen tanks for oxygen storage, and oxygen was added to the exhaust gas and recirculated. The excess exhaust was cooled and pumped overboard. However, the project was cancelled by the OKM because of "competing priorities"!

Several attempts to develop CCD have been made over the years, including one involving BAE Systems (descendant of Vickers), and at least one of these systems used argon as a 'padding gas' to improve thermal efficiency. However, overall there are systems with more advantages. Kockums of Sweden used Stirling engines successfully, and Japan bought the Kockums system, but fuel cells seem to be the front-runners for air-independent propulsion (AIP) now.

MAN M6V 40/46 with KBB Turbocharger

The turbocharged submarine diesel engine was also tried in the Type XXI U-boat. By 1942, Dönitz was becoming concerned about the loss of tactical advantage because of the low submerged speed and, of course, as radar emerged as a threat, their losses mounted alarmingly, and an engine that could snorkel to charge batteries whilst submerged became important.

Pielstick's combined supercharger/turbocharger solution was back on the agenda and, by 1943, the M6V engine fitted with both gear-driven supercharger and KBB turbocharger (built by Kompressorenbau Bannewitz GmbH) and an aftercooler, appeared for the Type XXI U-boat. This engine claimed a power output of 1.5 MW at 520 rpm (cf 1640 kW for the M9V turbocharged version), and the impressive fuel consumption of 214 g/kWh.

The MAN engines in the U-boats were originally directly coupled to the shafts. Reversing was accomplished by stopping engines, shifting the camshaft to switch the valve timing, then restarting the engine backwards.

The Type XXI was an electro-boat, with a big motor on the same shaft, which doubled as submerged propulsion and as generator for battery charging when driving with the diesels. This could also reverse the boat, so the second camshaft position wasn't needed for reversing. Pielstick kept the camshaft shift gear, and arranged for two different timings, with 150° overlap for surface running and 44° for snorkelling, when the speed was limited by the masts and less power was needed. I suspect the impressive fuel consumption was only achieved with the 150° timing.

Turbocharging

Looking back at the MAN M9V 40/46 in comparison, it was a big engine (522 L) and at 520 rpm and low boost pressure, air consumption would have been about 3–4 m^3/s for each engine. The boat was of 1819 t submerged displacement, so about half the size of the Collins class, and the engines were consuming about the same amount of air, so the internal air pressure would fall about twice as fast if the snort mast closed. The snorkel needed a valve like a modern snort mast to avoid flooding the boat if a large wave came over it, so the pressure would drop very rapidly if this happened.

Turbocharged diesel engines seem to have disappeared from diesel-electric submarines in the western world and not reappeared until the 1980s. What do we learn from this? There's nothing new under the sun (or sea)…

Technology that didn't work before, might work later because we know a bit more about how things work. This applies to both common-rail fuel injection and, at least for the submarine community, turbocharging.

In comparison to the MAN M9V 40/46, modern submarine engines tend to be relatively high-speed engines (1300–1800 rpm):

- Hedemora VB is 210×210 mm (7.27 L per cylinder)
- Pielstick PA4 is 200×210 mm (6.6 L per cylinder)
- MTU 396 is 165×185 mm (4.0 L percylinder)

The Collins-class Submarine Engines

Why do we have the engines we do in the Collins-class submarines? Basically, they were specified in the early 1980s and the contract was signed in 1987, with off-the-shelf or low-risk items specifically required.

Pielstick had, by 1983, decided on a combined turbocharged and mechanically supercharged system, but it had not yet been tested. It promised significantly poorer fuel consumption than a turbocharged engine but better than a pure supercharged engine, and claimed more stable running when snorting in a seaway.

MTU had demonstrated the 12V396SB configured for snorting, but was said to be good for <1 MWe for a then-untested 16V396SB version.

Hedemora had demonstrated the V12B configured for snorting, and promised that the V18B would work as well, giving 1.4 MWe. However, they had never actually built a turbocharged V18B14SUB, but had built lots of V18B engines for industrial power and marine generator sets, and had tested a V12B against submarine-type conditions. They had built a number of V12A (smaller bore) submarine engines for the Royal Swedish Navy, the latest examples being turbocharged. Therefore the V18B14SUB was accepted as an off-the-shelf design, which it really wasn't. But then, nothing else seems to have met the specification either.

Now we have all 19 of the Hedemora V18B14SUB engines in the world! The V indicates the vee configuration, the 18 is the number of cylinders, the B is the larger bore (210×210 mm), the 14 is the speed (1400 rpm), and the SUB category is the monolithic engine (not bedplate mounted) for submarines.

Hedemora V18B engine at the Submarine Training and Systems Centre, WA
(Photo courtesy DST Group)

A supercharged engine of the time might achieve 275–295 g/kWh, combined super- and turbo-charging claims 265 g/kWh, and turbocharged engines achieve about 230–240 g/kWh when snorting. It was felt that a turbocharged engine was needed because it promised significantly better fuel economy than the alternatives. In 1987 a long range was specified, and Kockums was naturally more concerned about achieving the range than about fuel costs and pollution, but we can see that, on paper at least, the turbocharged engine is the best option on all counts if it can be made to work reliably. The technology was really 1970s, with individual jerk pumps for fuel injection and a hydraulic governor.

Defence has a research engine, the HAD V6B, built from various parts by Hedemora Australia. The camshafts and the turbocharger are almost the only new parts to special order. This engine was chosen by DST Group, as they expect to be living with it in Collins class boats for another 20 years, and hoped to learn some things that can be directly applied to the Collins class, as well as improving their understanding to place them better to judge the offerings for the next class.

Diesel Engine Technologies for Undersea Platforms

Marine platform (including undersea) lifecycles are of the order of 20–30 years, while those in the automotive and transport industries are of the order of 5–10 years. Given the evolution of technology in recent years, especially in the car industry, why does it take so long to get the new methods into marine platforms? Mainly because there are vastly different market volumes and drivers.

Drivers for technology in the automotive and transport sectors include competition, production-cost reduction pressures, development time, product refinement, fuel economy, and the requirement for emissions control. Some of these are beginning to matter in Defence, but are not key drivers.

Additional undersea environmental factors include salt water being present in both fuel and air, dynamic exhaust pressures due to wave action, and dynamic inlet pressures. These things are the keys, specifically for submarines, but are not important or even recognised as issues in other markets.

Modern Common-rail Fuel Systems

So let's look at what we could get with a modern electronic fuel-injection system.

Modern common-rail systems use extreme pressures, in excess of 2000 bar (200 MPa) and carry significant volumes of compressed fuel in the rails. Double sheathing of all high pressure fuel lines is therefore required. It is essential that high-pressure fuel cannot leak into the atmosphere.

With electronic fuel-injection control, there is an engine-control unit (ECU) like on your modern car engine. It is well suited to deal with transients, controls both the start and end of injection, allows multiple injections, controls fuel consumption and emissions, gives quicker and more accurate response to changes in demand, gives better response for variable ambient conditions and can be optimised for lower noise.

Safety Issues

With fuel supply at around 2000 bar (200 Pa), containment is critical. All components, including pumps, need to be safely contained. MTU have developed (or are developing) a submarine variant of their 4000 series engine (it is mentioned on their website). However, many in the submarine community remain nervous of such high pressure systems.

Performance Issues

Such an engine would require significant work on the control system and turbocharging arrangements. The control system would need load control, not just the conventional speed control. MTU is well capable of this, but one would need to be reassured that they were applying it to cope with open-ocean sea states. Likewise for the Pielstick engines, which may be favoured by a French supplier, although Pielstick is now back in the MAN stable after many years in French hands.

Nuclear Power?

A lobby is in favour of changing to this option. However, there seems to be no immediate prospect of doing so. There is a lack of Australian expertise for support, and a lack of political will to go nuclear — on land or sea!

It is clearly not an option for SEA1000, as tenderers have already been selected. However, the performance comparison is not as black-and-white as the claimants make out. The crew go stir-crazy if they are confined underwater for too long. A nuclear-powered vessel can steam around the world without refuelling, but having to feed and water the crew is then the dominant problem. Nuclear boats are steam-turbine driven and, because all the machinery cannot be shut down, may not be as quiet as a conventional electric boat which can shut down nearly all machinery when necessary. The Collins-class vessels have, at times, sneaked undetected through US defences and been able to pick off US vessels in RimPac exercises.

Battery Storage

Lead-acid still seems quite likely to be a viable contender in the immediate future. Nickel-metal hydride (NiMH) has probably been overtaken. Lithium-ion or lithium-polymer versions also look promising.

However, different battery types cannot be a direct replacement in existing vessels due to differing mass and dimensions, and testing in a Collins class vessel would present real problems.

Other technologies are emerging, and we need to be open to change this time.

Air-independent Propulsion

All tenderers for SEA1000 are known to have some technology in this area. We will likely want something, and a fuel-cell fit shows much promise. All non-nuclear air-independent propulsion possibilities require both fuel and oxygen supplies, which provide another sort of hazard. The timing of the new class and the options available suggest some flexibility for future development.

Conclusion

We looked at the emergence of the diesel engine as the universally-preferred means of propulsion and power generation in submarines from the beginning of the 20th century until the emergence of nuclear power. The use of pressure charging, the pros and cons of turbochargers and the issues that arise were considered and the emergence of electronic control and the use of common-rail fuel systems. These also have issues for submarine applications, and we have looked at where the technology might go from here, including weighing the pros and cons of nuclear power and non-nuclear air-independent propulsion and power-generation systems.

Questions

Question time elicited some further interesting points.

Ceramic liners have never been really looked at for the Hedemora diesels for the Collins class. Hedemora were, generally, open to discussion, and did change a number of aspects of the design. However, this is not typical of most diesel engine manufacturers.

There have been issues with fuel and water mixing in the Collins-class vessels. However, this is so in many navy vessels, both submarines and surface ships. Fuel tanks need to breathe and, in rough seas, they breathe in salt-laden air and sometimes salt water. Also, submarines displace fuel with salt water, and rough seas lead to mixing. All ships require water separators for their fuel systems.

The vote of thanks was proposed, and the certificate and "thank you" bottle of wine presented, by Greg Hellessey.

The 21st Century Aircraft Carrier

John Jeremy, of the Royal Institution of Naval Architects, gave a presentation on *The 21st Century Aircraft Carrier* to a joint meeting with the IMarEST attended by forty-five on 2 March in the Harricks Auditorium at Engineers Australia, Chatswood.

During World War II the aircraft carrier took over from the battleship as the capital ship of the world's navies. The rapid development of naval aircraft after the war soon rendered many of the ships constructed during the war obsolete, and prompted the development of the very large conventionally- and nuclear-powered aircraft carriers which have proved to be very effective as power-projection and strike assets in recent decades.

However, the cost of these complex ships and their aircraft is now so great that attention is again being directed towards less-expensive options. This presentation reviewed the design development of these large ships and the challenges facing ship designers when developing carriers which are intended to be the backbone of the major powers' fleets well into the second half of the 21st Century.

John's presentation is written up elsewhere in this issue of *The ANA*.

The vote of thanks was proposed, and the certificate and "thank you" bottle of wine presented, by the President of the Australian Division, Tony Armstrong.

Emissions Reduction Technology

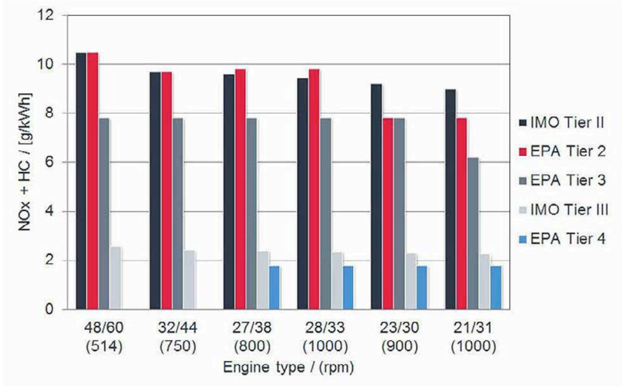
Eric Clarke of MAN Diesel & Turbo Australia, gave a presentation on *MAN Diesel & Turbo's Approach to Emissions Reduction Technology* to a joint meeting with the IMarEST attended by 29 on 6 April in the Harricks Auditorium at Engineers Australia, Chatswood.

Introduction

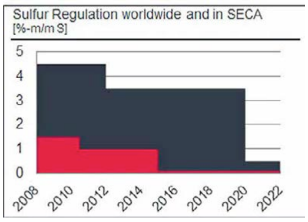
Eric began his presentation by saying that there are different approaches to emissions reduction for two-stroke and four-stroke engines, and that this is a brief overview of a huge subject.

To put marine emissions into perspective, globally there was a total of about 100 000 ships of more than 100 GT in 2007. These ships carried 95% of inter-continental transport, and 71% of total global trade. However, they produced only 14% of the human-made NOx and only 3% of human-made CO_2 emissions. On a g/t-km basis, this about one-fifth of the NOx and one-tenth of the CO_2 emissions of cargo aircraft, for example.

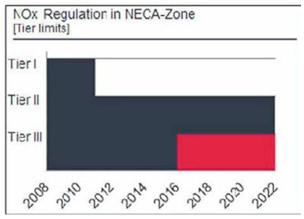
The IMO and various Environmental Protection Agencies now have regulations in place to limit the emissions from ships, with the regulations tightening about every five years. Marine engines are all now Tier II compliant, and engine manufacturers have been working hard on Tier III. At the first hint of regulations, engine manufacturers have to start work immediately, because it takes approximately five years (minimum) to design/re-design and produce a new engine.



IMO and EPA limits
(Image courtesy MAN)



SOx IMO and EPA limits
(Image courtesy MAN)



NOx IMO and EPA limits
(Image courtesy MAN)

Emissions

Among the impacts of the main emissions on the environment and human health can be listed the following:

Carbon dioxide (CO_2)	Global warming effect.
Sulphur oxides (SOx)	Acidification of water and land, acid rain, inflammation of airways, sulphurous particles, sulphuric acid.
Nitrogen oxides (NOx)	Photosmog, ozone, acid rain, irritation of respiratory tract, nitric acid aerosols, nitric acid

These all present challenges, but there are solutions, including:

Carbon dioxide (CO_2) Common-rail technology, more-efficient power train, and gas as marine fuel.

Sulphur oxides (SOx) Low-sulphur fuel (MGO), de-sulphurisation (wet scrubber), and gas as marine fuel.

Nitrogen oxides (NOx) Catalysts (SCR), exhaust gas recirculation (EGR), and gas as marine fuel.

De-SOx Technologies

The control systems (engine and exhaust) are all integrated, and talk to each other. There are only one or two things that can be done for SOx. The next challenge will be running on low-sulphur fuel before entering harbour and, subsequently, when leaving harbour too. Low sulphur in the fuel means that there is less heat in the fuel, and they may have to start heating diesel fuel, which would be a real shock! Wet scrubbers are not used widely because they are costly, and because everything has to be removed and stored on the vessel for discharge ashore, as the products cannot go overboard.

Emission Control Areas

There are already emission-control areas in Europe (covering the North Sea and the Baltic) for SOx, and in North America (covering the east and west coasts of Canada and the USA) for both SOx and NOx. There is a lot of traffic in the European areas.

New owners look at the costs of the various technologies, and where they are going to operate the vessel. Some owners were caught because the keels of some vessels were to be laid before 31 December 2015, but were delayed, and now they need to fit emission-control gear.

One solution is to go to gas fuel immediately, and solve all problems, which is what some large two-stroke engines do. All marine MAN engines built now are Tier III compliant.

De-NOx Technologies

Selective catalytic reduction (SCR), LNG fuel, and exhaust gas recirculation (EGR) can all meet Tier III requirements. Fuel-water emulsion (FWE), humid air motors (HAM), and internal engine modifications (IEM) cannot meet the Tier III requirements (by varying margins) on their own.

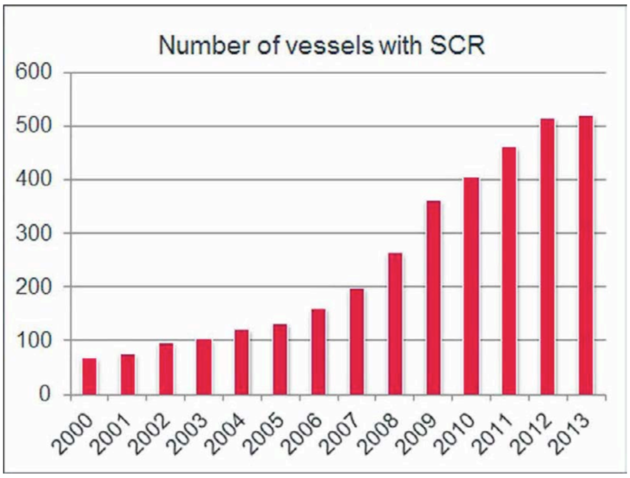
Four-stroke Engines

SCR has been chosen as the primary Tier III solution for medium-speed engines. EGR is under development, and requires new engine technology. In fact, EGR does not yet work well on four-stroke engines, as there is insufficient gas flow. The exhaust gas is cleaned and put back into the engine, but it is hard to get rid of the sulphur which must be stored on the vessel.

MAN engines are Tier II compliant by themselves, and are very different to the diesel engines of 20 years ago. MAN engines with an SCR unit in the exhaust line are Tier III compliant.

SCR Technology

SCR units use urea as the reduction agent. There is a number of advantages, including the fact that it is a proven and commercially-available technique (as has been verified extensively in the automotive industry), and has high NOx-reduction potential (up to 90%). Challenges for its use include the need for consumables (the urea-solution), and control of the exhaust gas temperature. Urea is produced worldwide, with a global production capability of approximately 70 Mt/a. It is widely available in Europe, the Mediterranean, the Middle East and Asia, and at limited ports in North and South America, non-Mediterranean Africa, and at Sydney and Brisbane in Australia. Storage of urea on board the vessel must be in stainless steel tanks. Because of its efficiency, there is a rising market for SCR. It is expected that emissions will come more and more into the public interest and that further Nitrogen-ECAs will be adopted in the future due to public attention. SCR is therefore expected to become a standard for shipping.



Numbers of vessels with SCR
(Image courtesy MAN)

An interesting feature is that IMO is requiring one responsible party for compliance of the engine-plus-SCR-system, and the responsible party will be known as "The Applicant". MAN is licensed to install engines in ships, but must also prove that the whole system is compliant and will continue to be so. A third party comes in and tests the system to prove compliance, and so MAN becomes The Applicant.

MAN's SCR Approach

In Augsburg, Germany, MAN has a gas test bed. In order to test SCR systems, they built a full-scale SCR unit for use on an 18-cylinder, 48/60 engine producing 20 MW. This system has been on test since 2012 and now has 10 000 h of operation on SCR. The same engine and gensets were installed on the vessel *Petunia Seaways* in 2012, and the vessel is now Tier III compliant.

As engines get larger for more power, the SCR kits become larger and more numerous. MAN has kits for engines from 430 kW up to 22 MW.

The scope of supply for an SCR kit includes the reactor, catalyst elements, soot blower, sensors, air reservoir vessel, mixing devices, dosing unit, urea lance, urea pump, and safety control system.

Reduced operation temperature helps in saving fuel. A conventional SCR operates at 355°C at the turbocharger, because a high temperature is needed to clean the catalytic converter. However, MAN engines operate at 320°C at the turbocharger, with regular but infrequent bursts to 370°C for cleaning. The necessity for regeneration mode is detected by sensors, and the regeneration time varies depending on fuel quality.

MAN's Design Support for Customers

MAN provides support for customers, from rough planning to detailed design. There is a Clean Funnel Configurator available online, which gives an over-all view or step-by-step view, provides CAD-files for pre-planning and an auto-generated PDF-file of the summary. The next stage involves MAN's SCR design tools for urea consumption, the pump module and the mixing device. Finally, there is the Project Guide (available online) for installation guidelines, system specification, and dimensions.

MAN provides all tools for efficient planning and gives full support in all project stages. MAN also ensures an efficient process for Tier III certification.

MAN has secured the world's first IMO Tier III certification according to Scheme B approved by classification societies DNV GL and CCS, and certification to the other major classification societies is in progress.

Strengths of the Integrated Solution

Engine and SCR are set as a core competence at MAN. Intelligent exhaust gas temperature control optimises system efficiency. Up to 2.5 g/kWh of fuel oil consumption savings during SCR operation (compared to third party SCR supplier). Closed-loop control minimises urea consumption. All HFOs with up to 3.5% sulphur content can be accommodated. Modular kits of SCR components achieve minimum variety and cost. IMO Tier III certification responsibility rests with MAN.

Two-stroke Engines

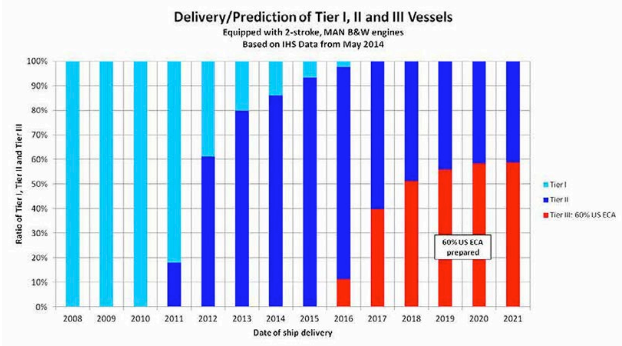
For two-stroke engines, the same principles apply, but everything gets bigger! The problem is what do we do, and how do we control it?

The volume is a problem; i.e. to fit parts onto the engine. It is hard to fit the EGR and SCR too, because their volumes get bigger. Two-stroke engines need a longer stroke then four-stroke engines to burn the fuel efficiently—four stroke engines are approximately square (with bore approximately equal to the stroke), but two-stroke engines are not.

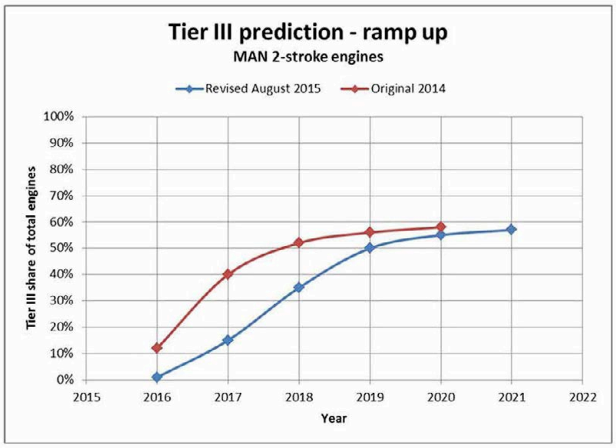
We have seen where there are existing emission control areas (ECAs) and other countries are considering, e.g. Mexico, the west coast of Norway, the Mediterranean, Singapore and Japan. What we don't know is when they will happen. Australia is really dragging the chain in in this area, as ECAs are not even being considered!

Historical data shows that 47% of ships entering the North American ECAs are MAN-powered. However, MAN power 83% of the large vessels due to licensing arrangements.

Here Eric showed a chart of forecast MAN low-speed engine deliveries for vessels of 2000 dwt or more, and a graph of the forecast Tier III engine take up.

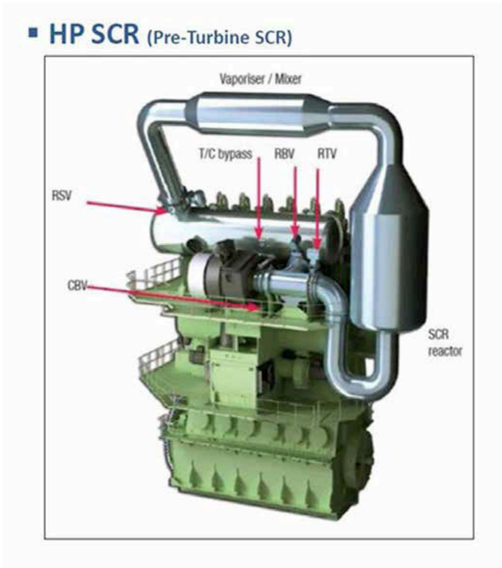


Forecast MAN low-speed engine deliveries
(Chart courtesy MAN)



Forecast MAN Tier III engine take-up
(Graph courtesy MAN)

MAN has a strategy for each fuel. ME-C engines are mechanical/electronically controlled, and use MDO or HFO as fuel. ME-C-GI are high-pressure gas injection engines and use methane, ethane, etc., as fuel. ME-C-LGI are high-pressure LF fuel injection engines and use propane, methanol, etc., as fuel. All types are diesel engines with same platform and emissions can be controlled with respect to performance, efficiency, emissions, turbocharging and timing.

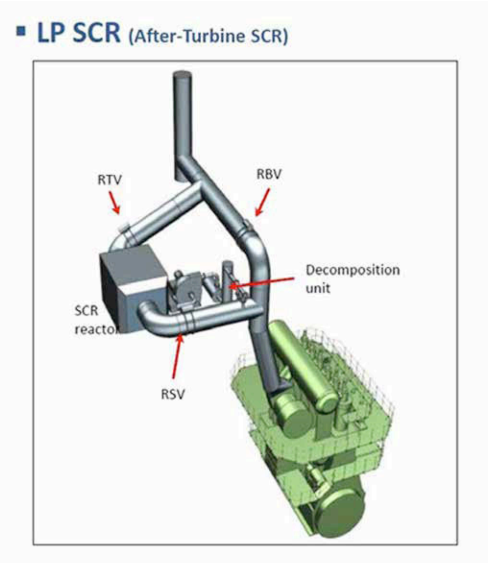


High-pressure selective catalytic reduction layout
(Image courtesy MAN)

Standard Emissions Technologies

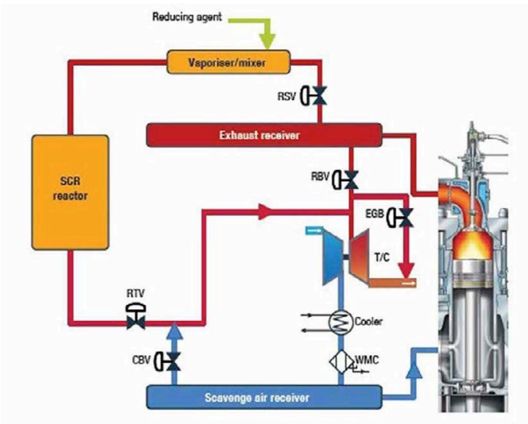
The two standard technologies to achieve Tier III requirements are selective catalytic reduction (SCR) and exhaust gas recirculation (EGR). EGR requires a new big-volume bit of kit on the side of the engine, where SCR is more condensed.

SCR can be either high pressure or low pressure, and each has a different layout.

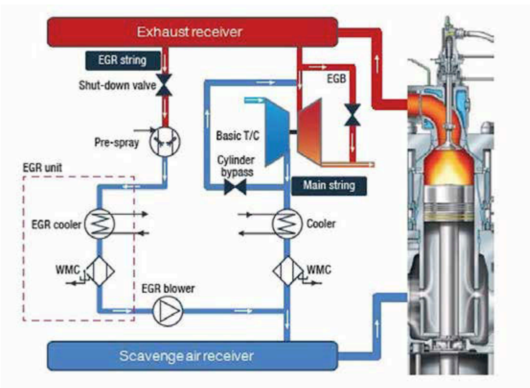


Low-pressure selective catalytic reduction layout
(Image courtesy MAN)

Here Eric showed slides illustrating the technology principles of SCR and EGR.

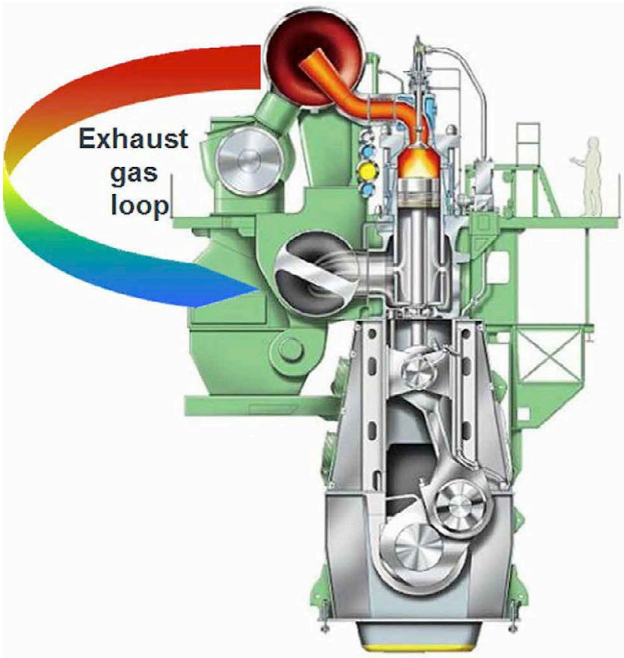


High-pressure selective catalytic reduction technology principle
(Image courtesy MAN)



Exhaust gas recirculation technology principle
(Image courtesy MAN)

In EGR, the oxygen in the scavenge air is replaced with carbon dioxide, which has a higher heat capacity than oxygen, thus reducing the peak temperatures. Reduced oxygen content in the scavenge air also reduces the combustion speed, thus further reducing the peak temperatures. Decreased peak temperatures reduce the formation of NOx.



The exhaust gas recirculation loop
(Image courtesy MAN)

EGR configurations depend on cylinder bore. For bores of 35–70 cm, EGR uses by-pass matching, while for bores of 80–95 cm, EGR uses cut-out matching.

Pros and Cons of EGR and SCR

For fuel flexibility or low first cost/CAPEX, there is little to choose between EGR and SCR for two-stroke engines. If there is no sludge protection, you want the same technology for main engines and gensets, or you have to comply with no excess condensate being discharged overboard, then SCR is preferable. However, if you want a compact engine, want low operating cost or operate many hours in ECAs, or you are faced with possible new Tier III modes (for HFO design), then EGR is preferable.

More Information

If you would like more information, visit the MAN Diesel & Turbo website at www.mandieselturbo.com and click to find Marine Engines and Systems/Two Stroke/Project Guides/Other Guides/Emission Project Guide.

This guide also includes information on SOx scrubbers, combined EGR and SOx scrubber, SFOC penalties, all consumptions, installation issues, and compliance.

Installations in Service

MAN Diesel & Turbo has installations in service on board

- Maersk vessel *Maersk Cardiff*. This installation is Tier III compliant, runs on HFO and is an integrated design; running with EGR primarily when there is an MDT crew on board. This is their primary EGR service experience platform, and now has 2000 h running. The EGR blowers have experienced no significant problems, but there are corrosion challenges and different materials are being tested.

- Chevron vessels *Polaris Voyager* and *Pegasus Voyager*. These installations are Tier III compliant, were set up for HFO but run on MDO, and are integrated designs. MAN Diesel & Turbo is using *Polaris Voyager* as an EGR test platform for low-sulphur fuel, and *Pegasus Voyager* intends to run EGR.
- Nisho Odyssey vessel *Santa Vista*. This installation is Tier III NOx compliant, has an engine-control system, uses a low-load method, and has an SCR control system and NOx sensors. Fields for improvement include valves, ammonia slip, maintenance of exhaust-gas boilers, integration of the SCR control system, and materials.

Conclusion

At present, we have achieved Tier III compliance for four-stroke marine diesel engines, and are working on two-stroke engines, principally on 240 000 t bulk carriers. There are issues with arrangements, because of the additional equipment required to be fitted into the engine room to achieve compliance. However, all engine manufacturers are doing the same things, and much of the technology comes from the automotive industry in cars and trucks; the equipment is just much bigger!

Questions

Question time was lengthy and elicited some further interesting points.

Efficiency in a two-stroke engine is improved with longer stroke. However, if there is a long throw on the crank, then the engine tends to move sideways. To counter this, the sideways thrust is taken by thrust pads in the crosshead.

The smallest marine engines are four-stroke, and the largest are two-stroke. Engine manufacturers need to be five years ahead of the game to get engines into production by the time requirements come into force.

With the engine builder in the role of The Applicant, thereby assuming responsibility for the EGR and SCR systems, what has this taken away from the Chief Engineer on board? It is the engine builder's responsibility to say that the equipment *can* do the job, and to tell the Chief Engineer that the system is compliant if xxx happens.

There are complex control systems, and they are all automated, but the Chief Engineer needs to monitor and maintain them.

The Chief Engineer on one vessel with MAN crosshead engines had a history of failures of crosshead pins. The crosshead has highly-loaded bearings, and the pins are highly polished. The biggest issue is not the pins (these have increased in size over time to overcome the higher loading), but the lubricating oil technology. They are now working with clearances and water content in the lube oil, which must be cleaned correctly, or you get a crazy-paving effect on the pins. The problem is not mechanical, but in the lubrication technology and how they work together.

New technology currently goes back to the bearing manufacturers and how to achieve bonding of bearing material to the backing in bearings subjected to high loadings. The lube oil manufacturers need to keep up with the bearing manufacturers and vice versa, so currently they have to use a larger wedge in the bearing to overcome the current lubrication issues. There is a need to avoid micro-seizures and crazy paving, so the usual solution is to constantly check/polish and to have temperature sensors on the crosshead pins.

The vote of thanks was proposed, and the certificate and "thank you" bottle of wine presented, by Bill Bixley.

Composite–Metal Bonded Joints in Ships

Bing Zheng Ho, a final-year naval architecture student at UNSW Australia, gave a presentation on *Design and Analysis of Composite–Metal Bonded Joints in Ships* to a joint meeting with the IMarEST attended by 26 on 4 May in the Harricks Auditorium at Engineers Australia, Chatswood.

Introduction

Bing Zheng began his presentation by asking What? Why? and How? i.e, What are we trying to achieve? Why are we doing this? and How are we going to do it? He then proceeded to give some insights.

What?

What we are trying to achieve is a method for analysing composite–metal bonded joints in ships. Bing Zheng's final-year thesis project has involved testing the strength of several different types of composite–metal bonded joints to failure. This determines the maximum load which can be borne by a particular type of joint.

The eventual aim (not achievable in this thesis alone) is to simplify the results into a decision matrix which can then be easily used by naval architects and shipyards to decide on the best type of joint for a particular application in a particular location.

Why?

Composites have a number of advantages. A quick search of the internet will throw up 101 advantages, including the following:

- Light weight: Composites are light in weight, compared to most woods and metals. Their lightness is important in ships, for example, where less weight means better fuel economy or more cargo, and less top-weight means better stability characteristics.
- High strength: Composites can be designed to be far stronger than aluminium or steel. Metals are equally strong in all directions. But composites can be engineered and designed to be strong in a specific direction.
- Strength/weight ratio: Composite materials can be designed to be both strong and light, and have a higher strength/weight ration than either of the other two common shipbuilding materials, steel and aluminium.
- Corrosion resistance: Composites resist damage from the weather and from electrolytic action which can eat away at steel and aluminium.
- High impact strength: Composites can be made to absorb impacts—the sudden force of a bullet, for instance, or the blast from an explosion.
- Design flexibility: Composites can be moulded into complicated shapes more easily than most other materials. This gives designers the freedom to create almost any shape or form.
- Dimensional stability: Composites retain their shape and size when they are hot or cool, wet or dry.

- Non-conductive: Composites are nonconductive, meaning that they do not conduct electricity.
- Non-magnetic: Composites contain no metals; therefore, they are not magnetic.
- Radar transparent: Radar signals pass right through composites, a property which makes composites ideal materials for military use.
- Low thermal conductivity: Composites are good insulators—they do not easily conduct heat or cold.
- Durable: Structures made of composites have a long life and need little maintenance. We do not know how long composites last, because we have not come to the end of the life of many original composites. Many composites have been in service for half a century.

However, it is not all beer and skittles! Composites are combustible, and require alternative arrangements for structural fire protection. Here Bing Zheng showed a slide of a fire on board a vessel, with all of the superstructure alight. Small vessels may be built entirely of composites — just check all the recreational motor boats and yachts! However, larger vessels are restricted by the rules of classification societies or of the International Maritime Organisation (IMO).

For a long time, the prescriptive rules for safety at sea in IMO's SOLAS Chapter II-2 excluded construction material other than "steel or equivalent material", which meant that aluminium or composite materials could not be used in superstructures, structural bulkheads, decks and deckhouses. However, since 2002, a new Regulation 17 in Chapter II-2 allows construction of material other than steel, provided that the material can give the same safety level as the ship would have had if it had been constructed according to the prescriptive rules for steel ships. This led to more vessels being constructed with composite superstructure and steel hull, thus reaping the benefits of the composite materials while staying within the regulations.

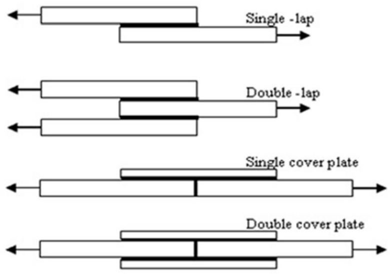
An example given was USS *Zumwalt* (DDG-1000), a guided-missile destroyer of the United States Navy. She is the lead ship of the Zumwalt class and the first ship to be named for Admiral Elmo Zumwalt. *Zumwalt* has a steel hull and composite superstructure (balsa-cored carbon fibre using vacuum-assisted resin-transfer moulding), with a bonded joint. She has stealth capabilities due to her tumble-home topsides and composite superstructure, and has the radar cross-section of a fishing boat despite her large size — length 182.9 m, beam 24.6 m, draft 8.4 m and displacement 14779 t.

To proceed further, bonded joints were chosen due to their numerous advantages. They prevent corrosion — bolted joints in steel are subject to rusting and electrolysis, for example. They can be designed to reduce stress concentrations and, hence, to reduce weight.

How?

This project is the inauguration of an ongoing program at UNSW Australia to develop the analysis matrix. Here we manufactured and tested four different types of bonded joints with two different types of adhesive, epoxy and vinylester.

USS *Zumwalt* sailing for acceptance trials on 20 April 2016
(US Navy photograph)

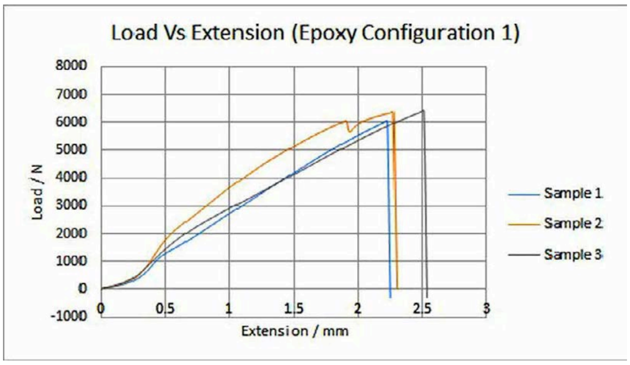


Types of joints tested
(Drawing courtesy Bing Zheng Ho)

The joints were laid up and vacuum resin infused on the layup table in the laboratory at UNSW Australia.

Layup on table ready for infusion
(Photo courtesy Bing Zheng Ho)

The joints were then tested to failure in the 50 kN Instron testing machine, using three tests for each type of joint. A typical set of results is shown in the graph for Configuration 1 using epoxy as the adhesive.



Results for three tests on Configuration 1 using epoxy adhesive
(Graph courtesy Bing Zheng Ho)

The set of results is as follows:

Adhesive	Maximum Load (kN)			
	Configuration 1	Configuration 2	Configuration 3	Configuration 4
Epoxy	6.39	5.99	4.42	7.35
Vinylester	1.22	2.10	6.36	5.51

The results for epoxy Configurations 2 and 3 seem somewhat anomalous, and may need to be checked further. However, the results in general show that symmetrical joints perform better than unsymmetrical joints.

The project can easily be extended by investigating the effects of different types of surface preparation on the metal, different metals, the length of the overlap, the bondline, and various composite materials.

Conclusion

This project has made a survey of the need for, and advantages of, using composites in conjunction with metals in ships, and has made a start on analysing the strength of composite–metal bonded joints, and has come up with useful results.

Questions

Some further interesting points were elicited during question time.

The long-term durability of adhesives is not well-known. An example was given of composite sewer pipes which were fastened together with Araldite, but which had to be pulled up years later when the Araldite failed! Unfortunately, the condition of bonded joints cannot be checked as can, for example, a bolted joint in steel or aluminium.

The configuration of the bonded joint in USS *Zumwalt* is not known, but it is expected that it would be a symmetrical joint with the composite superstructure bedding down in a U-shaped channel in the steel.

USS *Zumwalt* is not the only vessel with a steel hull and composite superstructure, as a search of the internet will show.

The vote of thanks was proposed, and the certificate and "thank you" bottle of wine presented, by Bing Zheng's thesis supervisor, David Lyons.

Phil Helmore

COMING EVENTS

NSW Technical Meetings

Technical meetings are generally combined with the Sydney Branch of the IMarEST and held on the first Wednesday of each month at Engineers Australia, 8 Thomas St, Chatswood, starting at 6:00 pm for 6:30 pm and finishing by 8:00 pm.

The program of meetings for 2016 (with exceptions noted) is as follows:

1 Jun — Tim Asome, General Manager,
and Marcus Ekholm, Ship Manager,
ASP Ship Management
CSIRO's New Research Vessel, Investigator

6 Jul — Mick Dunne, Mercy Ships,
Conversion and Operation of Hospital Ship Africa Mercy

3 Aug — Steve Quigley, Managing Director
One2three Naval Architects
Innovations on Wild Oats XI

7 Sep — Nick Browne, Research Supply Icebreaker Project Manager, Australian Antarctic Division
Australia's New Antarctic Vessel

5 Oct — Drew Shannon, Manager East Coast,
London Offshore Consultants
Salvage of Rena *in New Zealand*

1 Dec — SMIX Bash

Basic Dry Dock Training Course

DM Consulting's Basic Dry Dock Training is a four-day course which covers the fundamentals and calculations of dry docking. The next course in Australia will be held on 15–18 November 2016, in Australia, with exact location to be advised.

The course begins with the basics and safety concerns, and progresses through all phases of dry docking: preparation, docking, lay period, and undocking. The course ends with a discussion of accidents and incidents.

It is designed to be relevant to dock masters, docking officers, engineers, naval architects, port engineers and others involved in the dry docking of ships and vessels. The course is presented through classroom lectures, student participation in projects, and practical application exercises. The course addresses the deck-plate level of practical operation needed by the dock operator and the universally-accepted mathematical calculations required to carry out operations in accordance with established sound engineering practices.

"The course was excellent, straight forward and comprehensive. Instruction was great, expected 'death-by-PowerPoint, but was pleasantly surprised. I am better acquainted with dry dock basics after the course and can trust the accuracy of the training based on the extensive experience of the instructors. Thank you! Very informative, very thorough."

Topics to be covered include:

- Basic dry docking community terminology
- Calculations
- Safe dry docking procedures
- Lay period
- Undocking evolutions
- Docking Plans
- Docking and undocking conferences
- Hull boards
- Vessel stability
- Incidents/accidents

"Fantastic. Really good course. Personally, I got a lot out of the course and will certainly recommend it to my work colleagues."

"Very informative. Subject matter which was dry, was taught without being boring. Class was great, learned a lot! Thank you."

Joe Stiglich, the course leader, is a retired naval officer, qualified NAVSEA docking officer and holds a master's degree from MIT in naval architecture and marine engineering. Responsible for over 250 safe docking and undocking operations, he currently runs a series of conference and training courses for personnel involved in all phases of the dry docking industry and acts as a consultant for ship repair companies.

For further information, please see www.drydocktraining.com/.

This training will be held in conjunction with the Australian Shipbuilding and Repair Group (ASRG). Registration and payment may be made directly to ASRG. Contact Liz Hay at liz.hay@asrg.asn.au or call (07) 5597 3550.

Pacific 2017 IMC

The next Pacific International Maritime Conference, held in conjunction with the Pacific International Maritime Exposition and the Royal Australian Navy's Sea Power Conference, will be held in Sydney on 3–5 October 2017 to coincide with Navy Week, and Pacific 2017 will be held at the brand-new Sydney Exhibition Centre at Darling Harbour.

The change in dates from the previous January–February timeslot is a result of the success of Pacific 2013, which was held in October 2013 to coincide with the Royal Australian Navy's Centenary celebrations and International Fleet Review on 4 October. Pacific 2015 was also successfully held in October. In consultation with the Royal Australian Navy, the biennial Pacific International Maritime Exposition will in future coincide with Navy Week during the first week in October.

The domain name of www.pacific2017.com.au has been registered and the website is parked. For further initial details, contact expo@amda.com.au.

Put these dates in your diary and watch this space!

HPYD6

HPYD is a series of conferences on high-performance yacht design organised by the Royal Institution of Naval Architects (RINA) NZ and the University of Auckland. The first conference was held in December 2002. Since then, the conferences in 2006, 2008, 2012 and 2015 have showcased the latest developments in yacht research from around the globe. The conference enables naval architects, engineers, designers and researchers to present and hear papers on the current state of high performance yacht and power craft technology.

Agreement has been reached between HPYD, SNAME (Chesapeake Section) and Ecole Navale (Innov'Sail) to provide a coordinated rolling three-year program of high-quality yacht technical conferences. As a result, HPYD6 will be held in Auckland, New Zealand, in early 2018 during the stopover of the Volvo Ocean Race.

The call for papers will be posted in 2017. You can follow HPYD on Facebook, LinkedIn or sign up for their mailing list to get the latest news.

See www.hpyd.org.nz for more details.

CLASSIFICATION SOCIETY NEWS

LR Issues Technical Guidance for Cyber Shipping—Ship Design in a Digital Age

Lloyd's Register's new guidance provides the shipping industry with a route map to understanding the implications of digital technology. As a trusted provider of safety assurance to the marine industry, LR is ready to help all stakeholders in the cyber-enabled ship market ensure that information and communications technology (ICT) is deployed safely. This is the first edition of LR's guidance to clients on cyber-enabled ships and is the result of detailed work and consultation with industry and academia.

A cyber-enabled ship will consist of multiple, interconnected systems. Due to the rapid pace of technology development, prescriptive approaches to risk management are not suitable. Instead, a 'total systems' approach is required, taking into account all systems on board and — critically — on shore, how they are designed and installed, how they connect, and how they will be managed.

LR describes a non-prescriptive, risk-based process. From the earliest concept stage, through on-board integration, to operation, it is based on LR's extensive experience of system design and installation on board ships and on other marine platforms.

LR explains what is meant by cyber systems and looks at their impact on shipping. The guidance describes six key areas of risk which need to be considered and addressed in order to assure safety and dependability: systems, human-systems, software, network and communications, data assurance, and cyber-security. The guidance illustrates LR's risk-based assurance process, which culminates in system appraisal and, ultimately, issue of approval-in-principle.

References are made in each section to the relevant ISO and IEC standards and the LR Rules which govern and guide the requirements for ICT systems. The guidance will be supported with full ShipRight Procedures for cyber-enabled ships. These will goal-based, addressing all the requirements for detailed system design.

Luis Benito, LR's Marine Marketing Director, commented: "ICT is revolutionising shipping, ushering in a new era — an era of the cyber-enabled ship. Today, leading manufacturers and ship operators want, or have the potential, to innovate using the latest ICT systems, going beyond traditional engineering to create ships with enhanced monitoring, communication and connection capabilities — ships that can be accessed by remote onshore services, anytime and anywhere, for safety and performance benefits.

"We are here to provide the assurance required to develop a safe, dependable, cyber capability in shipping."

Download LR's guidance on cyber-enabled ships now at www.lr.org/cyber.

LR *Press Release,* 22 February 2016

GENERAL NEWS

Future Submarine Announcement

On 26 April the Prime Minister announced in Adelaide that the 12 next-generation submarines for the RAN will be constructed in Adelaide, with DCNS of France selected as the preferred international partner for the design.

The $50 billion future-submarine project is the largest and most-complex defence acquisition Australia has ever undertaken. It will deliver a regionally-superior submarine which meets Australia's unique national security requirements, as detailed in the 2016 Defence White Paper.

The announcement follows the comprehensive competitive-evaluation process involving DCNS, TKMS of Germany and the Government of Japan. Each bidder submitted very high quality proposals and the Australian Government thanked both TKMS and the Government of Japan for their ongoing commitment to Australia and their participation in the process.

The rigorous and independent process was led by the Head of the Future Submarine Program, RADM Greg Sammut, and General Manager Submarines, retired US Navy RADM Stephen Johnson, who was previously in charge of the program to replace the Ohio-class ballistic missile submarines.

The process was overseen by an independent Expert Advisory Panel, chaired by the former Secretary of the United States Navy, Prof. Donald Winter. It was peer reviewed by retired US Navy VADM Paul Sullivan and retired US Navy RADM Thomas Eccles.

This decision was driven by the French bid's ability to best meet the unique capability requirements. These included superior sensor performance and stealth characteristics, as well as range and endurance similar to the Collins-class submarine. The Government's considerations also included cost, schedule, program execution, through-life support and Australian industry involvement.

Subject to discussions on commercial matters, the design of the future submarine with DCNS will begin this year.

A Shortfin Barracuda Block 1A pre-concept design
(DCNS image)

Short Lists for OPVs and Frigates Announced

On 18 April the Prime Minister announced first-pass approval for the RAN's future offshore patrol vessels and the future frigates.

Construction of the OPVs is planned to begin in Adelaide in 2018, following the completion of the air-warfare destroyer program and then OPV construction will transfer to Western Australia when the future-frigate construction begins in Adelaide in 2020.

As part of the competitive evaluation process, three designers have been shortlisted for the OPVs — Damen of the Netherlands, Fassmer of Germany and Lürssen of Germany. They have now been asked to refine their designs. This program is estimated to be worth more than $3 billion and is expected to create over 400 direct jobs.

Three designers have been shortlisted for the future frigate — BAE Systems with the Type 26 Frigate, Fincantieri with the FREMM Frigate and Navantia with a redesigned F100. They will now be called on to refine their designs. These frigates will all be built in Adelaide and will incorporate the Australian-developed CEA phased-array radar.

The competitive evaluation process for the frigates is on schedule for second-pass approval in 2018 which will allow construction to begin in Adelaide in 2020. This program is estimated to be worth more than $35 billion and is expected to directly create over 2000 jobs.

Contract Signed for New RAN Replenishment Vessels

On 6 May the Government announced that contracts had been signed with Navantia S.A. to build Australia's two replacement replenishment ships.

Australia's current supply ship, HMAS *Success*, will reach her end of life in 2021 and needs to be replaced as a matter of priority. The tanker HMAS *Sirius* will also be replaced by one of the new ships.

As part of the $640 million contract with Navantia, more than $130 million will go to Australian industry.

Local industry activity will include combat and communication systems integration, integrated logistic support, and elements of the on-board cranes.

In addition, an initial $250 million, five-year sustainment contract also signed with Navantia will be undertaken in Australia.

Contract Signed for New Icebreaker

On 28 April 2016 the Australian Government signed a contract for Australia's new icebreaker, with the new ship due to arrive in Australia in mid-2020.

The total investment is over $1.912 billion, with $529 million being invested in the capital cost of the icebreaker, and $1.38 billion to be spent on operations and maintenance over its 30 year lifespan.

More than $1.1 billion (around 80 per cent) of the operations and maintenance spend will be in Australia, with the majority expected in Tasmania.

Australian company DMS Maritime will project manage the overall ship design and building process, and will then operate and maintain the icebreaker from its home port of Hobart.

The state-of-the-art icebreaker will be uniquely tailored to meet Australia's needs, and will be faster, larger, and stronger than the Australian Antarctic program's current icebreaker, *Aurora Australis,* and will offer increased endurance and icebreaking capability.

An impression of Australia's new icebreaker
(Image Damen/DMS Maritime/Knud E Hansen A/S)

The new ship will provide a modern platform for marine science research in both sea ice and open water and a moon pool for launching and retrieving remotely-operated underwater vehicles.

DMS will subcontract Damen Schelde Naval Shipbuilding, part of the Damen Shipyards Group, to design and build the icebreaker. Construction will occur at Damen Shipyard Galatz in Romania. DMS Maritime and Damen Shipyards Group have a well-established relationship, having delivered over ten vessels across a range of sizes and complexity to the Australian Government, all of which were delivered on time and within budget.

DMS will operate and maintain the icebreaker from its home port of Hobart from the 2020–21 Antarctic season for an initial term of 10 years.

The general particulars of the ship are:

Length OA	156.0 m
Beam (max)	25.6 m
Draft (max)	9.6 m
Displacement	23 800 t
Icebreaking	1.65 m at 3 kn
Speed	12 knots economical
	Over 16 kn maximum
Range	Over 16 000 n miles
Endurance	90 days
Cargo fuel capacity	1671 t
Container capacity	96 TEU
Cargo capacity	1200 t
Passengers	116

A multi-beam bathymetric echo sounder will enable seafloor mapping, while portable science laboratories will offer scientists space to conduct research.

Pacific Patrol Boat Contract Signed with Austal

On 5 May the Government signed a contract with Austal Ships to build and sustain up to 21 steel-hulled vessels to replace the existing fleet of Pacific Patrol Boats as part of Australia's new Pacific Maritime Security Program.

As part of the $280 million contract, Austal will design and construct the first 19 vessels in Henderson, securing more than 120 jobs for Western Australia.

Two vessels have also been offered to a new member of the Program, Timor-Leste, with an option for these additional vessels to be constructed by Austal at an agreed fixed price should Timor-Leste accept the offer.

Austal has also been awarded a $24 million contract to provide support services to the replacement vessels for an initial seven-year period. The total investment in support and sustainment of the vessels, including the conduct of deep maintenance in Cairns, Queensland, is estimated at more than $400 million across the life of the vessels.

Austal's Pacific Patrol Boat design
(Image courtesy Austal)

The new Pacific Patrol Boat is based on Austal's proven patrol-boat designs and is 39.5 m long with a beam of 8 m and a loaded draft of 2.5 m. It will have a maximum speed of 20 kn and will have a range of 3000 n miles at 12 kn. Each vessel will be able to accommodate 23 people.

Construction of the new vessels will commence in mid-2017, with the first vessel to be delivered in late 2018.

The gifting of these larger and more-capable replacement vessels will build on the success of the current Pacific Patrol Boat Program to assist our Pacific Island partners in protecting their maritime resources and security interests.

The existing fleet is approaching its end-of-service life, and will be replaced with this new fleet of Australian-built vessels to assist Australia's Pacific Island partners in continuing to take an active role in securing their extensive exclusive economic zones.

Anzac-class Frigate Sustainment Contract

On 29 April the Government announced that it had signed a long-term contract for the sustainment of the RAN's Anzac-class frigates centred in Western Australia.

The strategic partnership between BAE Systems Australia Defence, Saab Australia, Naval Ship Management Australia (a joint venture between UGL and Babcock), and the Commonwealth will streamline a number of existing contracts for the whole-of-life sustainment for the Anzac-class frigates. The majority of the sustainment work will be done in Henderson, with additional work at Fleet Base East, cementing Henderson as one of Australia's naval shipbuilding and sustainment centres.

The open-ended sustainment contract has a value of over $2 billion for the first eight years and will provide certainty to the principal partners to invest in growing skills and capabilities. It will also provide increased opportunities for the engagement of small-to-medium sized businesses in the Australian maritime industry.

The strategic partnership between Defence and industry ensures that the Anzac-class frigates will remain highly capable, safe, environmentally compliant, and cost effective until their planned withdrawal dates.

HMAS *Stuart* is moved from the turntable as the ship is docked at BAE Systems' shipyard at Henderson WA, in preparation for her Anti-Ship Missile Defence (ASMD) upgrade
(RAN photograph)

Final Anzac-frigate Upgrade Begins

HMAS *Stuart* recently became the last of the Anzac-class frigates to enter the Anti-Ship Missile Defence (ASMD) upgrade.

Stuart docked at the BAE Systems Australia Henderson shipyard in Western Australia on 3 May and will remain out of the water until early March 2017.

During this time, contractors will replace numerous systems with the latest technological upgrades and, along with Navy personnel, undertake ongoing maintenance of the vessel.

Upgrade Program Delivery Manager, LCDR Felicity Petrie, said that *Stuart's* docking marks an important milestone.

"This represents the completion of a significant body of work by a number of Navy personnel and civilian contractors across the Anzac fleet," she said.

"*Stuart's* upgrade will signal the end of the 'classic' configuration and herald a new era in Navy capability."

During the upgrade, the ship will have both mast modules removed, modified and replaced, be blasted back and repainted, and have significant sections of the combat system replaced by the upgraded Saab Systems Mk3E system.

Thousands of metres of fibre-optic cables will also be installed to allow the Australian designed CEA phased-array radar and other sensors to communicate with the new combat system.

"The operations room will be completely overhauled, bringing the entire Anzac fleet up to current standards for ergonomics and information display," LCDR Petrie said.

Stuart will spend about three months less in dry dock than her sister ships, and is expected to return to service, following sea and harbour trials, in October 2017.

Prior to their ship docking, *Stuart's* ship's company swapped onto HMAS *Parramatta* which recently underwent a similar upgrade.

HMAS *Parramatta* being prepared for undocking after her Anti-Ship Missile Defence upgrade at BAE Systems' Henderson shipyard
(RAN photograph)

HSSVs for Oman Named at Austal

On 15 April Austal welcomed the Commander of the Royal Navy of Oman (CRNO), RADM Abdullah bin Khamis bin Abdullah Al Raisi to the company's shipyard in Henderson, Western Australia, to officially name two 72 m high-speed support vessels (HSSVs) designed and built by Austal for the Royal Navy of Oman (RNO).

In a formal ceremony, RADM Abdullah bin Khamis bin Abdullah Al Raisi named the ships RNOV *Al Mubshir* (S11) and RNOV *Al Naasir* (S12).

The first vessel, RNOV *Al Mubshir*, is on schedule for delivery in the first half of 2016 whilst the second vessel, RNOV *Al Naasir*, was launched in April and will be delivered following further fitout, sea trials and acceptance in the second half of 2016.

Speaking at the ceremony, RADM Abdullah bin Khamis bin Abdullah Al Raisi remarked "The high-speed support vessel is an important new addition to the Royal Navy of Oman fleet and a continuation of a modernisation process which is reinforcing Oman's naval capabilities and supporting the Sultan Armed Forces (SAF). The HSSV will help us fulfil our national mission to protect Omani waters and meet other joint operational support requirements, including search-and-rescue and humanitarian and disaster relief."

"Austal is to be congratulated on a successful build program and we look forward to deploying both *Al Mubshir* and *Al Naasir* in 2016."

Austal began construction of the two HSSVs in August 2014, following the award of the $US124.9 million contract from the RNO in March 2014.

The 72 m high-speed support vessel RNOV *Al Mubshir* during sea trials off Western Australia in March 2016
(Photo courtesy Austal)

The unique first-of-class naval vessels are an evolution of the proven expeditionary fast transport developed for the United States Navy by Austal which is now operating around the world with US Military Sealift Command. The innovative design offers high-speed performance, multiple-mission capability and operational flexibility. and demonstrates Austal's ability to develop unique, customised naval solutions-based on proven designs, for export markets.

The 38 kn, all-aluminium HSSV offers exceptional speed, manoeuvrability and carrying capacity (for up to 260 embarked troops plus equipment and vehicles) for a range of military operations and logistic-support roles. Featuring a shallow draft of 3 m, a 900 m^2 vehicle deck, 395 t carrying capacity and medium-lift aviation capability (for a NH-90 helicopter), the HSSV provides support for both open-ocean and coastal missions.

Austal Chief Executive Officer, David Singleton, congratulated RADM Abdullah bin Khamis bin Abdullah Al Raisi on the RNO's strategic investment in the innovative HSSV platform, and confirmed that Austal would provide in-service support to the RNO and the two HSSVs through the company's Middle East Service Centre in Muscat, Oman.

RNOV *Al Naasir* was launched at Austal's Henderson shipyard in April 2016
(Photo courtesy Austal)

New Austal Contract for EPF 12

On 5 May Austal announced that it had been awarded a $US18.5 million contract to procure long-lead-time materials for the twelfth expeditionary fast transport vessel (EPF 12), for the US Navy.

The award covers materials, including main propulsion engines, water jets, stern ramp and other long-lead-time items, to support the detail design and construction of EPF 12.

Chief Executive Officer David Singleton said that the contract award was an important step on the critical path to a new shipbuilding contract.

"This award is a clear indication from the US Navy that they value the platform and stand committed to the program. Our delivered EPFs have achieved operational success around the world, and this announcement is a crucial step to growing the fleet to 12 ships and potentially beyond", Mr Singleton said.

Costs incurred will be reimbursed, but no profit will be recognised prior to execution of the shipbuilding contract.

Austal is constructing ten 103 m expeditionary fast transport vessels under a $US1.6 billion contract from the US Navy, with six already delivered and the remaining vessels under construction at Austal's US shipyard. Austal is also procuring long-lead time materials for EPF 11 under a previously-awarded contract from the US Navy.

AWD Project update

A major milestone for the air-warfare destroyer (AWD) project was achieved on 8 April when the Royal Australian Navy officially opened its Navy Training Systems Centre at Randwick Barracks in New South Wales.

The purpose-built facility will provide the location for the RAN to deliver training for both the AWD and Landing Helicopter Dock (LHD) capabilities, demonstrating one of the many facility requirements that the AWD Alliance has delivered as part of the project to date.

Hobart, *Brisbane* and *Sydney* under construction at ASC in Adelaide in February this year (Photo courtesy AWD Alliance)

This milestone comes as the first AWD, *Hobart*, advances further towards sea trials with the activation of a number of significant combat systems.

The AWD Alliance team, comprising Raytheon Australia, ASC and the Department of Defence, has invested over the last decade in developing the people, processes, tools and supplier relationships required to integrate and activate such highly-technical and complex systems.

In its role as the combat systems integrator, Raytheon Australia is responsible for the design, integration, testing and activation of the Hobart-class combat system for all three destroyers, as well as delivery of the associated land-based support facilities. This involves the integration of ten major subsystems, including the Aegis weapon system, which is provided through US Foreign Military Sales, and associated delivery of more than 3500 major pieces of combat-system equipment required to establish the warfighting capability of the AWD for the RAN.

The AWD Program Manager, CDRE Craig Bourke CSC RAN, said that the collegiate approach for developing the Hobart-class combat-system solution, led by Raytheon Australia, has achieved the expected 'best-for-program outcomes' working with the US Navy and a range of original equipment manufacturers, such as Ultra and Lockheed Martin.

"The Combat System architectural principles applied by Raytheon Australia have given the Commonwealth an overall solution with effective balance between a system with a strong parent Navy pedigree and the Australian indigenous capability to select, manage and tailor sub-systems, weapons and effectors to best meet the capability needs of the Royal Australian Navy along with inherent through life support benefits," CDRE Bourke said.

The AWD Alliance General Manager, Lloyd Beckett, also reinforced the importance of this activity as a demonstration of the complex work being undertaken by the Alliance. "The activation of the combat system is an exciting time for a first-of-class ship such as *Hobart.* It is a further demonstration of the demanding work which we are executing on this project and proof of our ability to manage the risks associated with highly-complex integration activities. I am immensely proud of what the AWD Alliance is achieving together as one team," he said.

As at April this year:

- *Hobart* was 92% complete and on track to commence sea trials later this year, with a number of key combat systems activated, including the vertical-launch system, the Australian tactical interface, the Aegis software operating environment, and the SPY1D-V phased-array radar, along with various navigation and ship systems. In coming weeks, *Hobart* will complete the activation of her main engines, in preparation for sea trials later this year.
- *Brisbane* was 75% complete as she prepares for launching in the coming year.
- *Sydney* was 49% complete, with the final block delivery due to occur in May 2016.
- Both *Brisbane* and *Sydney* have benefitted from the lessons learned from *Hobart,* with significant efficiency gains being measured from the first ship to the third ship. ASC and Navantia have worked closely together with the broader Alliance team over the last few months to realise these gains.
- Overall, more than 85% of the project's combat system scope of work has been completed.

The AWD Alliance successfully completed its final Training Readiness Review with the RAN, signifying agreement from the Navy that the program is ready to commence crew training for the AWD capability.

Bali Hai Catamaran Design by IMC

The design of Bali Hai Cruises' next-generation day-cruise catamaran will support a diverse range of operations and feature clean, efficient propulsion.

Building on a relationship spanning more than 20 years, Bali Hai Cruises selected International Maritime Consultants (IMC) of Western Australia for the design of its new aluminium catamaran late last year and the two companies have since continued to work collaboratively to further develop and refine the design.

Releasing the first images and further details of the new design, IMC's Managing Director, Justin McPherson, said that the catamaran reflected a powerful combination of the two organisations' knowledge, experience, and skills.

"While our staff has tremendous expertise and skills across all areas of vessel design and engineering, the Bali Hai Cruises personnel have contributed a huge amount of operational insight which has enabled us to generate a truly bespoke design for them," he said.

In particular, McPherson noted that insights into the operating and maintenance environment in Indonesia, as well as passenger behaviours and preferences, had all been incorporated.

"While we have had staff visit the operation, we could never hope to replicate the knowledge base that Bali Hai Cruises has developed in operating similar vessels in the same trade for more than a quarter of a century," he said.

"Absorbing that information, and developing a design response, has been a key part of the engineering process."

The 42.7 m long by 11.2 m beam all-aluminium catamaran will accommodate 417 passengers across three decks, featuring a contemporary tropical finish. The main deck has internal grouped seating for 229, while also accommodating a state-of-the-art food preparation area, bar/kiosk, food servery, DJ station and dance floor. The bridge deck seats 130 passengers internally in relaxed lounge seating with another 58 seats externally around a bar/kiosk, live band stage and dance floor. The promenade deck provides uninterrupted 360 degree views with mixed seating for 134, all serviced by a dedicated third bar/kiosk.

The vessel is designed to be quickly reconfigured from the island day-cruise operation to evening dinner-cruise mode catering for multi-group sit-down buffet dinners and cocktail-style receptions simultaneously. With a cabaret show offered on the main deck and live band on the bridge deck, the audio-visual system is the cornerstone of the onboard entertainment experience.

Conscious of minimising the carbon footprint of the Bali Hai organisation, the IMC team has incorporated a diesel-electric hybrid-drive system, allowing the vessel to conduct its low-speed evening dinner-cruise operation without the use of its larger main engines. Driven by an electric motor off the back of each gearbox, the vessel can be propelled in all electric mode providing minimal noise and emissions.

Bali Hai Cruises is also drawing on IMC's acquisition-management expertise to assist with shipyard selection, contract management and construction supervision for the new construction project. Working through the range of technical, commercial and regulatory requirements specific to the passenger operation in Bali, Indonesia, IMC is assisting BHC mitigate the range of risks involved in bringing the project to reality.

An impression of Bali Hai Cruises' new catamaran
(Image courtesy IMC)

Special Purpose Ship Certified by Commercial Marine Solutions

As the market changes, ship owners are looking at other ways to hire their ships. Recently Commercial Marine Solutions (CMS) worked with a client to provide additional certification of their vessel to open up new opportunities. The ship was classed as an offshore supply vessel (OSV) with DNV GL, but the owner wanted to increase utilisation of the vessel, tasking it with a greater variety of roles.

Some of the new roles required a larger number of technical staff who were not ship's crew. Under the IMO rules for commercial shipping, these technical staff are treated as passengers. A standard OSV can carry up to 12 passengers, but with the additional certification of Special Purpose Ship (SPS) the ship can carry an additional 48 personnel.

CMS undertook a gap analysis to determine the modifications required to meet SPS certification. The gap analysis identified that additional documentation was required.

CMS undertook an analysis of the damage stability of the vessel and produced a new damage-control booklet. CMS also provided information for the updating and creation of drawings including the damage-control plan. This was all completed to the requirements of the IMO and SOLAS.

30 m Barge from Commercial Marine Solutions

Commercial Marine Solutions has announced the completion of a 30 m barge for container and break-bulk disembarkation from an island location. The all-steel barge has a load capacity of 300 t and a deck loading of 15 t/m^2. The vessel has been certified by Lloyd's Register.

Principal particulars of the new vessel are

Length OA	30.0 m
Beam OA	12.0 m
Depth	3.00 m
Power	Unpowered
Construction	Steel

Sean Johnston

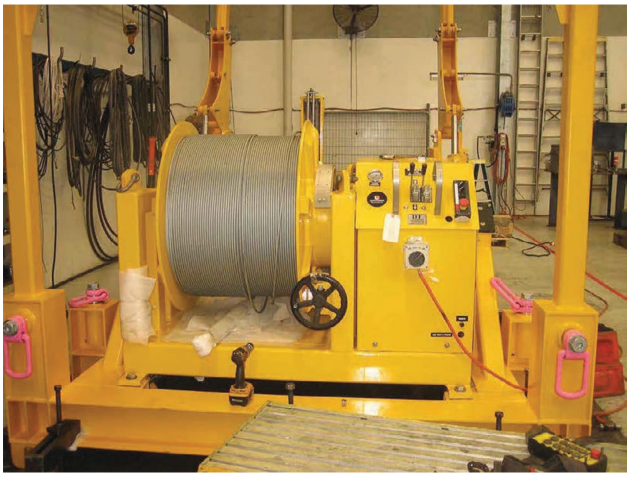
30 m steel barge
(Photo courtesy Commercial Marine Solutions)

IMC LARS supports RAN's Submarine Rescue Capability

In 2015 L-3 Oceania commissioned International Maritime Consultants (IMC) to design an air-deployable launch and recovery system (LARS) for an L-3 Deployable Side Scan Sonar. The system was configured to be rapidly deployable by land, sea or air and fitted to a vessel of opportunity with minimal integration.

Designed in compliance with Lloyd's Register *Code for Lifting Appliances in a Marine Environment* and DEF(AUST) 9009A, the IMC folding A-frame LARS with its ISO container footprint was manufactured in Western Australia by Fremantle Hydraulics, complete with all hydraulic and electrical controls to support the L-3 Klein winch system and tow fish. With 2000 m of armoured cable, the Klein 3000 side-scan sonar tow fish operates at 100 and 445 kHz and produces detailed seabed images for accurate object detection.

The deployable side scan sonar system will be utilised as a part of Australia's recently-enhanced submarine-rescue capability. In the event of a distressed submarine (DISSUB) incident, the system will provide detailed images of the topography of the sea floor and hazards within the rescue area. The system could also be used for locating other assets on the seabed and a variety of subsea survey work.



LARS being prepared for factory testing
(Photo courtesy IMC)

Due for commissioning in 2016, once operational the system will be integrated onto the RAN's submarine escape gear ship *Besant*. One of two new ships acquired to enhance the Royal Australian Navy's submarine search-and-rescue capability, based at HMAS *Stirling* in Western Australia, the 83 m steel monohull will be used to provide an early intervention role in the event of a disabled submarine.

Built by Damen in Vietnam, *Besant* is operated by DMS Maritime, part of the international service company and Australian government contractor, Serco. IMC qualified to be part of the Serco Defence Technical Support Network in 2015.

50 m Multi-mission Patrol Vessels from Incat Crowther

Incat Crowther has announced a contract to design a 50 m multi-mission monohull patrol vessel for the Philippines Government. Two identical vessels of this type will be built in Manila by Josefa Slipways. The primary role of the vessels will be to combat illegal fishing for the Philippines government. With the local fishing industry losing billions of dollars to illegal fishing, these assets will enhance law enforcement's capability to patrol and protect territorial waters. The multi-mission nature of the vessels also affords the flexibility to lead in disaster-relief and/or -rescue operations, as well as to serve as a platform for research.

The Department of Agriculture (DA) with their operating agency, the Bureau of Fisheries and Aquatic Resources (BFAR) will operate the vessels.

Notable features of the steel vessel are a spacious aft working deck to accommodate both a rescue craft launched from a deck crane, as well as a 9 m RHIB deployed from a specially-designed well with a transom door. Ahead of the aft working deck, the main cabin houses a spacious galley with adjoining freezer and cold rooms, a medical clinic with adjacent laboratory, a large mess hall for the crew, and a private mess hall for officers. A large conference room accommodating 36 personnel is at the forward end of the main cabin.

Below deck are the engine, control and equipment rooms as well as full accommodation for 42 personnel.

Accommodation for officers and engineers is on the mid deck. Forward on the mid deck is a conference room with the capacity for 14 personnel.

The large pilot-house gives an unobstructed view forward and plenty of desk area for electronics and charts. It also has sleeping quarters for two pilots.

The vessels will be powered by two Mitsubishi S16R2-T2MPTK engines, coupled with Masson MM W18000 gearboxes and fixed-pitch propellers. Two Yanmar 6HAL2-WHT generators will service the vessel's electrical needs with an additional emergency generator.

Incat Crowther is pleased to work with both Josefa Slipways and the Philippines Government in developing a vessel which will serve their country's needs, both in protecting territorial waters or disaster relief.

Principal particulars of the new vessels are

Length OA		50.5 m
Length WL		48.0 m
Beam OA		9.00 m
Depth		4.00 m
Draft	(hull)	1.95 m
	(propellers)	3.20 m
Personnel		60
Fuel oil		148 000 L
Fresh water		55 000 L
Grey water		8000 L
Black water		8000 L
Main engines		2×Mitsubishi S16R2-T2MPTK each 1884 kW @ 1500rpm
Gearboxes		2Masson MM W18000
Propulsion		2×fixed-pitch propellers
Generators		2×Yanmar 6HAL2-WHT Each 240 kWe
Speed	(service)	15 kn
	(maximum)	18 kn
Construction		Steel
Flag		Philippines
Class/Survey		Philippine Maritime Industry Authority (MARINA) Bureau Veritas ✠ Hull Mach Special Service-Multi-Mission Unlimited Navigation

Starboard bow view of 50 m multi-mission patrol vessels
for the Philippines
(Image courtesy Incat Crowther)

Design and Aluminum Kits for Monohull Crewboats from Incat Crowther

Incat Crowther has announced a contract with the shipbuilder Astinave EP of Guayaquil, Ecuador, for the supply of vessel design services and aluminum component kits for a pair of 22.5 m monohull crewboats which are currently under construction for an undisclosed client. The vessels will operate in support of Ecaudor's state-owned oil and gas company, Flota Petrolera Ecuatoriana (Flopec).

The 20 kn crewboats feature modern styling combined with a robust and simple-to-build structure. Propulsion is enabled by two Cummins QSK19 marine engines rated at 559 kW @ 1800 rpm driving Teignbridge fixed-pitch NiBrAl propellers. Electrical power is supplied by two Cummins 55MDDCM generator sets each rated at 55 ekW @ 1800 rpm.

Tank capacities include 11 000 L of fuel oil and 7000 L of potable water.

The crew accommodation located ahead of the engine room features private staterooms for three crew, with each having a locker/cabinet for storage. A galley, mess area and washroom complete the crew accommodation.

The main deck includes a generous 40 m^2 cargo deck covered in hardwood planking, and a passenger cabin featuring twenty-five seats, two WCs, luggage shelves, two PFD storage lockers, and a deck locker.

On the upper deck sits the pilot-house, complete with forward- and aft-facing helm positions and a chart table. Two inflatable life rafts are aft of the wheelhouse and are arranged for easy launching.

The supply of the aluminum kits represents another capability of Incat Crowther outside of its proven vessel-design capabilities. The kits were processed by US-based suppliers and shipped via sea freight from Houston to Guayaquil. Completion of the vessels is scheduled for October.

Principal particulars of the crewboats are

Length OA		22.5 m
Length WL		21.8 m
Beam O		6.00 m
Depth		3.00 m
Draft	(hull)	1.22 m
	(propeller)	1.68 m
Personnel		25
Crew		3
Fuel oil		11 000 L
Fresh water		7000 L
Black water		600 L
Main engines		2×Cummins QSK 19 each 559 kW @ 1800 rpm
Gearboxes		2×Twin Disc MGX-5145 SC
Propulsion		2×5-blade Teignbridge propellers
Generators		2×Cummins 55MDDCM gensets each 55 ekW @ 1800 rpm
Speed	(service)	18 kn
	(maximum)	20 kn
Construction		Marine-grade aluminum
Flag		Ecuador
Class/Survey		Lloyd's Register

Zach Dubois

Starboard bow of 22.5 m monohull crewboats for Flopec
(Image courtesy Incat Crowther)

Kilimanjaro VI from Incat Crowther

Incat Crowther has announced the launch of *Kilimanjaro VI*, the eighth Incat Crowther-designed vessel delivered to Tanzanian operator Azam Marine. Built by Richardson Devine Marine Constructions, the 39 m catamaran ferry builds on the operational experience of the fleet and brings improvements to passenger accommodation and propulsion, as well as a new, sleeker appearance.

Kilimanjaro VI features four ramps per side to load passengers and luggage. Two ramps per side service economy-class passengers, leading them directly to the aft stairs for the upper deck and the main-deck economy cabin respectively. The forward-most ramp on each side feeds directly to dedicated stairs to the Royal-class upper cabin, sporting a very high level of finish. The remaining ramp each side loads directly to the luggage room, facilitating the loading of standardised luggage trolleys.

Jointly refined over generations of Kilimanjaro vessels, the boarding arrangement allows all classes of passengers to board independently, as well as being completely separated from luggage movement. This improves both safety and efficiency, allowing the operator to turn the 566-passenger complement around quickly and continue operating profitably.

The main deck has a total 255 internal seats, in addition to a kiosk and four toilets. The upper deck has 64 seats inside and 104 outside. The sundeck seats 95 passengers.

All interior spaces are serviced by aircraft-style catering trolleys. Accommodation for four crew members is fitted to the hulls.

Kilimanjaro VI shows her paces
(Photo courtesy Incat Crowther)

Kilimanjaro VI is powered by a pair of Cummins QSK60-M main engines, each producing 1715 kW and has a top speed in excess of 32 kn.

Kilimanjaro VI and her sisters continue to contribute to the operator's strong patronage and economic growth in the region.

Principal particulars of *Kilimanjaro VI* are

Length OA	39.00 m
Length WL	38.90 m
Beam OA	11.00 m
Depth	3.90 m
Draft (hull)	1.48 m
(propellers)	2.25 m
Passengers	566
Crew	10
Fuel oil	2×6000L
Fresh water	2×1500 L
Sullage	2×1500 L
Speed (Service)	30 knots
Main engines	2×Cummins QSK60-M each 1715 kW @ 1900 rpm
Propulsion	2×propellers
Generators	2×Cummins 170 kVA
Speed (maximum)	32 kn
Construction	Marine-grade aluminium
Flag	Tanzania
Class/Survey	MAST 1C

Evolution from Incat Crowther

Incat Crowther has announced the delivery of the 33 m catamaran dive cruise vessel, *Evolution*. Built by Marine Engineering Consultants on Queensland's Gold Coast, *Evolution* was recently delivered to Down Under Dive, whereupon it has become the benchmark for customer experience on the Great Barrier Reef.

Designed from the keel up to provide a sleek and modern feature-packed vessel, *Evolution* blends motor-yacht style with commercial vessel efficiency and ruggedness. Featuring a high level of glazing and modern fit-out, the interior spaces are light and airy, whilst outdoors paces are well protected from the sun.

Whilst *Evolution* promises to be the most comfortable vessel transiting to and from the reef, it truly comes into its own when stationed on the reef. The traditional lifting dive platform, pioneered by Incat Crowther in the 1980s, has been taken to the next level with port and starboard fold-down platforms adding to the stern platform to completely encircle the aft end of the vessel and provide an expanse of space to access the water safely. All three platforms feature stair access with ample hand rails and ladders into the water.

Adjacent to the ramps and stairs is a large aft main deck with toilets and storage for wetsuits, snorkels and dive tanks. Overlooking this space, at the aft end of the upper deck, is a lifeguard lookout station, with an uninterrupted view of the platforms and water.

Passengers board *Evolution* through gates aft on the main deck, doors midships on the main deck, or additional gates on the upper deck. Once aboard, they are greeted with high-quality yet durable lounges, seats and teak-look flooring.

The main cabin seats 148 in a mixture of booth configurations. Passengers are served by two large catering counters aft — a bar to port and a kiosk to starboard — with ample milling space for passengers to line up for the signature barbecue buffet.

A large set of stairs on the aft main deck leads to the upper deck, with outdoor seating for 35. Inside the upper deck cabin, there is booth seating for 46 passengers, as well as a gold-class room aft, allowing the operator to offer a premium experience to a select 10 passengers.

Forward of the wheelhouse are comfortable built-in sun lounges for passengers to relax, as well as a stairway down to the foredeck allowing good passenger circulation.

The roof deck features forward-facing seats as well as lounges aft. This deck is covered by a solid roof and accommodates 70 passengers, who enjoy comfort and an excellent 360 degree outlook.

Evolution is fitted with two MAN D2862 LE463 engines driving fixed-pitched propellers. She performed excellently on sea trials, easily achieving her service speed of 25 kn, as well as demonstrating exceptional seakeeping characteristics.

Principal particulars of *Evolution* are

Length OA	33.1 m
Length WL	32.4 m
Beam OA	9.30 m
Depth	3.20 m
Draft (hull)	1.30 m
(propellers)	2.10m
Passengers	200
Crew	20
Fuel oil	2×4000 L
Fresh water	2×3000 L
Sullage	2×2000 L
Main Engines	2×MAN D2862 LE463 each 1029 kW @ 2100 rpm
Propulsion	2×fixed-pitched propellers
Generators	2×Cummins 6BT5.9-D(M) 50 Hz
Speed (service)	25 kn
maximum)	27 kn
Construction	Marine-grade aluminium
Flag	Australia
Class/Survey	NSCV Class 1C

Port quarter of *Evolution*
(Photo courtesy Down Under Dive)

Spirit of Loch Ness from Incat Crowther

Incat Crowther has announced a contract to design a 20 m catamaran passenger ferry to ply the waters of Loch Ness, Scotland, taking tourists in search of Nessie, the lake's famous monster. Construction of the vessel for Cruise Loch Ness is underway at Exeter Fabrication in England. The vessel will be the first vessel to be fully designed in Incat Crowther's Europe office, providing a full service from preliminary design through to functional and production design.

In addition to regulatory guidance, the preliminary design phase included an analysis of the vessel's platform, and a narrow-beam catamaran was proposed, giving good efficiency whilst allowing the vessel to access the loch via a canal and lock.

The main deck is spacious with large windows for monster-spotting opportunities. Toilets and a bar are located aft.

The upper deck is effectively an interior space, being open at the side whilst being covered above. This allows the cruise to operate in various weather conditions, without forcing passengers inside.

As with a number of other Incat Crowther vessels, this design features an asymmetric wheelhouse. This incorporates an enclosed wing control station on the port side (which will see all docking movements), and an open-access passage to starboard. This open passage allows direct access for crew between the wheelhouse and foredeck, whilst also giving the flexibility of passenger flow between foredeck and upper deck.

The vessel will be powered by a pair of Volvo D9 MH main engines. Producing 313 kW per side, these efficient engines are capable of propelling the vessel to speeds of over 20 kn.

The Cruise Loch Ness project confirms Incat Crowther's commitment to providing Europe with a level of service, experience and expertise consistent with the company's global network.

Principal particulars of the new vessel are

Length OA	21.0 m
Length WL	20.0 m
Beam OA	7.00 m
Draft (hull)	1.00m
Passengers	220
Crew	4
Fuel oil	2×1000 L
Fresh water	1×500 L
Main engines	2×Volvo D9 MH each 313 kW @ 2200 rpm
Propulsion	2×fixed-pitched propellers
Generators	2×Kohler 11 EFKOZD 11 kVA
Speed (service)	19.9 kn
(maximum)	22 kn
Construction	Marine-grade aluminium
Flag	UK
Class/Survey	MCA

Starboard bow of *Spirit of Loch Ness*
(Image courtesy Incat Crowther)

Harbour Master from Incat Crowther

Incat Crowther has announced the launch of *Harbour Master*, a new generation of tour vessel operating on Tasmania's picturesque Macquarie Harbour. Developed in collaboration with World Heritage Cruises, the 220-passenger, 35 m catamaran combines the operator's layout and propulsion concepts with Incat Crowther's naval architectural expertise. *Harbour Master* leverages the experience of six previous Incat Crowther-designed vessels which WHC have operated on Macquarie Harbour and creates an excellent experience for visitors to the World Heritage-listed area.

Passengers enter the main-deck cabin through a large central passageway, serviced by ladies and gents toilets, forward of which is a large, well-designed food-preparation area and bar. Serveries are located just aft of the passenger seating for service of the operator's famous lunch buffet. 136 passengers are seated forward of this, in a mixture of forward-facing and booth configurations.

The mid deck, which seats 82 passengers, is serviced by a pair of services supported by a dumb waiter. This allows mid-deck passengers to be served lunch en suite, reducing the load on the main-deck facilities.

Stairs on the starboard side of the vessel lead down to a children's playroom.

The upper deck has a large open area for standing passengers, as well as the wheelhouse which is recessed into the deck below to create a sleek appearance.

Harbour Master on Trials
(Photo courtesy Incat Crowther)

All seats are fitted at a large pitch for extra leg room and to allow good passenger circulation, whilst deep windows give the cabins an open, airy feel and increase visibility of the surroundings.

Harbour Master is defined by its use of an advanced propulsion package, consisting of four 634 kW Scania main engines, driving a quartet of Sea Fury surface-piercing drives. The propulsion system has excelled on sea trials, on the vessel's delivery trip and in service. On trials, she achieved a speed of 34 kn while in service, with a full complement, *Harbour Master* is easily achieving a speed of 30 kn at moderate engine speeds. As well as excellent efficiency, the propulsion system gives the vessel drive redundancy and a low draft.

Principal particulars of *Harbour Master* are

Length OA	35.75 m
Length WL	34.70 m
Beam OA	9.00 m
Depth	3.10 m
Draft (maximum)	1.10 m
Passengers	220
Crew	8
Fuel oil	10 000 L
Fresh water	1500 L
Sullage	4000 L
Main engines	4×Scania DI16 072M each 634 kW @ 2300 rpm
Propulsion	4×Sea Fury SF38 surface-piercing drives
Generators	2×Isuzu 6BGIT each 90 kVA @ 50 Hz
Speed (service)	30 kn
(maximum)	34 kn
Construction	Marine-grade aluminium
Flag	Australia
Class/Survey	NSCV Fast Craft Class 1C

Najla McCall from Incat Crowther

Incat Crowther has announced the delivery of *Najla McCall*, the second vessel in SE-ACOR Marine's Express Plus class of fast support vessels (FSV). Sister-ship to the acclaimed *Alya McCall*, launched in November last year, *Najla McCall* features striking lines and a very high service speed which take this class of vessel into the 21st century.

Najla McCall has seating capacity for 100 personnel and achieved an operational speed in excess of 38 kn during recent trials. This performance is remarkable for a large vessel of this type and is enabled by a quintet of Cummins QSK 60, EPA Tier 3-compliant diesel engines, each producing 1998 kW brake power. The engines are coupled to Twin Disc MGX 61500 SC reverse reduction gearboxes driving Hamilton HT-810 water jets through a shafting system by Driveline Service of Portland.

Station-keeping capability is provided through the combination of three Thrustmaster 30TT200 electro-mechanical tunnel thrusters working in conjunction with the azimuth-like waterjets, all of which are controlled by a Kongsberg K-Pos DP-2 dynamic positioning system.

Electrical power is derived from three Cummins QSM11 gensets, each producing 290 ekW. Dual FFS firefighting pumps and remotely-controlled monitors provide Fifi-1 equivalent firefighting capacity for combatting off-ship fires. A Naiad Dynamics ride-control system is also fitted to improve passenger and crew comfort while underway.

The vessel is certified by the USCG and by the American Bureau of Shipping as a High-Speed Craft with DP-2 and Fire-Fighting Capability notations.

Najla McCall was constructed by Gulf Craft in Franklin, Louisiana, who is well progressed on construction of additional Express Plus class vessels.

This latest delivery complements previous very fast vessels including *Alya McCall* and the Crewzer class of very fast catamarans, all of which are the result of Incat Crowther's partnership with SEACOR Marine and Gulf Craft. All three parties share a commitment to service and a philosophy of innovation.

Principal particulars of Express Plus Class vessel *Najla McCall* are

Length OA	62.8 m
Length WL	58.9 m
Beam OA	9.80 m
Depth	4.60 m
Draft	2.80 m
Passengers	100
Crew	16
Deck size	41.6 m × 8.1 m
Deck area	328 m²
Deck cargo	300 t
Fuel oil	316 000 L
Fresh water	28 000 L
Grey water	2270 L
Black water	2270 L
Lube oil	2650 L
Waste oil	1893 L
Bilge oil	1893 L
Main Engines	5×Cummins QSK 60 each 1998 kW @ 1900 rpm
Gearboxes	5×Twin Disc MGX 61500 SC
Propulsion	5×Hamilton HT-810 waterjets
Generators	3×Cummins QSM 11 each 290 ekW
Bow Thrusters	3×Thrustmaster 30TT200ML
Speed	38 kn
Construction	Marine-grade aluminum
Flag	USA
Class/Survey	USCG Subchapter T, Oceans ABS A1 HSC Crewboat ✠AMS ✠DP2 Fire-fighting capable

Najla McCall on trials
(Photo courtesy Incat Crowther)

Nordic Barakuda from Incat Crowther

Incat Crowther has announced the delivery of the 30 m catamaran workboat *Nordic Barakuda*. Built at Marine Diesel Services, Singapore, the vessel was successfully delivered to Nordic Maritime in late 2015. *Nordic Barakuda* has been built on the expertise and experience which Incat Crowther has demonstrated in previous vessels such as *Unlimited, Limitless, Straight Shooter* and *Vejunas*. This vast experience has resulted in one of the most capable and versatile vessels of its type and size.

With seating for 60 day personnel, accommodation for an additional 10 overnight personnel, and six operational crew, the vessel will perform seismic and crew-supply roles in South East Asia.

Nordic Barakuda's 70 m^2 aft deck has a load rating of 3 t/m^2 with multiple lashing points to support the transit of containers and other freight. It has been fitted out with pad-eyes for towing, a 3 t A-frame, as well as an integrated winch base and a deck crane.

Dedicated to personnel in transit, the aft portion of the main-deck cabin features a four-person cabin, changing room, bathroom, showers, medevac, seats for 42 and ample luggage racks. Personnel accommodation continues in the hulls with a four-person cabin and a two-person cabin, both with en-suites. The forward end of the main-deck cabin features a crew galley and mess, as well as access to the hulls.

The hulls also house a cool room, a pantry and a laundry, further enhancing the vessel's long-range credentials.

Nordic Barakuda is powered by a pair of Caterpillar C18 main engines, each producing 533 kW. The vessel's service speed is 12 kn, with a top speed of 15 kn.

Principal particulars of *Nordic Barakuda* are

Length OA		29.9 m
Length WL		28.5 m
Beam OA		8.50 m
Depth		3.60 m
Draft	(hull)	1.35 m
	(propellers)	1.90 m
Personnel		60 day
		10 overnight
Crew		6
Fuel oil		31 500 L
Fresh water		1500 L
Sullage		1500 L
Main engines		2×Caterpillar C18
		each 533 kW @ 2100 rpm
Propulsion		2×propellers
Generators		2×Caterpillar C4.4 86 kVa
Speed	(service)	12 kn
	(maximum)	15 kn
Construction		Marine-grade aluminium
Flag		Indonesia
Class/Survey		ABS ✠ A1 HSC Crewboat

Stewart Marler

Nordic Barakuda on trials
(Photo courtesy Incat Crowther

NSW Cruising

The summer season continued through late February with visits to Sydney by *Seabourn Odyssey, Pacific Jewel, Diamond Princess, Dawn Princess, Arcadia, Azamara Journey, Carnival Legend, Voyager of the Seas, Pacific Pearl, Explorer of the Seas, Norwegian Star, Magellan, Queen Mary 2, Queen Elizabeth, Black Watch, Seven Seas Navigator, Carnival Spirit,* and *Noordam.*

The season wound down through autumn, with return visits in March by many of these vessels plus visits by *Celebrity Solstice, Aurora, MS Insignia, MS Sirena, Seabourn Alpha, Queen Victoria, Emerald Princess, Sun Princess, Pacific Dawn, Artania, Costa Luminosa, Radiance of the Seas,* and *Seabourn Sojourn.*

April saw return visits by some of these vessels and added visits by *Sea Princess, Pacific Eden,* and *Golden Princess*, while May only saw return visits.

Pacific Eden, Pacific Jewel, Pacific Pearl, Sun Princess, Sea Princess, Golden Princess and *Carnival Spirit* are scheduled for cruises over the winter months, the increasing number (up from two a couple of years ago) being indicative of the increasing demand for winter cruises. The arrival of *Seven Seas Expedition* on 20 September will signal the start of the next summer season.

Phil Helmore

HMAS *Success* Turns Thirty

On the evening of Friday 22 April 2016 a reception was held at Garden Island in Sydney to celebrate the thirtieth anniversary of the commissioning of the RAN's fleet underway replenishment ship HMAS *Success* on 23 April 1986.

HMAS *Success* was built by Cockatoo Dockyard and was the largest naval vessel constructed in Australia at that time and the last ship to be built in Sydney. Cockatoo Dockyard was closed at the end of 1992.

HMAS *Success* was the first ship to be built for the RAN to a French design. She was based on the second of the class to be built for the French Navy, *Meuse*, but incorporated some 41 Australian design changes and 140 material substitutions.

HMAS *Success* has always been very busy with operational commitments including a long deployment to the Middle East during the 1990–91 Gulf War, service at Bougainville, East Timor, border protection duties, Southern Ocean operations, RIMPAC exercises (she has missed only four of fourteen during her time) and, most recently, the search for MH370 in the southern Indian Ocean and six months in the Middle East on Operation MANITOU last year.

Since commissioning HMAS *Success* has deployed overseas every year except for 2012 and 2013. She has spent over 70 000 hours underway at sea and had steamed 909 670 n miles by the time she began a major refit by Thales at Garden Island last year. That refit, completed on time with sea trials just before her anniversary celebrations, will set the ship up for six more years of service until she is replaced by one of the two new underway replenishment ships to be built for the RAN by Navantia in Spain.

HMAS *Success* conducting a dual replenishment at sea with HMAS *Anzac* and HMNZS *Te Kaha* in the Mediterranean Sea on their way to Centenary of Anzac commemorations in Gallipoli and Greece last year
(RAN photograph)

FROM THE CROWS NEST

Costa Concordia Aftermath

The wreck of *Costa Concordia* — or at least, what's left of her — continues to be broken up in Genoa, Italy, in preparation for final demolition sometime later this year. According to GCaptain's February update, about 200 technicians were busy working on cutting Decks 5 to 3, while stripping internal fittings on Decks 2 and 1.

With the wreck lighter, crews continued to remove the sponsons which were used for flotation throughout the salvage, most recently with the removal of the sponson known as S3, and earlier S1 and P1. In the coming weeks, the sponsons S2, P2 and P3 will be disconnected from the ship and removed.

Operations are also continuing to restore the ship's buoyancy so that all sponsons can be removed and the wreck can be transferred to dry dock where final demolition will take place.

For the latest information, use the search function on the GCaptain website, www.gcaptain.com.

Hydrometer Calibration Revisited

It is some time since we last reviewed hydrometer calibration in the August 2005 issue of *The ANA*, and the National Standard for Commercial Vessels has come into force, replacing the Uniform Shipping Laws Code, so it may be timely to revisit the issue.

The National Standard for Commercial Vessels, Part C, Subsection 6C, Annex A has this to say about hydrometers and calibration:

A5.7 Hydrometer

A relative density hydrometer with a range sufficient to cover the anticipated density of the water in which the vessel will be measured shall be provided to measure the density of the water during the experiment. The hydrometer shall—

(a) be of glass construction;

(b) not have any signs of damage; and

(c) have a certificate verifying that it has been calibrated within the five years preceding the date of the inclining experiment.

NOTES:

1. Refer to Marine Notice 5/2006 for further information on the types and uses of hydrometers.
2. Metal hydrometers are no longer usually being accepted for calibration by the National Measurement Institute.

By way of explanation, Marine Notice 5/2006 has been superseded by Marine Notice 2/2012, and describes the differences between draft survey (apparent density) hydrometers and load line (relative density) hydrometers (visit https://apps.amsa.gov.au/MOReview/MarineNoticeExternal.html to download the current notice).

Marine Notice 2012/02 echoes the first sentence above, saying specifically

"These [draft survey] hydrometers should not be used for load line purposes."

It is worth noting that some other types of hydrometer also should not be used for load line purposes. In particular, hydrometers designed for use with petroleum products are for use with fluids of low surface tension, whereas water is of medium surface tension. If used in water, then such hydrometers would read too low a value of density.

Putting all of that together, for your inclining experiment you must be using a load line hydrometer, it must be of glass construction, and it must have been calibrated within the last five years.

Load line hydrometers are available from Carlton Glass Pty Ltd, PO Box 6331, Mooloolah, Qld 4553, phone (07) 5445 4999, email sales@carltonglass.com.au (the only known manufacturer in Australia). These are of glass construction and cost $266.20 + GST.

For calibration, there are a number of services available including, but not limited to:

- The National Measurement Institute at West Lindfield calibrates glass hydrometers for $943—this is a calibration traceable directly to international standards of length, mass and time. NMI says that there are no NATA-accredited laboratories in Australia which can perform this same calibration.
- CI Scientific Pty Ltd, 11/4 Garling Rd, Kings Park, NSW 2148, phone (1300) 2255 424, email service@ciscientific.com, calibrates load line or draft survey hydrometers for $519 + GST.
- HK Calibration Technologies has eight locations Australia wide (including Brisbane, Sydney, Melbourne, Hobart, Adelaide, and Perth), phone (1300) 309 881 email info@hkcalibrations.com.au, and calibrates hydrometers for $135 + GST.

Based on those figures, it is almost cheaper to buy a new glass load line hydrometer every five years!

If you know of other sources for purchase of glass load line hydrometers, or calibration services, then please let us know and we can publicise them in *The ANA.*

Calypso Shipped to Turkey for Renovation

Jacques-Yves Cousteau's ship, *Calypso*, one of the most-famous vessels in the world, has been shipped to Turkey, where she will undergo renovation.

Calypso was originally a minesweeper built by the Ballard Marine Railway Company of Seattle, Washington, USA, for the United States Navy for loan to the British Royal Navy under lend-lease. A wooden-hulled vessel, she was built of Oregon pine and launched on 21 March 1942. She was commissioned into the Royal Navy in February 1943 as HMS J-826 and assigned to active service in the Mediterranean Sea, based in Malta, and was reclassified as BYMS-2026 in 1944. Following the end of World War II, she was decommissioned in July 1946 and laid up at Malta.

In May 1949 she was purchased by Joseph Gasan of Malta, who had secured the mail contract on the ferry route between Marfa, in the north of Malta, and Mġarr, Gozo, in 1947. She was converted to a ferry and renamed *Calypso G* after the nymph Calypso, entering service in March 1950. After only four months on the route, Gasan received an attractive offer and sold her.

The Irish millionaire and former MP, Thomas Loel Guinness bought *Calypso* in July 1950 and leased her to Cousteau for a symbolic one franc a year. Cousteau restructured and transformed the ship into an expedition vessel and support base for diving, filming and oceanographic research. *Calypso* carried advanced equipment, including one- and two-man mini submarines developed by Cousteau, diving saucers, and underwater scooters. The ship was also fitted with a see-through bulbous bow/observation chamber 3 m below the waterline, and was modified to house scientific equipment and a helicopter pad. From 1951, *Calypso* then sailed the world undertaking scientific explorations.

On 8 January 1996, a barge accidentally rammed *Calypso* and sank her in the port of Singapore. She was raised by a 70 m crane, patched, and pumped dry.

The next year, Jacques-Yves Cousteau died on 25 June 1997.

Calypso was later towed to Marseille, France, where she lay neglected for two years. Thereafter she was towed to the basin of the Maritime Museum of La Rochelle in 1998, where she was intended to be an exhibit. A long series of legal and other delays kept any restoration work from beginning. In late 2006, Loel Guinness (grandson of Thomas Guinness) transferred ownership of *Calypso* to the Cousteau Society for the symbolic sum of one Euro. On 11 October 2007 the ship was transferred to Concarneau, France, where the Piriou shipyard commenced restoration, but progress was marred by further legal disputes.

On 6 January 2016 the Cousteau Society announced that a solution had been found to allow the ship to return to service and, on 14 March 2016, *Calypso* was loaded onto the chartered vessel, *Abis Dusavik,* for transport to Turkey, where she arrived on 25 March for the restoration work to be completed.

When renovated, *Calypso* will remain in the service of science and education, as Jacques Cousteau wished.

For further information, check out *MarineLink.com,* 30 March 2016, and Wikipedia, *https://en.wikipedia.org/wiki/RV_Calypso.*

Phil Helmore

First Ship to Transit the Expanded Panama Canal

China's COSCO Shipping has won the draw for the first transit through the expanded Panama Canal during the waterway's inauguration on Sunday 26 June 2016. The shipping line's container vessel *Andronikos* will be making the inaugural transit. The vessel, which has a maximum capacity of 9400 TEU, has a length of 299.98 m and a beam of 48.25 m. In addition, more than 100 neo-panamax ships have already made reservations for commercial transit through the new locks, which will begin on 27 June following the inauguration.

The Panama Canal invited its top customers to participate in the draw which took place on 29 April. Wallenius Wilhemsen Lines and COSCO Shipping participated in the draw. WWL participated with the car carrier *Thalatta*, which has a maximum capacity of 8000 CEU (car equivalent units), has a length of 199.97 m and a beam of 36.5 m.

"It is a great honour to have one of our top customers celebrate this historical moment with us," said Panama Canal Administrator, Jorge L. Quijano. "We are excited and prepared to continue providing the same reliable and efficient service within the Expanded Panama Canal that our customers have come to expect through the years."

More than 70 heads of state from around the world have been invited to the 26 June inauguration of the expanded canal.

www.maritime-executive.com

THE 21ST CENTURY AIRCRAFT CARRIER

John Jeremy

In the first decade of the 20th century, two technological developments were to radically change naval warfare — the submarine and the aircraft. The rapid adoption of these new craft was impressive. Last year we commemorated the centenary of the landings at Gallipoli on 25 April 1915. Few will be aware that this landing was supported by aircraft from one of the Royal Navy's first aircraft carriers, HMS *Ark Royal*.

The development of the aircraft carrier was rapid, considering how new the technology was and how much it challenged well-established beliefs in the nature of naval power. Many could see that both the submarine and the aircraft were to revolutionise warfare at sea, but belief in the big-gun battleship persisted for many years.

World War II soon changed everything. Swordfish torpedo bombers from HMS *Victorious* and HMS *Ark Royal* played a significant part in the sinking of the German battleship *Bismark* on 27 May 1941 [1] but, if there was one engagement which demonstrated the power of the aircraft carrier, it was the Battle of Taranto on 11 November 1940, thirteen months before Japanese carrier-borne aircraft changed the course of World War II in a similar attack at Pearl Harbour. Swordfish torpedo bombers from HMS *Illustrious* attacked the Italian fleet putting three battleships out of action — two were disabled for five and six months and one never went to sea again [2].

Illustrious was soon to suffer greatly at the hands of the Luftwaffe. On 10 January 1941 she was attacked by 40 Ju.87 and Ju.88 dive bombers assisted by Italian high-level and torpedo bombers. She was hit by six heavy bombs and completely disabled as an aircraft carrier with 200 of her crew killed or wounded. She managed to reach Malta, but was further damaged by air attack there and had to be sent to the United States for repair [3,4].

The survival of *Illustrious* was attributed by some to her armoured flight deck or, more accurately, her armoured hangar. The design of British aircraft carriers during the 1930s was unique — they were the only carriers built with armoured hangars to protect them from air attack. The aircraft carrier was a powerful weapon system of attack but it was less able to defend itself from attack by aircraft, relying heavily on its escorts for defence and the hangar was a vulnerable target, full of valuable aircraft and inflammable aviation fuel. The added mass of the armour high in the ship and the need to design ships within treaty limits constrained the size of the ships and reduced the number of aircraft they could carry. The last British fleet aircraft carrier design of World War II, that of *Gibraltar*, *Malta*, *New Zealand* and *Africa*, cancelled in 1945, was largely unarmoured. The carriers developed by the other major maritime powers, notably the United States and Japan, had so-called open hangars — unarmoured hangars and flight decks — and consequently were less able to withstand concentrated air attack than their British contemporaries. The real difference between the British and the other carriers lay in the hull design. In the British ships, the flight deck was the uppermost strength member of the hull. In the US and Japanese ships the hangar deck was the uppermost strength member and the hangar and flight deck were superstructure and most ships had unarmoured flight decks.

As US Navy carriers increased in size, their shallow hull girder meant that they suffered higher hull stresses than the British ships and it was logical that the US would adopt the British-style hull for post-war designs. The need for a strong hull girder meant that the flight deck of these later designs was particularly strong, affording a good deal of protection to the hangar but that protection was not the primary consideration [5].

The flight deck of the World War II built Essex-class carriers was completely unprotected. This is USS *Franklin* on 19 March 1945 after being hit by two 250 kg bombs which penetrated the flight deck and exploded amongst fuelled and armed aircraft in the hangar. Most of the damage to the ship was done by her own aircraft and munitions. 807 men were killed. *Franklin* survived and managed to return home but had to be rebuilt from the hangar deck up and was never reactivated (US Navy photograph)

At the end of World War II, both the Royal Navy and the US Navy had large numbers of aircraft carriers, mostly new, ranging from large fleet carriers to escort carriers. The latter were simple ships usually based on merchant-ship hulls and were intended as anti-submarine carriers. The large number of available ships provided opportunities for other navies to adopt the aircraft carrier as a major element of their fleets, including Australia which successfully operated three of the British light fleet carriers.

The usefulness of these large numbers of ships was affected by the rapid development of aircraft during the war, which had grown in capability but also in size and mass. The advent of the jet engine placed further demands on the ships which were to carry them. Three British developments were to become a feature of the post-war carriers as they were modernised or designed to operate the new-generation aircraft — the angled flight deck, the steam catapult and the mirror landing aid. The largest of the British World War II designed carriers to be completed, *Eagle* and *Ark Royal*, were completed in 1950 and 1955. From the outset, *Ark Royal* had the new design elements which were also fitted to *Eagle* during modernisation.

There was a new weapon available in 1945 which was also to greatly influence the design of the post-war carrier, the atomic bomb. At that time, the atomic bomb weighed something like 5 t and required an aircraft with a take-off weight of about 45 t to deliver it. This requirement drove the development of the super carrier intended to be USS *United States*. This design was notable in that the island superstructure was dispensed with — although this gave enormous problems with the disposal of funnel gases which adversely affect flying operations. As the design proceeded, the size of the ship grew and another restriction came into play — the size of available docks for her construction and later docking. As finally developed, the ship had an overall length of 330 m, a moulded beam of 43 m and a flight deck beam of 57.6 m. The ship was to be powered with steam turbines of 209 mW for a speed of 33 kn. Although designed with an armoured flight deck, the ship was not as well protected as the earlier *Midway*, the first US carrier design with an armoured flight deck. CVA 58, as she was designated, was defeated by the development of heavy land-based bombers and she was cancelled on 23 April 1949. The fact that the US already had a large number of new ships which were capable of modernisation was also a factor [6].

Between 1945 and 1950, US carrier operations were refocussed from strategic strike to tactical strike and lighter atomic bombs and aircraft to deliver them became available. The large carrier design was revived, resulting in the construction of the Forrestal-class aircraft carrier of which eight were built, four of an improved design, all completed between 1955 and 1968. The design owed much to the design of CVA 58 and it incorporated the angled flight deck and steam catapult. The ships had a full load displacement of 77 250 t, an overall length of 315 m, waterline beam of just-under 39 m and a flight deck beam of 75.8 m. The ships could carry about 70 aircraft, depending on the mix, and were designed to achieve 32 kn at 194 mW. Her complement comprised a crew of 2641 and an air group of 1675 for a total of 3316 [7].

USS *Forrestal* was the first of the new-generation post-war aircraft carriers built after 1955 for the US Navy
(US Navy photograph)

Today it would seem inevitable that nuclear power would be considered for these large aircraft carriers but, in the 1950s, it was their escorts which had priority. The carriers had enormous capacity for fuel, which actually comprised part of their protection against torpedo attack, but they also required regular replenishment of aviation fuel which needed a fuel-supply chain. However, nuclear power provides vast reserves of energy which can make the liquid fuel, used to fuel non-nuclear escorts, go further whilst also providing all the power required for the ship to steam at high speed for long distances with the reserves needed for flight operations. The first US nuclear aircraft carrier was USS *Enterprise*, completed in October 1961. Her full load displacement was 87 036 t with an overall length of 331 m, waterline beam of 40.3 m and extreme beam of 77.3 m. She could carry about 70 aircraft of up to 36 t, launched by four steam catapults. *Enterprise* was powered by eight reactors delivering 209 mW for a speed of about 33 kn. Her total complement was 4980 men [8].

USS *Enterprise* at anchor in Sydney Harbour
during her world cruise of 1964
(Photograph John Jeremy)

It has been said that the value of nuclear power in these large ships was not really appreciated until a task force comprising *Enterprise*, the nuclear cruiser *Long Beach* and the frigate *Bainbridge* demonstrated the power-projection capability of the group by completing a round-the-world cruise in 1964 — it was during this voyage that *Enterprise* visited Sydney. These large and very costly ships are regarded by many as a vulnerable target but there has been at least some evidence to prove just how tough they can be. Fire is an enormous risk in an aircraft carrier where large quantities of aviation fuel and munitions are being handled constantly and many important advances in fire-fighting technology have been developed in aircraft carriers. A major fire occurred on board USS *Forrestal* in 1967 during operations off Vietnam. An aircraft started 'hot' — shooting a long tongue of flame into parked aircraft, setting off a missile and starting a chain reaction with bombs cooking off and blowing seven holes in the flight deck. The fire burned for 13 hours and left 134 dead and 64 injured. There was a similar fire on board USS *Enterprise* in January 1969. Bombs blew five holes in the flight deck, which sagged under the heat. Remarkably, the ship was able to resume flying operations within four hours. [9]

USS *Enterprise* on fire in January 1969
(US Navy photograph)

USS *Enterprise* was a very expensive ship and, for some time, design effort was spent trying to produce a less-expensive nuclear carrier. However, aircraft carrier design is volume driven, and the next design, CVN 68, had a hull based on *Enterprise* but with the flight deck of the last of the conventionally-powered US carriers, USS *John F Kennedy* (CVA 67). USS *Nimitz* (CVN 68) was completed in May 1975. Since then nine sister ships have been built to this design — the last, USS *George H. W. Bush*, was completed in January 2009. Changes have been incorporated over the construction period, particularly in the last two ships. The full load displacement of the ships has grown from 90 647 t (CVN 68) to 105 248 t (CVN77). Dimensions were once again dictated by the available shipbuilding facilities and were similar to the earlier ships. The number of aircraft carried naturally depends on the mix but is around 70 aircraft. The ships are propelled by two Westinghouse nuclear reactors delivering 209 mW to four shafts. The total complement is about 5820.

The Nimitz-class aircraft carrier USS *Carl Vinson* (CVN 70) underway in the Indian Ocean (US Navy photograph)

The design of the Nimitz-class carriers is now very old. Early this century, design work was begun on a new class of carrier which would incorporate many new technologies and become the standard for construction into the 21st century. The design was generally based on the Nimitz-class hull but the ship is substantially a new design.

Improvements in the design of CVN 78 include new reactors and propulsion plant (she is an all-electric ship), a new, smaller island moved well aft to maximise space on the larger flight deck, electro-magnetic catapults (EMALS) instead of steam catapults, advanced arresting gear which is lighter than the present system and is software controlled to reduce wear and tear on aircraft, major internal rearrangement, electromagnetic weapons lifts and a manpower reduction of about 500 people. Other new technologies include a dual-band radar which helps to reduce the size of the island.

CVN 78 will have about 2.5 times the electrical generation capacity of the Nimitz class and is planned to have a 25–33% increase in the daily sortie rate. Aircraft capacity will be similar to the earlier ships — about 75 aircraft.

The US Navy expects a reduction of the through-life maintenance cost of the new-design ship of about $4 billion. This is to be achieved by the elimination of steam-driven auxiliaries and steam service throughout the ship, fewer overall components — one third to half as many valves, the elimination of 70 sea chests, three instead of four aircraft elevators and two instead of three hangar bays. High-efficiency lighting will be fitted throughout the ship and the air-conditioning system will be improved. There will be one half-life refuelling and the ship is designed for a 43 month maintenance cycle with the interval between dry-docking periods extended to twelve years [10]. Considering that the life of the new ships is expected to be fifty years, the saving is surprisingly small.

Noting that the design for CVN 78 and her sister ships is the first new US carrier design in about forty years, it is not surprising that it is the first to adopt 3D computer modelling and computer-aided design from the outset. The cost of the detailed design and non-recurring engineering for the new ship is about $US3.3 billion.

All US aircraft carriers ordered since 1958 have been built by Newport News Shipbuilding at Newport, Virginia. Now part of Huntington Ingalls Industries, this is the only

The aircraft carrier USS *Harry S. Truman* (CVN 75) during full-power steering-gear trials in the Atlantic Ocean (US Navy photograph)

An aerial view of Newport News Shipbuilding, looking south-west, on 3 June 2013. The aircraft carrier *Gerald R. Ford* (CVN 78) is under construction in the foreground. The carrier USS *Enterprise* (CVN 65) is arriving in the background for inactivation.
(Photo by John Whalen, Newport News Shipbuilding)

shipyard in the United States capable of building nuclear-powered aircraft carriers. The first order for CVN 78, now named *Gerald R. Ford*, was placed with NNS in May 2004 for detailed design, long-lead procurement and advanced construction. Cutting of steel and fabrication began in August 2005, but the full construction order was not placed until September 2008. USS *Gerald R. Ford* was launched on 19 November 2013 and the first of the crew moved on board in the middle of 2015. She will be delivered to the USN in September 2016 [11].

The cost of these new carriers is very high. *Gerald R. Ford* is expected to cost $US12.9 billion, about 22 per cent more than originally expected. Much of the cost increase has been due to problems and delays with the new technology incorporated in the design. The cost in manhours is equally sobering. *Ford* is consuming some 55.8 million manhours. The cost of maintenance of these nuclear-powered carriers is also staggering. USS *Dwight D. Eisenhower* (CVN 69), the second-oldest of the Nimitz-class carriers, completed a 23-month ‘dry-docking planned incremental availability’ on 28 August 2015. The workload, which grew by 50% during the availability, required about 10 million manhours to complete [12]. The mid-life refuelling and complex overhaul of USS *Abraham Lincoln* (CVN 72), expected to be completed in 2016, will have taken 44 months and consumed 23 million manhours [13].

Not surprisingly, the US Navy is under great political pressure to reduce the cost of these ships. At least two more Ford-class carriers will be built, USS *John F. Kennedy* (CVN 79) and USS *Enterprise* (CVN 80) planned for delivery in 2023 and 2027 respectively. To meet US Congressional

Gerald R. Ford (CVN 78) after floating out of her building dock in November 2013
(US Navy photograph)

requirements for eleven carrier battle groups to be maintained, further ships will need to be commissioned in 2032, 2037, and 2042 — and that is perhaps far enough to look ahead. Each ship will take about nine years to build.

The US Navy and the shipbuilder have agreed to make changes in the construction program to reduce cost. The guiding principles are

- maximise planned work in the shops and early stages of construction;
- revise the sequence of structural-unit construction to maximise learning-curve performance through ‘families of units’ and work cells;
- incorporate design changes to improve producibility;
- increase the size of erection units to eliminate

disruptive unit breaks and improve unit alignment and fairness;

- increase outfitting levels for assembled units prior to erection in the dry-dock; and
- increase overall ship completion levels at each key event.

The shipbuilder also intends to:

- increase the amount of temporary and permanent covered work areas;
- add ramps and service towers for improved access to work sites and the dry dock; and
- increase lift capacity to enable construction of larger, more fully outfitted blocks.

The targets for CVN 79 include:

- the ship to be 75 per cent complete at launch (15 per cent better than CVN 78);
- 85–90 per cent of cable to be pulled prior to launch (25–30 per cent better);
- 30 per cent increase in front-end shop work (piping details, foundations, etc.);
- all structural unit hot work complete prior to blasting and painting;
- 25 per cent increase to work package throughput;
- 100 per cent of material available for all work packages in accordance with the integrated master schedule;
- zero delinquent engineering and planning products; and
- resolution of engineering problems in less than 8 hours [14].

This last target seems ambitious but one might wonder why most of these ambitions weren't achieved many years ago. The keel of USS *John F. Kennedy* (CVN 79) was laid on 22 August 2015. Further into the future, the shipbuilder intends that CVN 80 will be built without 2D paper plans. All production information will be provided in 3D on tablets.

The other large 21st century aircraft carrier approaching completion at present is the largest ship ever built for the Royal Navy — HMS *Queen Elizabeth*.

The rapid development of aircraft during World War II meant that the Royal Navy had six fleet carriers which were unable to operate modern aircraft. Their hangars had insufficient height and the permissible aircraft mass was limited. With a perceived need for nine fleet carriers by 1950, plans were developed for the reconstruction of the earlier ships, which had an estimated remaining hull life of 20 years, to supplement *Eagle* and *Ark Royal* when completed. Reconstruction was considered to be far cheaper than building new ships [15]. The reconstruction of *Formidable* and *Victorious* was approved to a standard similar to the large light fleet carrier *Hermes*, then due to be completed in 1952.

Work started on *Victorious* at Portsmouth Dockyard in October 1950 at an estimated cost of £5.4 million. The work was extensive. Whilst the armoured flight deck was retained, the ship was completely rebuilt from the hangar deck up. The beam was increased, all electric cables were replaced, the boilers were replaced, the auxiliary machinery was replaced and the generating capacity doubled. The work grew as it proceeded, adding an angled flight deck, new radar and US 3-inch (75 mm) guns. The cost increased enormously and

An impression of the future USS *John F. Kennedy* (CVN 79)
(Image Newport News Shipbuilding)

A module of *John F. Kennedy* (CVN 79) being placed
in the building dock in April 2016
(Photo by John Whalen, Newport News Shipbuilding)

plans to modernise other ships were abandoned in 1952. *Victorious* was not completed until 1958, by which time the cost had risen to £30 million, nearly six times the original estimate.

The construction of *Hermes* was delayed, as priority was given to finishing HMAS *Melbourne* and she did not complete until 1959. She ultimately played a major role in the Falklands war and has subsequently served in the Indian Navy until paying off this year.

In 1952–53 some work was done to develop a new 56 000 t carrier design more suitable to operate modern jet aircraft. First steps to acquire a new ship began in 1958. She was initially intended to replace *Victorious* but, by 1963, to replace both *Victorious* and *Ark Royal*, with two further ships to replace *Hermes* and *Eagle* in due course. By early 1963 a sketch design had been selected which was developed into the final design by December 1965 [16].

CVA-01, as the ship was known, had a full load displacement of 54 983 t and an overall length of 292 m. Her waterline beam was 37 m and the overall beam was a little over 70 m. The flight deck was to be constructed of 32 mm thick QT 35, a high-strength notch-tough steel used for the pressure hull of nuclear submarines, and QT 35 was also specified for the hangar deck and part of the longitudinal under-water protection scheme. The amount of QT 35 was reduced late in the design process to make the ship easier to build.

Propulsion was to be by steam turbines delivering 100 mW on three shafts for a maximum speed of 30 kn. She was intended to carry a mix of 47 aircraft with a mass of up to 32 t.

Construction of the ship posed a considerable challenge. By the mid-1960s the British shipbuilding industry had changed a great deal. There was little enthusiasm for the project amongst the builders and it seemed likely that only one consortium of Tyneside builders might bid.

The final design was approved on 27 January 1966, but the project was cancelled on 14 February, just before the tender documents were to be issued. CVA-01 had incorporated many risky innovations and the project leader, Prof. Louis Rydill, said in 1966 that 'cancellation was the happiest day in my life'.

British carrier aviation waned in the following years. After 1966 the carrier was seen more as a means of operating helicopters in an anti-submarine or commando-carrier assault role. The successful development of a VSTOL aircraft, the remarkable Harrier, reprieved fixed-wing carrier aviation with the design and construction of the Invincible class, initially described as 'through-deck cruisers'. The first ship, HMS *Invincible*, was ordered in April 1973, although the decision to incorporate Harriers was not made until May 1975. The operational payload of the Harriers was greatly increased by the development of the ski-jump and the first was fitted to *Invincible* when she was completed in July 1980 [17].

HMS *Invincible* was a small ship of 19 855 t, a little over 205 m long overall, and her aircraft capacity was limited. However, the great advantage of carrier-borne fixed-wing aircraft, even in a small carrier, was dramatically demonstrated during the Falklands war in 1982. Winning that war might not have been possible without *Invincible* and *Hermes* and their Harriers. The development of successful VSTOL aircraft has also put fixed-wing carrier aviation within the reach of many other navies. *Invincible* and her two sister ships, *Illustrious* and *Ark Royal*, have now gone, but their legacy is evident in the growing number of small carriers being built today.

The British Strategic Defence Review of 1998 identified a requirement for two new aircraft carriers to replace *Invincible*, *Illustrious* and *Ark Royal*. A project team was established to develop and assess the various options for the new ships with the intention of placing a design and construction contract in 2008 with the ships to be completed in 2014 and 2016. Competitive industry studies were begun by BAE Systems and Thales in 1999. In 2001 the Joint Strike Fighter (now known as the F35 Lightning II) was selected and the options were reduced to catapult launch and arrested recovery (CV) or short take off vertical landing (STOVL) versions of the ship [18].

In September 2002 the decision was made to adopt the F35 STOVL variant, but to design the ship to be able to be converted for CV operations later in the ship's life. By mid-2006 the design was sufficiently complete to allow accurate cost estimates to be made. The cost was higher than anticipated and changes were made to policies and standards to reduce cost without changing the arrangement of the ship. A construction contract was placed for two ships in July 2008 and structural fabrication began in January 2009.

The ships are being built by the Aircraft Carrier Alliance which, in 2005, comprised the UK Ministry of Defence, Babcock, BAE Systems, Thales UK and the VT Group. Later the VT Group sold its shipbuilding operations to BAE Systems and there are now four members of the ACA. By the time this project had begun, the British shipbuilding industry was even slimmer than that which was asked to consider building CVA-01. The only practical means of constructing the new carriers was for industry to share the work, with large sections of the ship, or modules, being constructed by the members of the alliance in Portsmouth, Glasgow, Appledore and Rosyth, with the modules all being brought together in Rosyth for assembly and completion by Babcock.

The design finally accepted is a 66 183 t ship with an overall length of 280 m and an overall beam of 70 m with a depth to the flight deck of 29 m. The ship is designed to carry about 34 aircraft, a mix of F35Bs and Merlin helicopters, and the ability to operate up to 40 aircraft for short periods of time. The 13 000 m^2 flight deck has a runway leading to a single ski-jump. There are two islands, an arrangement adopted for spatial considerations, survivability and sensor separation. The bridge is located in the forward island and FLYCO (the flying control centre) in the aft island, although there is some degree of interchangeability.

There is a gallery deck below the flight deck which provides space for the future fitting of conventional launch-and-recovery equipment. The ship is all electric, with power being provided by two Rolls-Royce MT30 gas turbine driven alternators and four large diesel alternators. The total installed power is 110 MW. Propulsion is by electric motors on two shafts for a maximum speed of around 26 kn and a range of up to 10 000 n miles.

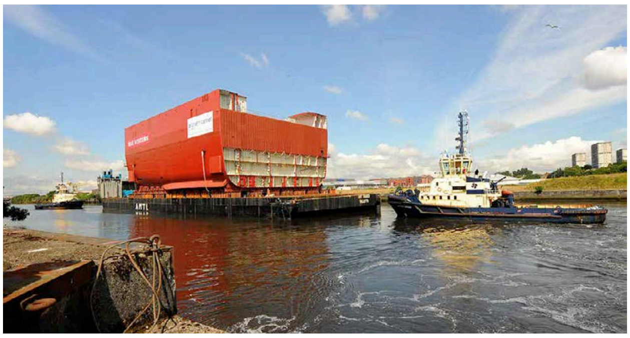
The ship has a full complement of 1600, of which the ship's crew number 679. This relatively low number has been made possible by the mechanisation of weapons handling systems and extensive automation. The crew are all accommodated in cabins with a maximum normal occupancy of six. This contrasts with the maximum of 40 per space in the latest US carriers.

The carriers are the first British warship to be designed from the outset to Lloyd's Naval Ship Rules with Lloyd's commercial rules applied to equipment where appropriate. Defence standards apply only where essential for survivability, shock, and self-defence, for example.

The design of these ships is particularly notable for their design for production and support. The hulls are divided into five vertical zones which are as autonomous as possible to maximise survivability and help the build strategy of assembly from super-blocks as fully fitted out as possible before assembly in the dock. Accommodation is modular to simplify installation and outfit.

The largest block, Lower Block 04, was built for each ship in Glasgow and was shipped to Rosyth, like all others built away from Rosyth, by barge. The block weighed about 11 000 t and in all the blocks, fitting out was well advanced before delivery.

The construction of the Queen Elizabeth-class carriers has been controversial, not least because they constitute an enormous proportion of Royal Navy expenditure and resources. In October 2010 the UK MOD decided to change the version of the F35 to be operated from the carriers to



With fitting out well advanced, Lower Block 04 for HMS *Prince of Wales* on the way to Rosyth (Photo Aircraft Carrier Alliance)

the catapult-launched version, the F35C. The ships were, after all, designed with such a change in mind. However, a considerable redesign of the ships was necessary to incorporate the US electro-magnetic catapults and advanced arresting gear, both of which were suffering delays. In 2012 it was decided that the additional cost and delay was unacceptable and the project reverted to the original choice of aircraft. This indecision was expensive and added to the already substantial growth in the cost of the ships and their aircraft [19]. When completed, the ships will also be able to operate a range of helicopters in a combined operations role, including Chinook and Apache helicopters and the V22 Osprey tilt-rotor aircraft.

The first of the carriers, HMS *Queen Elizabeth* was launched on 4 July 2014. She is expected to be commissioned in May 2017 (three years late) and achieve full operational capability in 2020. The assembly of HMS *Prince of Wales* is already well advanced and the work is benefitting from the experience with the first ship. She is expected to be completed in 2020 (four years late). The delays and indecision surrounding this project have resulted in considerable cost growth. From an original estimate of £4 085 million in 2007, the cost had risen by 2013 to £6 200 million (about $10.3 billion). It is realistic to expect that it will rise further before both ships are operational.

It seems inevitable that the construction and operation of the modern attack aircraft carrier is to become the privilege of a select few wealthy nations. In May 2001 France commissioned the nuclear-powered aircraft carrier *Charles de Gaulle*, a 43 783 t carrier with the capacity for about 40 aircraft. Designed in the 1980s, *Charles de Gaulle* was ordered in February 1986, but her construction was delayed by budget cuts and design changes. A second carrier, PA 2, was included in the 2003–08 French defence plan and, in 2004, it was announced that the ship was to be built in cooperation with the British programme. Since then a decision to proceed with the ship has been deferred, and it now seems likely that the planned ship may ultimately be built to replace *Charles de Gaulle* at the end of her service life in the 2040s. Studies for a new ship are, however, continuing.

Russia operates one 59 000 t aircraft carrier, *Admiral Kuznetsov*, completed in 1990. There are plans for a new class, but funding is a problem and any new ships seem a long way off.

China, meanwhile, is learning how to operate a carrier with a Kuznetsov-class ship purchased incomplete from Russia. *Liaoning* was commissioned in 2012 and China has plans to build a Chinese-designed carrier for completion about 2025.

India has ambitious aircraft carrier plans for its navy. Having operated two British-built ships for many years, India acquired a carrier from Russia which was completed in 2013 — the ship had been under construction since 1978. A 40 000 t Indian designed and built carrier, INS *Vikrant*, was recently launched for completion by 2018. All these

HMS *Queen Elizabeth* after her launching at Rosyth, Scotland (Photo Aircraft Carrier Alliance) ships depend on STOVL aircraft, but design work has started on a 65 000 t carrier with catapult-assisted take-off and arrested recovery capable of carrying around 35 fighters and 20 helicopters (although perhaps not all at once). India approached defence firms in Britain, France, Russia and the United States for assistance with the design of *Vishal* and nuclear propulsion is being considered. It seems that a Russian design may be favoured. As no Indian shipbuilder has the capacity to build such a ship at present, construction may be some way off.

Other nations operate carriers with fixed-wing aircraft. Spain and Italy are examples. The Italian Navy's multi-role carrier *Cavour* stands out. This 27 000 t ship was built between 2001 and 2009. Gas-turbine powered, *Cavour* has capacity for 20 fixed wing aircraft and helicopters. She operates Harriers at present, but there are plans to modify the ship to operate F35Bs by 2017. [20]

The Italian Navy's multi-role carrier *Cavour*
which was completed in 2009
(Italian Navy photograph)

If one looks beyond the larger fixed-wing aircraft carriers, there are many ships in the world's navies which are capable of operating aircraft. They include ships like the US Navy's recently-commissioned amphibious assault ship USS *America* (LHA 6). In addition to helicopters, this 45 820 t ship can operate and support the MV22 Osprey and up to 23 F35B STOVL aircraft.

An aircraft carrier in all but name — the amphibious assault ship
USS *America* (LHA 6)
(US Navy photograph)

On 27 August 2015 Japan launched the second of a new class of helicopter carrier (classified as a destroyer in Japan). *Kaga* displaces 24 437 t at full load and, in 2017, will join her sister ship *Izumo*, completed in March 2015, as one of the largest ships in the Japanese navy. Two similar, but smaller, ships were commissioned in 2009 and 2011. *Kaga* and *Izumo* have the potential to operate F35Bs, but Japan has no plans at present to do so.

In 2007 Korea completed *Dokdo*, an amphibious ship of 19 000 t with the capability of operating ten helicopters. A second ship, *Marado*, has been funded and it has been suggested that this ship might be fitted with a ski-jump to enable her to operate VSTOL aircraft.

Of course, we must not forget our own ships — HMAS *Canberra* and HMAS *Adelaide*. Whilst these ships are intended only to operate helicopters in RAN service, the ship on which they are based, *Juan Carlos I*, is operated by the Spanish Navy as an aircraft carrier, at present with Harriers, but with the capability to operate F35Bs in future.

Helicopters are, of course, a normal part of the weapons fit in modern destroyers and frigates. Helicopters can now be operated from remarkably small ships and are likely to be provided for in many offshore patrol craft where they can dramatically improve the ship's capability.

One type of aircraft which is developing rapidly today is the unmanned aerial vehicle or UAV. They have been around for a long while — remember the Australian target drone *Jindivik* which first flew in 1952 — but today they come in many sizes and are capable of many roles from surveillance to attack. The US Navy recently completed trials with a demonstration unmanned combat air vehicle, the Northrop Grumman X-47B. This aircraft was capable of semi-autonomous operation from a conventional aircraft carrier. Further development of this concept has been deferred in favour of an unmanned airborne refuelling aircraft.

An X-47B Unmanned Combat Air System demonstrator is
launched from the aircraft carrier USS *George H.W. Bush*
(CVN 77) on 14 May 2013 in the Atlantic Ocean
(US Navy photograph)

Not all UAVs of the future will be so large and complex. Many will be capable of launching from small ships and the equipment required can be quite simple. Recovery is a much greater challenge. Rotary-wing UAVs can easily operate from existing flight decks, but the recovery of fixed-wing UAVs by small ships at present is either by ditching or the use of some form of crash barrier. This is an interesting challenge for warship designers in the near future.

Another major challenge for warship designers is how to contain the enormous cost and lead time for the modern aircraft carrier. In 1982 the US Navy developed a portable, modular aviation facility for installation on container ships, known as project ARAPAHO. Sea testing was carried out in

The ability of ships like HMAS *Canberra* and her sister ship *Adelaide* to operate a wide range of rotary wing aircraft and, when so fitted, STOVL fixed-wing aircraft, is redefining the role of the aircraft carrier in the 21st century
(RAN photograph)

late 1982, but by then the concept had been tried in anger by Britain during the Falklands War earlier that year. The rapid conversion of commercial ships proved invaluable, but the vulnerability of such conversions was also demonstrated when *Atlantic Conveyor* was destroyed by two Exocet missiles on 25 May 1982, together with all the aircraft remaining on board at the time.

Similar proposals appear today — even suggesting the deployment of aircraft like the F35 from such platforms. Considering the extremely high cost of the aircraft and the people who fly and maintain them, these attempts at economy are a very high-risk solution.

As today's aircraft carriers are designed for lives of up to half a century, perhaps the greatest challenge for the warship designer is to design ships to operate for decades into the future with payloads which are not yet even the gleam in anyone's eye.

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Australian Maritime College Sim Centre Upgrade

Students and commercial clients now have access to the latest in state-of-the-art simulation training technology thanks to a $1.4 million upgrade at the Australian Maritime College, a specialist institute of the University of Tasmania.

The upgrade includes the world's first installation of Panasonic's ultra-high resolution 4K Full Mission Bridge Simulation Projection System, providing users with unparalleled realism.

"This upgrade provides a higher level of immersion in the simulator," AMC Centre for Maritime Simulations Manager, Damien Freeman, said.

"The image is clearer, brighter and more colourful with less visible pixels, so the user experiences a more-realistic perception of the simulated environment."

AMC National Centre for Ports and Shipping Director, Prof. Thanasis Karlis, said that the $660 000 projection system was part of a multi-stage upgrade, including the installation of two 360-degree tug simulators plus new desktop simulator software specialising in liquid-cargo handling and engine room operations.

"These significant upgrades have allowed us to reconfigure the Centre for Maritime Simulations to meet the changing needs of our clients and students, and we're pleased to be able to offer them the most advanced simulation training experience in the world," Prof. Karlis said.

"Our facilities are used for maritime human factors research and investigation into port development, ship manoeuvring, and improving ship and port safety. They also help bridge the gap between theory and practice in the training of ship masters and deck officers. The upgraded Panasonic projector system enhances that capability and ensures that AMC continues to be a leader in maritime simulation."

An interactive, 60 inch (152 cm) electronic chart table has also been developed in-house to record training sessions in the ship simulator and provide clients with debriefing capabilities. The final stage of the upgrade will be the installation of a stand-alone, touch-screen engine room simulator, expected to come online mid-2016.

Damien Freeman said that touchscreen technology was a recent advancement for training simulators and would allow for a more tailored experience.

"The advantages of having touch-screen and computer displays are that you can load a variety of different engines and bring them up to do type-specific training. So the students will be virtually trained using the engines they encounter in the real world," he said.

"The major benefit of using simulators is that they allow you to do high-risk and contingency training. If you get something wrong and the engine seizes, we can just reset the exercise. You can't do that in real life."

The Panasonic System

- The Panasonic projectors are the world's lightest 3-chip DLP laser projectors with 4K resolution available today, offering unprecedented image quality.
- AMC's set-up uses five projectors which each produce 10 000 lm brightness and a 20 000:1 contrast ratio.
- Images are sent from a computer in a remote server room via HDMI to a Lightware HDBaseT transmitter. The signal is then converted and transmitted 30 m via CAT6 cable directly to each projector.
- The images are projected on to a 240-degree, 7.2 m radius by 4.5 m tall cylindrical screen and viewed from the cabin of the main bridge ship simulator.

About the Centre for Maritime Simulations

The Australian Maritime College's Centre for Maritime Simulations features some of the world's most advanced simulation equipment, including:

- Full-mission ship's bridge simulator.
- Two, 360-degree tug simulators.
- Advanced dynamic positioning bridge simulator.
- Six basic dynamic positioning simulators.
- Six ship operations cubicles and an 18-seat electronic chart display lab.

The simulator database includes most Australian and New Zealand ports, as well as areas of Europe, Malaysia, and Indonesia. AMC also provides regular pilot simulation training to maritime organisations such as TasPorts, Newcastle Ports Corporation, Rio Tinto, Port Kembla, Southport (NZ), TT Line, Woodside Energy and Port Nelson.

AMC Centre for Maritime Simulations Manager, Damien Freeman, in front of the main projection screen (Photo by Simon Brooke, courtesy AMC).

World-first Trial Aims to Harness Potential of Wave-energy Farms

Key players in the ocean renewable-energy sector have met at the Australian Maritime College to observe a world-first trial testing the performance and impact of wave-energy farms at model scale.

A number of wave-energy devices were grouped together in an array for a series of experiments under various wave conditions in the model test basin during the six-week trial.

The project is a collaboration between AMC and Swinburne University of Technology, with industry partners BioPower Systems and Carnegie Wave Energy, and supported by funding from the Australian Renewable Energy Agency (ARENA).

Swinburne University of Technology project lead, A/Prof.

Richard Manasseh, said that the information gleaned from these experiments would be used to develop a free online modelling tool to assess the ocean wave energy resource in a particular area.

"This research will give industry and investors an impartial assessment of the performance of wave-energy farms and provide greater confidence when negotiating large developments. It may also uncover the best arrangements for the devices to provide optimum performance," A/Prof. Manasseh said.

Researchers converged on AMC to discuss two ARENA-funded ocean-energy projects. ARENA CEO, Ivor Frischknecht, said that the two-day meeting would provide an overview of the projects, identify links and explore opportunities for them to work together in the future.

"This is an excellent example of knowledge sharing, bringing together expertise from across Australia's wave-energy sector. This kind of collaboration is critical to advancing renewable energy in Australia and is actively encouraged by ARENA," Mr Frischknecht said.

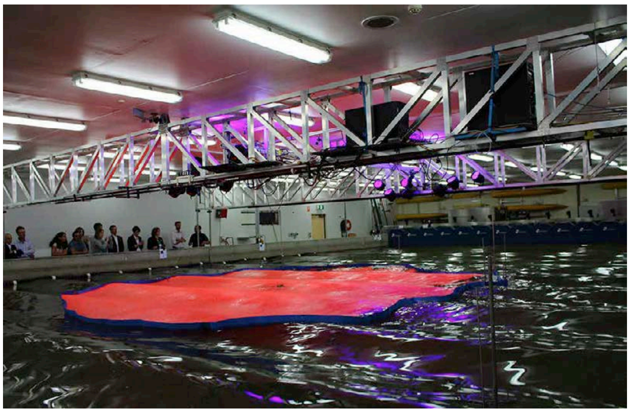
"Wave arrays enable economies of scale, so determining how devices interact in the ocean will be crucial to the commercialisation of wave power. Testing at AMC could one day lead to wave-energy arrays being deployed off Australian coastlines or islands, feeding affordable renewable energy to onshore users."

The second project is the Australian Wave Energy Atlas project, led by CSIRO in collaboration with the Bureau of Meteorology and AMC, with industry partners Carnegie Wave Energy and Biopower Systems.

"The Atlas project is focused on removing obstacles for Australia's ocean-energy industry. This includes making baseline information on the available energy resource and allocations of the marine domain easily available to the sector," CSIRO Oceans and Atmosphere project lead, Dr Mark Hemer, said.

AMC project lead, A/Prof. Irene Penesis, said both projects sought to understand the downstream impact of wave-energy farms on the shoreline and marine environment. Very limited modelling work has been completed worldwide and results have never before been validated with physical experiments.

Dr Mark Hemer (CSIRO), A/Prof. Richard Manasseh (Swinburne University of Technology) and A/Prof. Irene Penesis (Australian Maritime College) in the model test basin with a wave energy device model
(Photo courtesy AMC)



The devices were tested under a range of wave conditions generated within the model test basin.
The model wave-energy devices are located beneath the surface
(Photo courtesy AMC)

"No-one really understands the impact that an array of devices will have further downstream," A/Prof. Penesis said

"When you have more than one device located near shore, each of those devices will capture energy from the waves and convert it into mechanical and electrical power. But in doing that, we're taking energy away from the nearby system and the environment — so we need to understand what happens when we take that energy out of the waves.

"What impact does this have on our nearby shorelines and how long does it take for those waves to recover to the shore? How does it affect the marine environment and things like fish spawning patterns? These are the questions we are aiming to answer, in addition to how much power can be generated from the devices."

New Directors at AMC

The Australian Maritime College at the University of Tasmania has appointed two new senior executives to oversee the direction of its maritime engineering and ports and shipping departments.

Prof. Athanasios (Thanasis) Karlis has been appointed Director, National Centre for Ports and Shipping and joins the college from Greece, where he most recently held management positions with the Port of Piraeus and the Business College of Athens.

Michael Woodward joined AMC as A/Prof. of Marine Engineering and is also working in the post of Director, National Centre for Maritime Engineering and Hydrodynamics, after spending almost 20 years working in the same field at Newcastle University in the United Kingdom.

The duo's primary focus will be ensuring that AMC's teaching and research programs remain relevant and responsive to industry needs, as well as identifying opportunities to expand its product offerings.

A/Prof. Woodward sees the challenge of operating vessels in harsh environments like Antarctica as an area of potential growth — from the design of ships which can operate safely in such an extreme and isolated environment through to the questions of how best to respond to emergency situations.

He also believes that AMC is in a unique position to address some of the topical issues in emerging fields such as deep-ocean mining, marine renewable energy and ship design informed by operational simulation.

"We have expertise in the hydrodynamics and the operation of ships, deployment of subsea technologies and autonomous underwater vehicles. In addition, by working in collaboration with other University of Tasmania research groups, we have the ability to ensure that development is considered in a way that is sensitive to vulnerable ecosystems," A/Prof.Woodward said.

"It's my firm belief that, when designing a marine vehicle to perform in a certain way, you must ensure it's possible to simulate that behaviour, that you have the capacity to train people to exploit the design advantages, and that you understand how it will be used in reality. Working hand-in-hand with our partners in Ports and Shipping puts us in a unique position to do exactlythis."

Prof. Karlis sees improved logistics as the most vital building block to encouraging economic growth at both state and national level.

"For Australia, logistics is a must. Due to the sheer distances you need to travel to get from one point to another, and because we are geographically isolated from the rest of the world, we need to apply logistics in order to cut down prices," he said.

"Competitive prices depend on logistics and cost-effective transportation systems. So having reliable, cheap, constant connections is very important and this is an area that we need to focus on."

Prof. Karlis said that the AMC is well positioned to provide expert analysis on policy matters, such as the debate around cabotage laws for foreign-flagged vessels, and to offer reliable research and information to help inform the decision-making process.

The Australian Maritime College's new senior executive appointments, National Centre for Maritime Engineering and Hydrodynamics Director, Michael Woodward, and National Centre for Ports and Shipping Director, Thanasis Karlis, (Photo courtesy AMC)

He plans to further build connections with industry, both locally and internationally, and expand training in the logistics, shipping and cruisesectors.

"South-East Asia and the Oceania area is a focus for cruise companies now, so we need to concentrate on developing port operations training which meets the needs of the cruise sector. Australian ports are already very good at handling large quantities of bulk cargoes, but there is scope to further develop the logistics needed to process 5000 passengers disembarking off a cruise ship at once," he said.

In the research space, Prof. Karlis said that the work which AMC has done on the holistic approach of handling unmanned ships will continue to be very topical as the industry progresses towards the future.

"Eventually all ships and all modes of transport will minimise or even eliminate crew or staff on board, so it is pleasing to see that AMC has already advanced research on the subject and we need to boost that," he said.

"Even an autonomous ship has to interface with human control somewhere along the voyage. Human factors do not vanish, they move to other points of the link.

Experience from the US Air Force shows that unmanned platforms still engage teams of between 150 and 300 people, and the same principle applies for handling unmanned ships. Human, legal and environmental impacts need to be included in the development of these vessels to ensure efficient and safe operations."

University of New South Wales

Student–Staff Get-together

The naval architecture students and staff held a get-together on Tuesday 15 March. This was to enable the students in early years to meet and get to know the final-year and post-graduate students and the staff on a social level, and to discuss the stream and matters of mutual interest. Pizza, chicken, beers, wine and soft-drink were provided and, after a slow start, conversation was flowing pretty freely an hour later! This year we have four students in the third year, about fifteen in fourth year (some expecting to complete in mid-year), and eleven study-abroad students, about half of whom attended as well as four full-time staff. A broad mix, and some wide-ranging discussions ensued.

Student Visits to Industry

The Year 3 students in NAVL3610 Ship Hydrostatics and Practice have continued the usual industry visits accompanied by David Lyons and Phil Helmore:

- On 15 March we visited Incat Crowther at Belrose, where Brett Crowther gave us in introduction to the company (the largest naval architectural consultancy in Australia, with offices now in the USA and the UK), the vessels which they design, and some of the problems which they have encountered and how they have dealt with them. Sam Foster then gave a presentation on the more-technical details of some of their designs, and how they go about the various tasks and analyses.
- On 22 March we visited One2three Naval Architects on board *Ocean Flyer* berthed at the Fish Markets in Blackwattle Bay. *Ocean Flyer* is one of the two 33 m 375 passenger vessels designed for Manly Fast Ferries by One2three and built by Incat Tasmania in Hobart.

Rob Tulk, Senior Naval Architect at One2three, gave the students a presentation on the vessels which they design, some of the problems, how they go about it, and some of the skills required in a graduate naval architect. Rob followed this with a tour of the vessel, pointing out features and design points.

- On 6 April we visited Thales Australia at Garden Island. Murray Makin, Naval Architect Support Manager, gave the students a presentation in the Drawing Office on Thales Australia and the work which they do, both at Garden Island by way of ship repair and refit, and worldwide in the electronics field. Sue-Ellen Jahshan, Naval Architect, then guided us on a tour of the dock where FFGs HMAS *Newcastle* and the decommissioned *Sydney* were docked side-by-side, and pointed out features of the dock and the underwater hulls. Sue followed this with a tour of the pump house (where the three main pumps for the dock are housed and dock flooding and pumping are controlled), and the galleries which surround the dock for provision of services and maintenance.

The visits to industry bring all the theory alive for the students.

Phil Helmore

Thesis Projects

Among the interesting undergraduate thesis projects under way are the following:

Fire Safety of Composite Materials in HSC

After several decades of use in high speed craft, composite materials still have limited application in the majority of high-speed craft due to regulatory requirements.

Samuel Free is investigating the latest materials, and methods to overcome any actual deficiencies.

Reducing the Discharge rate of Smartphone Batteries

Battery capacity in smartphones is crucial to their daily utility, and reducing their discharge rate can provide substantial benefits.

Alfred Ong is investigating methods of harvesting the kinetic energy of the phone in the user's pocket during daily activity to provide input to the battery. Methods are being investigated by way of experimentation and analysis.

David Lyons

Post-graduate and Other News

New Head of School

Our current Head of School, Prof. Anne Simmons, completed her tenure at the end of her current term on 30 April. She has been one of the strongest Heads of School at UNSW and has transformed MME. She has taken the School through a challenging period of renewal and simultaneously overseen the School during its major building renovation. The fruits of this effort by the School are exemplified in recent significant rises in research income and grant success, and the move back into the most-modern teaching and research facility in the Faculty. The School is now growing impressively. The hunt is therefore on for a new Head of School for Mechanical and Manufacturing Engineering.

In the interim, A/Prof. Con Doolan is Acting Head of School. He came to UNSW in January 2015 having been Director of Research in the School of Mechanical Engineering at the University of Adelaide, and a Research Scientist at the Defence Science and technology Organisation. His main field is in aerospace engineering.

In March and April we were visited by three of the candidates for the position of new Head of School to assist them in gaining an understanding of the School and UNSW, and for staff to meet and consider them as a future HoS. Each made presentations to the staff on their careers to date and their vision for the School, with comments invited by the Dean, Prof. Mark Hoffman. They are

- Prof. Jang-Kyo Kim: He is currently Chair Professor of the Department of Mechanical and Aerospace Engineering and Technology, and Director of the Finetex-HKUST Research and Development Centre, at the Hong Kong University of Science and Technology in Hong Kong.
- Prof. Jivka Ovtcharova: She is currently Director of the Institute for Information Management in Engineering (Mechanical and Electrical Engineering Research Division) and Founder and Manager of the Lifecycle Engineering Solutions Centre and Industry Collaboration Laboratory, at Karlsruhe Institute of Technology in Germany.
- Prof. Chun-Hui Wang: He is currently Director of the Sir Lawrence Wackett Aerospace Research Centre and Professor of Aerospace Engineering in the School of Engineering at RMIT University in Melbourne.

For the successful candidate, watch this space!

Phil Helmore

Series of Overseas Seminars Presented by Em/ Prof. Lawrence Doctors

During his recent trip to the USA, Lawry Doctors presented five seminars at technical institutions on his recent research work. The details of these talks are:

1. *A Study of Disparate Ship Types* at Webb Institute of Naval Architecture, Glen Cove, New York, on 14 March.
2. *Hydrodynamics of High-Performance Marine Vessels* at SNAME (New York Metropolitan Section), the American Society of Naval Engineers (New York Section), IMarEST and the Society of Marine Port Engineers, New York, on 16 March.

   Following this presentation, Lawry was presented with a Certificate of Recognition by Prof. John Daidola on behalf of ASNE.
3. *Hydrodynamics of High-Performance Marine Vessels* at the Naval Surface Warfare Center, West Bethesda, Maryland, on 24 March.
4. *Some Studies of Novel Planing Boats* at the Department of Naval Architecture and Ocean Engineering, United States Naval Academy, Annapolis, Maryland, on 28 March.
5. *Unsteady Effects in Ship Resistance and Wave Generation on Ship Models in Towing Tanks* at the Department of Naval Architecture and Marine Engineering, University of Michigan, Ann Arbor, Michigan, on 31 March.

Thirty-First International Workshop on Water Waves and Floating Bodies

On this occasion, this prestigious yearly workshop took place in Plymouth, Michigan, USA, on 3–6 April 2016. A large total of 54 papers was presented at the 31IWWWFB on all topics associated with water waves. Many of the papers were devoted to the matter of wave interaction with floating structures. However, some of the papers dealt with waves generated by ships and the influence of waves upon ships.

It is thought that there was a record attendance. There were four presentations by five Australian researchers, which is very impressive. The Australian contributions were:

1. L.J. Doctors (UNSW Australia), *The Raked-Wedge Hull: A Severe Test of Linear Wave-Making Theory.*
2. M.H. Meylan (University of Newcastle) and H. Wolgamot (University of Western Australia), *Symmetry in Multiple Body Calculations*.
3. D. Skene (University of Adelaide), L. Bennetts (University of Adelaide), M. Meylan (University of Newcastle), M. Wright (University of Michigan), and K. Maki (University of Michigan), *Comparison of Mathematical and CFD Models of Overwash of a Step.*
4. W. Zhao (University of Western Australia), H. Wolgamot (University of Western Australia), R. Eatock Taylor (University of Oxford), and P. H. Taylor, (University of Oxford), *Nonlinear Harmonics in the Roll Motion of a Moored Barge Coupled to Sloshing in Partially Filled Spherical Tanks.*

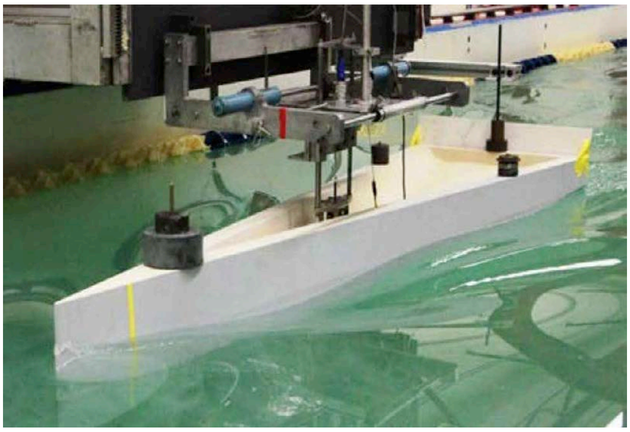
Figure 1 is a photograph of the unusual wedge hull which was the subject of the investigation by Em/Prof. Lawry Doctors, while Figure 2 is a computer representation of the same hull. A comparison of the resistance data from theory and experiment is plotted in Figure 3, for just one selected location of the longitudinal centre of gravity. The resistance data has all been rendered dimensionless by the use of the weight of the vessel. There are two sets of experimental data, measured at the US Naval Academy and at the Stevens Institute of Technology, respectively. Good agreement between these two sets of experimental data is demonstrated. With respect to the theoretical predictions, the short-dashed curve shows the wave resistance, the dotted curve is the transom resistance (negligible in this case), and the intermediate-length-dashed curve is the frictional resistance based on the ITTC 1957 correlation line.

The long-dashed curve is the simple sum of these three resistance components and provides an approximation to the total resistance; this simple sum falls a little short of the experimental data—an outcome in accordance with all previous research on the subject of ship resistance. Finally, the selection of a frictional form factor of 1.24 provides excellent agreement between the continuous (theoretical) curve and the experiments. The factor of 1.24 is considered to be reasonable in view of the fact that the relatively sharp bilges must substantially raise the viscous drag of the model. Figure 4 shows a comparison of the total resistance for all four positions of the longitudinal centre of gravity. It is gratifying that the small increase in total resistance (as the centre of gravity is shifted forward) is predicted by the analytic theory.

All of the papers are now available on the dedicated website www.iwwwfb.org. Indeed, the papers from the proceedings of all previous workshops have already been uploaded to this website, thereby providing a most useful and beneficial tool for naval architects and ocean engineers.

The Thirty-Second International Workshop on Water Waves and Floating Bodies is scheduled to take place in Dalian, China, on 23–26 April 2017. Further details will be available on the same website. Information may also be obtained from Em/Prof. Doctors at l.doctors@unsw.edu.au.

Lawrence Doctors



Wedge Hull in Small Towing Tank at US Naval Academy
(Photo courtesy Lawry Doctors)

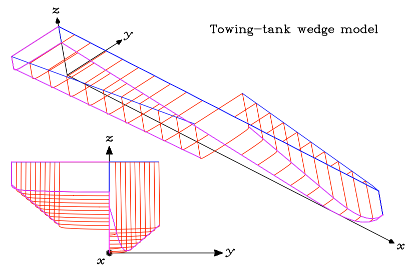


Figure 2: Computer Representation of Wedge Model
(Figure courtesy Lawry Doctors)

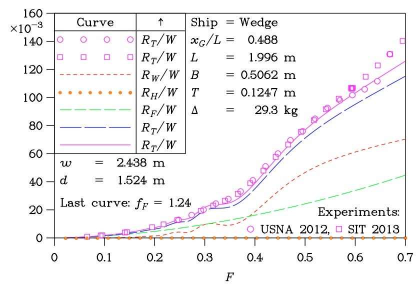


Figure 3: Resistance Components for Aft Location of LCG
(Figure courtesy Lawry Doctors)

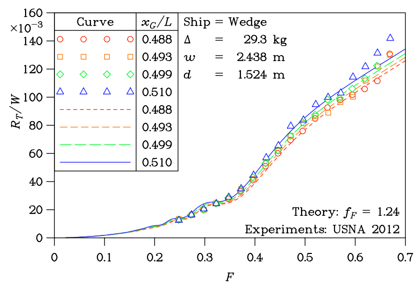


Figure 4: Comparison of Resistance for all LCG Locations
(Figure courtesy Lawry Doctors)

Centre for Defence Industry Capability

On 8 March the Prime Minister, the Hon. Malcolm Turnbull MP, the Minister for Defence, Senator the Hon. Marise Payne, and the Minister for Industry, Innovation and Science, the Hon. Christopher Pyne MP, announced that the new Centre for Defence Industry Capability (CDIC) will be headquartered in Adelaide.

The headquarters will both foster and drive innovation in the defence industry right across Australia and open up export opportunities.

A key initiative of the 2016 Defence White Paper, the CDIC will bring together the private sector, Defence and AusIndustry to transform the relationship between Defence and industry to help deliver the cutting-edge capability which Australia's armed forces need.

It represents a ten-year, $230 million investment which will create more jobs and drive growth in Adelaide and across the country.

The CDIC will work with small-to-medium enterprises across Australia to promote defence industry competitiveness and guide the priorities across defence industry.

The Centre will also offer a range of advisory services including mentoring, defence market access, export facilitation and global supply chain development.

In addition to its Adelaide headquarters, the Centre will have a network of advisors in key locations across Australia to engage directly with industry.

Led by an advisory board comprising senior members of industry and Defence, the CDIC will commence operations in the second half of 2016 and receive $230 million in funding over the next decade.

More information can be found at www.business.gov.au/CDIC.

Cairncross Dock for Sale

Australia's second-largest graving dock, along with 14 hectares of riverfront land on the Brisbane River, has been offered for sale. Owned by Forgacs since 2000, the dock was closed nearly two years ago. With the acquisition of the Forgacs name and the Forgacs Tomago shipyard by Civmec earlier this year [see *The ANA*, Vol. 20 No. 1, p. 42], the vendor of the Brisbane site is Cairncross Quays.

Whilst the land has not yet been rezoned for development, changes are expected which could value the land as a redevelopment site at about $100 million.

Cairncross Dock was built during World War II and was opened in September 1944. The dock has a length of 244 m, width at sill level of 33.5 m and a depth of 14.3 m. The dock was modernised between 1970 and 1976, but it was closed in 1987. Sold to Keppel Cairncross Shipyard, the dockyard was further improved and the dock reopened in August 1995. It was subsequently acquired by Forgacs but it was closed again on 4 July 2014.

Rolls Royce Diesel Generators for Type 26 Frigates

BAE Systems, the company responsible for UK's Type 26 Global Combat Ship program, has awarded an equipment contract to Rolls-Royce to manufacture diesel generators for the first three Type 26 frigates. The Type 26 has been short listed as a potential contender for Australia's future frigate program

This contract is the first Type 26 manufacturing contract to be agreed since the UK Ministry of Defence announced a £472 million contract extension in March 2016 to progress the Type 26 program.

An impression of the Type 26 frigate
(Image courtesy BAE Systems)

Rolls-Royce has previously constructed their MT30 gas turbine for the new ships. The company announced in January 2016 that the turbine passed the factory-acceptance test at the Rolls-Royce test facility in Bristol, UK.

Each Type 26 ship will require four of the MTU diesel generators based on the 20-cylinder MTU Series 4000 engines, which will provide a low-emission solution to the ships' electrical supply and slow-speed propulsion. Each generator set will deliver approximately 3 MW of generated power. MTU is a subsidiary of Rolls-Royce and is one of the leading manufacturers of large diesel engines and complete propulsion and drive systems for marine applications.

Knut Müller, Head of MTU Governmental Business, said "The Type 26 Global Combat Ship is the first newly-designed Royal Navy surface vessel to be equipped with MTU engines and the fact that we are involved in such a leading-edge project fills us with great pride."

It is the first time Rolls-Royce has supplied a naval vessel with an MTU propulsion system which meets the requirements of the IMO Tier III emissions directive. To achieve this, each of the four engines on the vessels will be fitted with an exhaust after treatment system, which uses a Selective Catalytic Converter unit to neutralise nitrogen oxide emissions.

The generator sets are bedded on specialist mounts and surrounded by an acoustic enclosure, ensuring that the propulsion system operates at low noise levels.

The UK Government committed to buy eight of the advanced anti-submarine warfare ships in its recent Strategic Defence and Security Review. The programme is set to replace the thirteen older Type 23 frigates of the Royal Navy.

In March 2010 BAE Systems was awarded a four-year contract to develop the Type 26 Global Combat Ship. The first Type 26 ship is expected to be delivered in 2022 and the Royal Navy expects the ships to remain in service beyond 2050s.

HydroComp PropExpert® 2016 Released

Employed by more than 250 professionals in over 40 countries, HydroComp PropExpert is the industry's most widely-used propeller-sizing tool for inboard-driven workboats and pleasure craft. PropExpert was developed to provide a reliable technical tool for the propeller sales process. It is used for application sizing and performance assessment by manufacturers and distributors of marine propellers, engines and transmissions. The 2016 release of PropExpert offers new propeller styles, an updated towing analysis, and improvements for fast high-pitch applications.

New MAU-type Propeller

A popular style of propeller in Asia for many years, the MAU propeller — and its MAUw variant with pressure-side "washback" — is now available in PropExpert. Similar in character to the B Series propeller (of European origin), the MAU is generally used for commercial, workboat, and motor yacht applications. The series supports propellers with three to six blades and a broad range of blade area and pitch ratios.

Supporting the performance prediction of the MAU in PropExpert is the corresponding new geometric models for both the MAU and MAUw propellers in the HydroComp PropCad® geometric modeling software.

Prediction Accuracy for High-pitch Applications

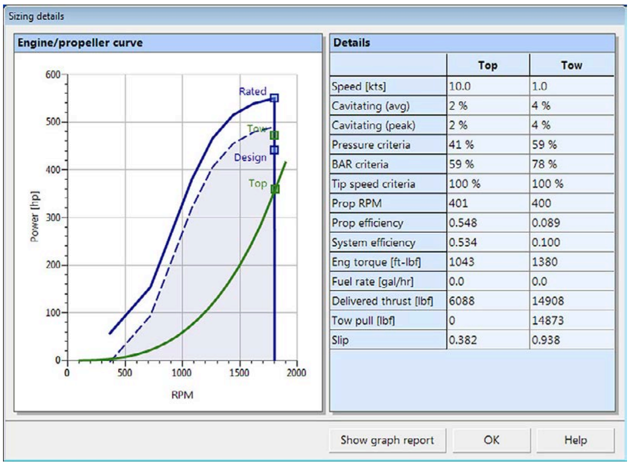
HydroComp has an active in-house research-and-development program to advance the accuracy of HydroComp's software products. One recent project improved the prediction of thrust and power for high-BAR Gawn-style propellers. A new R&D project of similar purpose now gives PropExpert the ability to reliably handle propellers with a pitch-to-diameter ratio as high as 2.0, expanding the applicability of PropExpert to very high-pitch propellers. Prior to this new development, a P/D of 1.4 to 1.6 was considered the reasonable limit of well-behaved performance for the Gawn, AEW and B Series propellers.

Towing Analysis

A major reconstruction of the towing analysis module in PropExpert now provides users with improved accuracy and ease-of-use for the prediction of top speed for a towing service. A prediction of towing pull is conducted for the user-selected towing speed, and a separate solution of top speed is performed. This allows users the ability to quickly assess the implication of a propeller sizing on both tow-pull and attainable top speed.

The screenshot below illustrates an engine power curve (with a parasitic power deduction), along with a speed-power curve and RPM-Power points for the propeller compromise design point, towing pull condition (Tow), and the selected top speed (Top).

For more information visit www.hydrocomp.com.



Sizing and analysis details summary [Towing]
(Image courtesy HydroComp)

Comprehensive Scope of Wärtsilä Solutions for New Cruise Vessels

Two new cruise vessels being built for USA-based Seabourn Cruise Line will feature a broad assortment of Wärtsilä propulsion, electrical and automation solutions. The ships are to be built at the Fincantieri yard in Italy. *Seabourn Encore* is already under construction and *Seabourn Ovation* is scheduled to join the Seabourn fleet in 2018. The contracts with Wärtsilä for the vessels' navigation and automation systems were signed in December 2015. The engine orders were signed in late 2014 and in the third quarter of 2015.

The comprehensive range of Wärtsilä navigation, automation and sensor systems to be installed on these vessels includes the Wärtsilä Nacos Platinum and Wärtsilä Valmatic Platinum systems. Wärtsilä will also deliver consoles for the bridge and engine control room, including a video wall. Also to be delivered by Wärtsilä is a tank-level and flood-detection system, as well as the valve remote controls.

The scope of supply also includes a complete Wärtsilä electrical propulsion system. For each of the vessels, Wärtsilä will supply four Wärtsilä 32 engines. The ships will be fitted with two 6 MW, low-noise diesel-electric propulsion units featuring a combination of innovative frequency-converter design and redundant layouts. Wärtsilä will also supply four thruster drives for the bow and stern, four diesel alternators, four AC motors for the thrusters, two dedicated 6.6 kV switchboards for high-voltage distribution, and four transformers for low-voltage mains supply.

"Modern cruise vessels are highly complex with unique operational requirements, and Wärtsilä has developed its technologies accordingly to meet these demanding requirements. We are, therefore, extremely pleased to have been once again chosen to provide our state-of-the-art systems for an important cruise vessel operator," said Maik Stoevhase, Director, Automation, Navigation and Control, Wärtsilä Marine Solutions.

The Wärtsilä Nacos Platinum solution integrates all navigation and automation system controls into a single system which enables the vessel to be navigated, controlled, and monitored from various onboard positions. The truly multi-functional work stations provide combined displays of radar, ECDIS (Electronic Chart Display and Information System) and conning information, as well

Two new cruise vessels being built for USA-based Seabourn Cruise Line will feature a broad assortment of Wärtsilä propulsion, electrical and automation solutions
(Image courtesy Wärtsilä)

as automatic steering and voyage-planning operations. Additionally, and on a similar product platform, the Wärtsilä Valmatic Platinum integrated automation system controls all onboard machinery, with added capabilities for vessel power management and integrated management. Complete management control is maintained via a dedicated communications network connected to multi-purpose work stations in the engine control room and on the bridge.

Wärtsilä 'Singing' Propeller Research Project

A joint research project carried out by Wärtsilä and City University London has succeeded in identifying the specific design parameters which create the risk of 'singing' propellers. Though rare, 'singing' is nevertheless an annoying problem which occurs as a strong tonal noise originating from the propeller, thus causing a negative effect on onboard comfort levels. The research programme reached its conclusions in December 2015.

The problem has long been recognised in the marine industry. While the general perception has been that the frequency of the propeller blades' vibration mode coincides with the frequency of the hydrodynamic excitation forces at the trailing edge of the blades, the current research indicates that there is more complexity and sensitiveness to this hypothesis.

"Our research has shown that the 'singing' phenomenon can be controlled by selecting the proper main parameters of the propeller blades, by careful attention to the flexural modes of the propeller blades, and by careful attention to the specific geometry at the trailing edge of the blades. It has shown that all these aspects interact and can prevent the 'singing' of propellers," said Arto Lehtinen, Vice President, Propulsion, Wärtsilä Marine Solutions.

Finite element method analysis tools have been used in identifying the risk indicators related to the main propeller design parameters. By correctly adjusting these parameters, the response-side risks can be minimised. Similarly, computational fluid dynamic (CFD) technology was used to analyse the vortex-shedding behaviour of the trailing-edge design. The results indicate that proper design of the trailing-edge details reduces the shedding and, therefore, also the excitation forces. Wärtsilä has used CFD in its hydrodynamic design processes for some 20 years.

Vessels at risk for 'singing' are identified in the design process. Along with the existing Wärtsilä propeller design features, notably optimum efficiency, strength, and limited cavitation and pressure pulses, the avoidance of 'singing' has now been added as a standard Wärtsilä design feature. Furthermore, the findings from the research project have been incorporated into the company's OPTI-Design, which was introduced as a new state-of-the-art design concept in 2014. That design offers fuel savings of up to 4 per cent and highly-reliable full-scale performance predictions.

Wärtsilä Ship Design Chosen for Offshore Maintenance Vessel

Wärtsilä has been awarded the contract to provide the design for a new jack-up lift vessel. The contract was signed in March with a well-known Chinese yard and there is an option for three more vessels. The Wärtsilä design was developed in collaboration with Altis, a consultancy company specialising in the lift-boat market.

Wärtsilä Ship Design has considerable experience in designing offshore and specialised vessels, and its selection for the design of a new, next generation, lift vessel is considered an acknowledgement of the company's strong track record. Lift vessels are self-propelled and provide an offshore elevating platform with manoeuvring capabilities to support various operations, including oil-well intervention activities, and the maintenance, repairs, upgrades and removal of offshore rigs. This latest Wärtsilä design provides better performance compared to conventional designs. In particular, its crane capacity, MLC (Maritime Labour Convention) compliance, accommodation, operational water depth, and DP2 (dynamic positioning) are all areas where improvements have been made.

"Wärtsilä was chosen to design this new series of vessels because of our expertise, as well as our strong track record in the offshore market. Furthermore, our global engineering and project-development services mean that we can be a valuable local partner to both the yard and the owner," said Riku-Pekka Hägg, Vice President, Ship Design, Wärtsilä Marine Solutions.

The 70.5 m long vessel can accommodate 250 people and will be capable of operating in water depths of up to 75 m. It is scheduled for delivery to the customer in September 2017.

Wärtsilä Gas Solution for Canadian Ferries

Wärtsilä has been awarded the contract by Gdansk Shiprepair Yard Remontowa S.A. to supply a comprehensive scope of engines, propulsion machinery, integrated automation systems, and gas-handling systems required for the mid-life upgrading of two ro-pax ferries and their conversion to operate on LNG fuel. The ferries, *Spirit of British Columbia* and *Spirit of Vancouver*, are the flagship vessels of British Columbia Ferry Services based in Victoria, Canada. The work will be carried by the Remontowa Shiprepair yard in Poland. The contract with Wärtsilä was placed in March 2016.

The work on the first of these ships will be carried out during the 2017–18 winter season, and during the following winter season for the second vessel. This means that the time allowed for completing the work is just seven months, including a delivery voyage of more than one month each way. This demanding schedule requires excellent logistics and integrated planning between Wärtsilä and the shipyard. The Wärtsilä equipment will be delivered to the shipyard in mid-2017 and mid-2018 prior to the arrival of the vessels.

The complexity of this project required intensive preparations between Wärtsilä and Remontowa, as well as detailed LNG feasibility studies. The full scope of Wärtsilä's supply includes four Wärtsilä 34DF dual-fuel engines with fuel gas systems, integrated automation systems and power-management systems, the Wärtsilä Pro-Touch propulsion-control system, the power transmission systems comprising two gearboxes, the Wärtsilä LNGPac comprising the fuel storage tank, bunkering station, gas-detection system and process-control automation, Wärtsilä rudders, site representation and integration engineering, and crew training. The upgrading work will involve surveying the stern tube and renewing components, surveying and overhauling the controllable pitch propeller (CPP) hubs, redesigning and renewing the CPP propeller blades, surveying, renewing and overhauling the oil distribution boxes, and renewing two bow thrusters and E motors.

In December 2014, Wärtsilä was contracted to supply the dual-fuel machinery for three new ferries being built at the Remontowa yard on behalf of British Columbia Ferry Services.

Wärtsilä has been awarded a comprehensive scope of supply to convert the two RoPax ferries for BC Ferries for LNG operation (Image courtesy Wärtsilä)

THE PROFESSION

Changes to MARPOL Annex VI

A number of amendments to MARPOL Annex VI (published as IMO Resolution MEPC.258(67) will enter into force on 1 March 2016. These include:

- changes to the definitions of 'fuel oil' and 'marine diesel engine';
- minor amendments to Regulation 13.7; and
- changes to the format of sections 2.2.1 and 2.5.1 of the Supplement to the International Air Pollution Prevention Certificate (IAPP Record of Construction and Equipment).

Impact of the new definitions on NOx Technical Code certification

The changes to the definitions mean that gas-fuelled engines installed on ships constructed (keel laid) on or after 1 March 2016, or gas-fuelled additional or non-identical replacement engines installed on or after that date, require NOx Technical Code certification. Dual-fuelled engines were already required to have NOx Technical Code certification.

New format IAPP Record of Construction and Equipment

The new format International Air Pollution Prevention (IAPP) Record of Construction and Equipment will be issued to existing vessels when the vessel's current IAPP certificate expires, as per the IMO guidance contained in circular MSC-MEPC.5/Circ.6. The IMO has issued guidelines, contained in circular MEPC.1/Circ.849, on how to complete it.

LR *Class News* No. 09/2016

The Future Naval Architect

What will the Naval Architect of the future look like?

Jesse Millar

Recently I was reminded, through my Professional Review Interview, that the role of the naval architect is not just to exercise core disciplines of naval architecture, but also to perform the role of systems engineer (as it was before it became a specialist discipline, and referred to herein as systems integrator to differentiate). Perhaps the most important function of a naval architect, is to integrate the engineering disciplines of naval architecture, with mechanical, electrical, and weapons engineering.

Ultimately, it is the naval architect who manages the design spiral and delivers assurance to the client that the product will meet performance specifications. We ensure that, throughout construction, structural and watertight integrity are maintained and that weights are as estimated, so that stability margins are maintained. The naval architect must then deliver a successful launching and co-ordinate trials so that, at handover, the client has what he has paid for and subsequently honours the agreed contractual payments.

This by no means implies that other disciplines are any less important. After all, a vessel would not be able to move, deliver power, or fight a war, if it were not for the highly-technically-skilled mechanical, electrical and weapons engineers. Arguably, these engineers are often more technically focused, with the naval architect performing a complementary communications role, in order to achieve systems integration.

The Naval Architect Offshore

The naval architect's systems integration skills are equally applicable in many other fields, and perhaps the most recent, wider application, is in the offshore industry. The move of naval architects across to the offshore industry is no more apparent than in Perth, where you will find a swing of the local RINA Section from having meetings close to the shipbuilding hub, in Fremantle, up to Perth where many of the major players in the oil and gas industry operate. Several of my class-mates moved across to the offshore field, taking advantage of increased opportunities and often achieving success as project engineers. To my mind, this highlights the naval architect's ability to view a project in a more holistic manner than perhaps another engineer could do. In addition to mechanical and electrical engineering skills, the naval architect in the offshore industry has also adapted to integrate other specialist disciplines such as ocean engineering, and marine and offshore engineering.

Looking at the recent Australian Oil and Gas Conference in Perth, the RINA component demonstrates other areas of experience which the naval architect has gained in this field which, from title alone, sees the naval architect's experience range from detailed FPSO design and analysis, to the wider survey and classification of offshore structures. Clearly, the naval architect has also adapted to specialisations within this field, but this evolution is inevitable. Undoubtedly the naval architect will continue to be valuable as the systems integrator for offshore systems, as is the case in the more-traditional industry of shipbuilding.

Designing for Support

With the recent economic downturn, there has been been a decrease in capital expenditure and a greater focus on through-life support at the design phase. In general, people are trying to "do more with less". One might argue that the government is bucking the trend with new acquisitions, but beneath this remains an underlying need to do more with a limited amount of resources ashore in support of the new capabilities.

Whilst elements of through-life support have always been considered, such as stability and corrosion margins, fatigue, paint schemes and rubbing plates, the ability to enable cost-effective management of these through-life design components has not always been achieved. In addition, the specification and application of the ideas around "designing for support" tended to be ignored, or overlooked, in favour of a lower capital cost.

Could it be that a ship with increased internal volume would improve through-life cost effectiveness, through improved machinery access and better removal routes? Whilst the fuel bill would be greater, this may be more than offset by reduced maintenance costs. Similarly, could improved remote analysis of structures, stability or propulsive efficiency, improve predictive maintenance and therefore decreased maintenance costs?

Given that naval architects are the integrators of design and construction, we must position ourselves at the forefront of through-life support. The aeronautical and rail industries have been improving their skills in through-life support for decades, but this is relatively immature in the maritime industry and we must somehow bring about change.

With the introduction of ISO55000, and the work which the Asset Management Council is doing with their Asset Management models, I would encourage all naval architects without exposure to formal asset-management training to consider a course. It may not introduce anything you don't know, but it does improve your ability to discuss through-life support aspects more clearly and reinforce the need to capture through-life support in designs, and handing over improved tools for management at acceptance.

The Future of Naval Architecture

There is little doubt that the naval architect will continue to assert his or her presence in areas which are not aligned with "traditional" skill areas. As such, we must continue to embrace these evolutionary skills and use them to promote the capabilities of the naval architect.

With increasing pressure on capital expenditure, there will be an ever-increasing need to ensure that through-life support aspects of new construction are better captured at design stages. At handover, the owner should have the tools needed to deliver assurance of continued performance, as well as enabling continuous improvement throughout the life cycle.

Given the naval architect's ability to act as the systems integrator, we should consider how we adapt and shape ourselves to maximise these skills as a ship, or other maritime platform, enters into service. Perhaps as the architects of the management systems, integrating logistic support artefacts and ensuring they are tied intimately with the operations?

Whatever it is, we must continue to look forward and ensure that all of our design efforts are effectively handed to the owner, and that the handover delivers systems, processes and tools which enable the owner to more effectively manage his asset throughout the whole of life cycle. This will inevitably come at an additional cost to the owner but, if we can understand the true value of benefits, it will enable the owner to be better informed on the tangible benefits.

In Defence, there is a push toward "maintaining design intent" which refers to the need to ensure that the original design intent is never lost and, although changes will inevitably occur, they can be traced back to the original design. This should forever be the key, throughout the whole of the life cycle with continuous improvement being the ultimate goal.

Jesse Millar is the Asset Management Lead at BMT Design & Technology, Vice President of RINA (Australian Division) and a Member of the Asset Management Council.

THE WALTER ATKINSON AWARD
A PRIZE FOR THE BEST WRITTEN PAPER PRESENTED TO A RINA FORUM IN AUSTRALIA

Are you thinking of presenting a paper at a conference in Australia or a RINA Section meeting? Have you already presented one this year? If it is a really good paper you may be eligible for the highly-prestigious Walter Atkinson Award.

The Walter Atkinson Award was established in 1971 and its aim is to raise the standard of technical papers presented to the naval architecture community in Australia.

The Award comprises three components:

- An engraved trophy or medal.
- A framed certificate for each author.
- Free entry to the event at which the award is to be presented.

The Award will be presented by the President of the Australian Division (or their nominee).

A nomination must be a written paper, first presented either at a RINA Section meeting or RINA-supported conference in Australia, or first published in a RINA-supported publication in Australia (e.g. *The ANA*).

Since the PACIFIC 2015 International Maritime Conference was held during the year, nominations may include written papers presented at that Conference or to Section meetings.

All authors are eligible – Australian or overseas, members or non-members. Papers by multiple authors are eligible. Visual presentations are not eligible unless they reflect the content of the presenter's written paper. Nominations of papers published in the period 1 July 2015 — 30 June 2016 must be received by the Secretary no later than 15 July 2016.

For further information or visit the Division page on the RINA web-site or contact the Secretary at:

Mail: PO Box 462, Jamison Centre, ACT 2614
email: rina.austdiv@optusnet.com.au
Phone: 0403 221 631

MEMBERSHIP

Australian Division Council

The Council of the Australian Division of RINA met on Wednesday 2 March 2016 by teleconference. As the meeting was Dr Tony Armstrong's last as President, on the day of the Division's AGM in Sydney, he chaired the meeting from Sydney.

Some of the more significant matters raised or discussed during the meeting are outlined as follows:

Appointment of Council Members for 2016–18

In accordance with the Division's By-laws, Council appointed Mark Devereaux (Qld), Sue-Ellen Jahshan (NSW), Karl Slater (Vic) and Kalevi Savolainen (WA) for the next two years as the nominees of their respective Sections. Nominations were still to be made by the ACT, Tasmania and SA–NT Sections, although Tom Dearling has subsequently been nominated by the ACT Section.

Noting that Jim Black was willing to continue to serve, Council appointed him to the vacancy arising from Dr Martin Renilson's election as President.

Australian Naval Shipbuilding and Repair Capability and Government Initiatives

As Council had been presented with a number of papers on this subject and needed to consider the outcome of the 2016 Defence White Paper, it referred these matters to the Naval Ship Group established at the March 2015 meeting. The Group was requested to make recommendations for action to the next meeting.

Notwithstanding this referral, the President was instructed to write to the Minister broadly welcoming the White Paper.

Possible Future Division Activities

Council expects a vision statement to emerge from the June meeting under Dr Renilson's Presidency to conclude discussions on this matter over the past year.

Financial Report

Council approved the audited accounts for calendar year 2015 for presentation to the AGM later in the day. It also approved minor adjustments to the Budget for the current year in accordance with discussions at the December Council meeting.

London Council Meeting

Council received a report on the outcome of the London Council meeting held on 9 February. While the main business of that meeting was to receive Committee reports and approve matters for consideration by the Institution's AGM in April, it was noteworthy that Tom Boardley of Lloyd's Register was elected as RINA's next President.

In relation to this, Council encouraged all members to include a profile of their interests with their membership details on "myRINA", so that they can be called upon to contribute their expertise to the new Committee structure expected to be finalised in June.

Joint Board on Naval Architecture

Noting that the Board had not met for some time and that the Division had a number of issues for it to address, Council undertook to arrange with Engineers Australia for the Board to meet before the next Division Council meeting.

Retiring President and Council Members

Council unanimously thanked Dr Tony Armstrong for the sterling work he had done during his Presidency. Dr Armstrong thanked retiring Council members for their contributions and service and invited them to consider serving again in future.

Next Meeting of Council

The next meeting of the Australian Division Council is scheduled for Wednesday 8 June 2016, tentatively at 1400 Eastern (1200 Western) Standard Time.

Rob Gehling
Secretary

55-year Membership Certificate

Prior to the technical presentation to RINA (NSW Section) and IMarEST (Sydney Branch) on 2 March, the Chair of the NSW Section, Alan Taylor, presented Noel Riley with a certificate for his fifty-five years of membership of RINA. Noel served his apprenticeship as a shipwright at Cockatoo Docks & Engineering Company, graduated with honours from the Naval Architecture Diploma program at Sydney Technical College, taught the Naval Architecture diploma program at Whyalla and two courses in the Naval Architecture degree stream at UNSW Australia. He was Eken and Doherty's first draftsman, before going to work for Alan Payne, formed the partnership Boulton, Riley and Hercus, and then his own company, Commercial Marine Design. He is a former President of the Australian Division of RINA.

Membership certificates commence at 45 years, are given more rarely at 50, and even more rarely at 55 years! Noel is now a member of a select club.

A number of former employees were present to congratulate Noel on his achievement.

Changed contact Details?

Have you changed your contact details within the last three months? If so, then now would be a good time to advise RINA of the change, so that you don't miss out on any of the Head Office publications, *The Australian Naval Architect*, or Section notices.

Please advise RINA London, *and* the Australian Division, *and* your local section:

RINA London		hq@rina.org.uk
Aust. Division		rina.austdiv@optusnet.com.au
Section	ACT	rinaact@gmail.com
	NSW	rinansw@gmail.com
	Qld	m-dever@hotmail.com
	SA/NT	danielle.hodge@defence.gov.au
	Tas	mfsymes@amc.edu.au
	Vic	siobhan.giles@dsto.defence.gov.au
	WA	rina.westaus@gmail.com

Phil Helmore

Registration as Registered Professional Engineer Queensland (RPEQ)

Professional Engineers in Queensland engaged in a professional engineering service must be registered under the *Professional Engineers Act 2002* (QLD), unless they work under the direct supervision of an RPEQ.

Assessment

A successful assessment of qualifications and competencies under Part 2 of the *Professional Engineers Act 2002* (Qld) is required before lodging an application with the Board of Professional Engineers Qld for registration as a Registered Professional Engineer of Queensland (RPEQ). Applicants must apply for assessment under an approved assessment scheme.

The Royal Institution of Naval Architects is approved as an Assessment Entity, i.e. authorised to assess applications for registration as RPEQ.

Following successful assessment, the Royal Institution of Naval Architects will issue a *Letter of Assessment* to be sent by the applicant to the Board of Professional Engineers QLD.

Requirements

Applications for registration as RPEQ will be assessed against the academic and professional competence requirements for Chartered Membership of the Institution, i.e. Member of the Royal Institution of Naval Architects (MRINA) and Chartered Engineer (CEng) with the Engineering Council of the UK. Applicants are not required to be members of the Institution.

The required academic qualification is a 4-year degree at BEng level or its equivalent, accredited by a signatory to the Washington Accord, or approved following individual assessment by the Institution.

Applicants are required to have achieved defined standards of professional competence in the fields of design, engineering practice and management.

Applicants are required to be currently practising naval architecture or a related engineering discipline at that level.

Application for Registration

Applicants for registration as RPEQ who are already Chartered members of the Institution are required to provide an updated Professional Review Report, detailing professional activities undertaken since gaining Chartered membership.

Non Chartered Members of the Institution

Applicants for registration as RPEQ who are not Chartered members of the Institution will be required to submit a Professional Review Report, detailing their academic achievement and professional activities since graduation. They will also be required to undertake a Professional Review Interview.

Applicants are required to submit certified photocopies of their academic qualifications. Applicants will be advised if individual assessment of academic qualifications is required, and the information to be submitted.

Successful applicants will not be elected as members of the Institution or registered with the Engineering Council, unless requested with their application. Appropriate membership and registration fees will then apply.

Application and more information

Queries and applications should be made to Membership@rina.org.uk.

THE INTERNET

Webcasts of NSW Section Technical Presentations

In 2011, Engineers Australia began recording selected technical presentations made to RINA (NSW Section) and IMarEST (Sydney Branch) for webcasting using Mediavisionz. The recordings were placed on the Engineers Australia website. All of the recorded webcasts up to 30 September 2014, together with hotlinks to each one, are listed at

www.rina.org.uk/NSWwebcasts.html.

In October 2014, Engineers Australia started using a new system for recording presentations, using three cameras and a hand-held microphone, with an audio technician in attendance. Webcasts were then placed on the Engineering on Line (EoL) website at www.engineeringonline.com. Our first presentation to be recorded with this new system was Graham Taylor's presentation on *LNG — The New Marine Fuel?* on 1 October, and the presentation is up on the EoL website at www.engineeringonline.com/video/xjkrsdrf/lng-the-new-marine-fuel. Details of how to access this recording were given in the February 2015 issue of *The Australian Naval Architect*.

However, in early 2015, Engineers Australia discontinued the new recording method and the EoL website for regular monthly presentations, and resumed using Mediavisionz while considering options for future recordings.

In 2015, only one recording of our presentations was made, of Warren "Skip" Miller's presentation on *Side Lifting Foils and Support Structure on* Wild Oats XI on 1 April, and the presentation is shown, with a hotlink, on the NSWwebcasts website.

In 2016, Engineers Australia discontinued recording presentations in the Harricks Auditorum. Recordings may still be made, but must be arranged and paid for by the society using the Auditorium. We are currently investigating options.

For future recordings, watch this space!

Phil Helmore

NAVAL ARCHITECTS ON THE MOVE

The recent moves of which we are aware are as follows:

Adam Brancher has moved on from the Australian Maritime Safety Authority and has taken up the position of Managing Director with Kedge, a growing marine survey company, in Tasmania. Friends can find out more at www.kedge.com.au.

James Gutherson continues consulting as BlueCOre Consulting and, after Spotless, spent some time with Western NSW Medicare Local and Marathon Health Australia as clients, and has now taken up the position of Compliance and Quality Officer with Housing Plus in Orange, NSW.

Jamie Howden has moved on from SO3 ME Systems and contracting to the Amphibious and Afloat Support Group, and has taken up the position of Engineering Operations Manager with Kellogg Brown and Root (KBR), working with the LHD Systems Program Office at Garden Island in Sydney.

Colin Johnson has moved on within BAE Systems Australia and has taken up the position of LHD Platform Engineering Manager in Melbourne.

Sean Johnston continues consulting as Commercial Marine Solutions in Melbourne.

Stephen Jones moved on from BAE Systems Australia in 2012 and has taken up the position of Equipment Maintenance Supervisor with Alcoa in Perth.

Scott Jutson has moved on from Mercator Studios and has taken up the position of CEO and Chief Designer of Jutson Marine Design in Vancouver, Canada.

Aneri Kaitara has moved on from Marine & Industrial Inspection (NZ) and has taken up the position of Marine Engineer with Farstad Shipping (Indian Pacific) in Wellington, New Zealand.

Tegan Kay moved on from JP Kenny in 2009 and, after some time at Technip and DOF Subsea, has taken up the position of Senior Installation Engineer with Technip Oceania in Perth.

Gerard Kenny moved on from Australian Marine Technologies in 2002 and, after some time with the Australian Department of Transport, Det Norske Veritas and Lloyd's Register, moved on to the Virgin Islands Shipping Registry in 2010, where he is now the Manager (UK) in London.

Chia How Khee has moved on within DNV GL and has taken up the position of Business Development Manager in Singapore.

Stephen Kretschmer moved on from Aquarius International Consultants in 2010 and, after some time at Woodside Energy and INPEX, took up the position of Lead Floatover Engineer with Chevron in Perth.

Antony Krokowski continues consulting as Aquamarine (Australia) in Brisbane.

Josh Lepine moved on from Austal Ships in 2007 and, after two years at Downey Engineering, returned to Austal Ships, where he has now taken up the position of Special Projects Manager in Mobile, AL, USA.

Constantine Ling has moved on within Bumi Armada and in 2012 took up the position of Senior Project Superintendent in Miri, Sarawak.

James Livesley moved on from the NT Department of Transport many moons ago and, after some time at DMS Maritime, Department of Defence and Baghwan Marine, has taken up the position of Project Manager (Defence) at AMW Professional Services in Darwin.

David Lugg has moved on from the WA Department of Transport and has taken up the position of Senior Naval Architect with the Australian Maritime Safety Authority in Perth.

Michael O'Connor completed his Erasmus Mundus master's degree program and, after a year-and-a-half at Piriou, has now taken up the position of Design Manager/Consultant with Naviculus in Nantes, France.

Simon Orr has moved on from Daya Offshore Constructions and has taken up the position of Engineering Manager with Cecon Contracting in Oslo. However, he has now taken six months' sabbatical leave from Cecon, and is sailing around the West Indies with a mate.

Dov Sobel, a graduand of UNSW Australia, has taken up a position as a naval architect at One2three Naval Architects in Sydney.

Peter Swain has moved on from Thales Australia and has taken up the position of Engineering Manager with Austal Ships in Fremantle.

This column is intended to keep everyone (and, in particular, the friends you only see occasionally) updated on where you have moved to. It consequently relies on input from everyone. Please advise the editors when you up-anchor and move on to bigger, better or brighter things, or if you know of a move anyone else has made in the last three months. It would also help if you would advise Robin Gehling when your mailing address changes to reduce the number of copies of *The Australian Naval Architect* emulating boomerangs.

Phil Helmore

THE AUSTRALIAN NAVAL ARCHITECT

Contributions from RINA members for
The Australian Naval Architect
are most welcome

Material can be sent by email or hard copy. Contributions sent by email can be in any common word-processor format, but please use a minimum of formatting — it all has to be removed or simplified before layout.

Photographs and figures should be sent as separate files (not embedded) with a minimum resolution of 200 dpi. A resolution of 300 dpi is preferred.

FROM THE ARCHIVES

A SPANISH CONNECTION

John Jeremy

When Cockatoo Dockyard was closed in 1992, one of the challenges faced during the decommissioning of the shipyard and dockyard, which had been operating for 134 years, was disposal of the enormous quantity of records, files and drawings which had accumulated over that period. All the most important material was preserved as a collection in the National Archives of Australia and it comprises one of the most complete records of an Australian industry of the nineteenth and twentieth century.

Many other documents were destroyed during the process but some, of historic interest but not apparently relevant to the history of Cockatoo Island, were nevertheless saved from destruction. One of those saved is a beautifully produced document commemorating the launching of the Spanish battleship *España* at Ferrol in north-western Spain on 5 February 1912. One hundred and four years later we can only speculate about how the document came to be in the records of Cockatoo Dockyard in Sydney, but its story does have links to Australian shipbuilding and even to the Royal Australian Navy.

España was the first of three battleships authorised to be built for the Spanish Navy by the Navy Law of 7 January 1908 which set out a plan for the reconstruction and modernisation of the Spanish Navy after the losses in the Spanish–American War of 1898. A Spanish company was established to construct these ships and others for the Spanish Navy at Ferrol, a port with a very long connection to the Spanish Navy dating back to 1730 when naval shipyards were established at Ferrol, Cartagena and San Fernando for the construction and repair of navy ships. Those shipyards became part of the new company, La Sociedad Española de Construcción Naval (SECN), which was 24.5% owned by the British shipbuilders Vickers, Armstrongs and John Brown. The remaining shares were held by a group of Spanish industrialists who were backed by the British companies Palmers Shipbuilding and Iron Company and William Beardmore and Company. Of these companies, Vickers and Armstrongs merged in October 1927 forming Vickers-Armstrongs Limited and Palmers became part of the Vickers group in the 1930s.

In the period leading up to the Navy Law of 1908, Vickers had proposed a design for a battleship armed with eight 12-inch (305 mm) guns and it became the basis of the

This 104-year-old souvenir of the launching of the Spanish battleship *España* was discovered when Cockatoo Dockyard was closed in 1992
(J C Jeremy collection)

requirements for a design competition. Subsequently SECN won the contract to build the ships on 14 April 1908. Due to economic constraints, the ships were the smallest dreadnought-type battleships ever built with a displacement of 15 700 t, an overall length of 140 m and a beam of 24 m. *España* was completed on 23 October 1913 and her sister ships, *Alfonso XIII* and *Jaime I*, were completed in 1915 and 1923 respectively, the last delayed by the impact of World War I on the supply of materials from Britain. *España* ran aground off Cape Tres Forcas on 23 August 1923 and became a total loss. *Alfonso XIII* was renamed *España* in 1931.

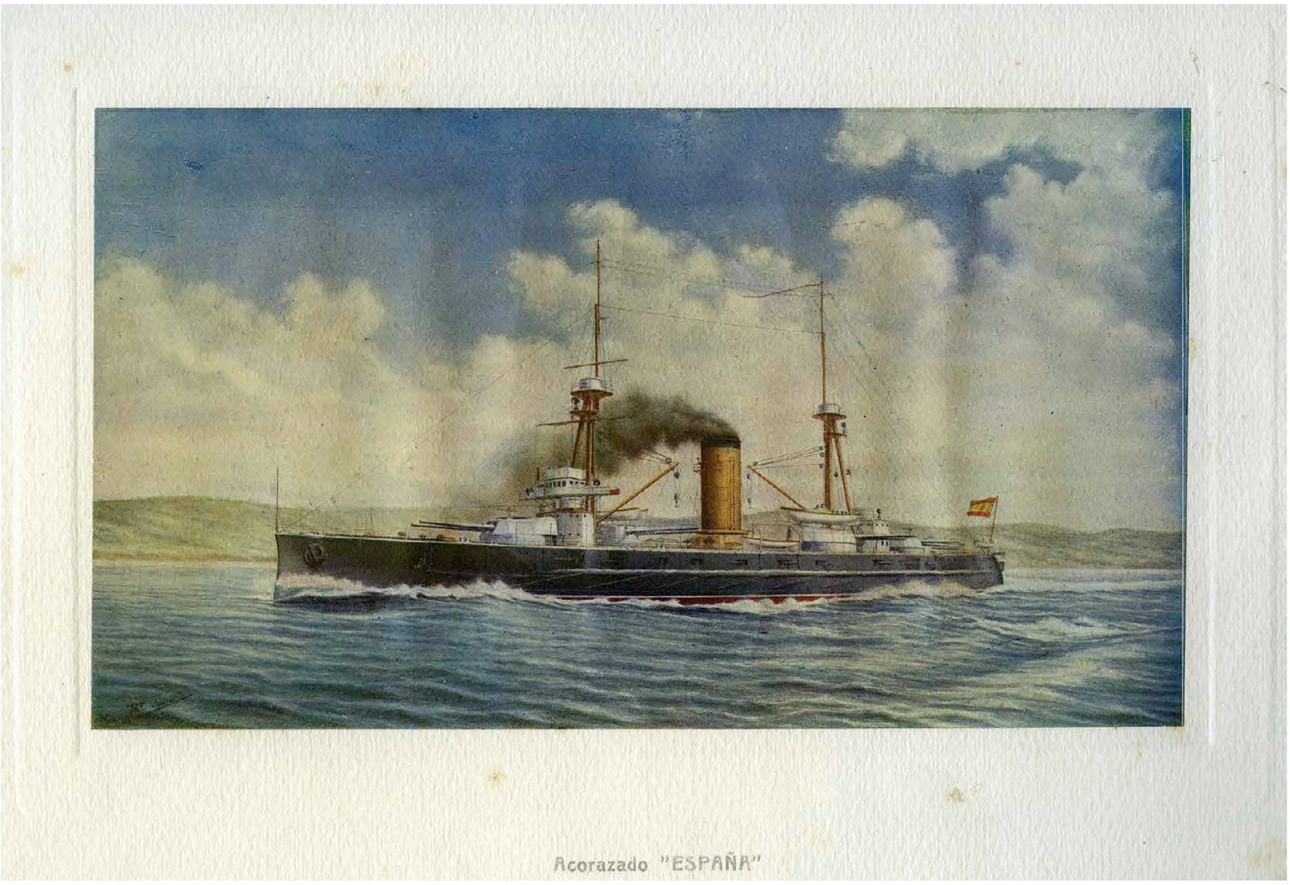
Meanwhile, in Australia, the new Royal Australian Navy was taking shape as the ships of the new navy were completed in Britain and construction of several more was begun at Cockatoo Island in Sydney by the NSW Government. Cockatoo Island was sold to the Commonwealth of Australia with the transfer completed on 31 January 1913 when the island became the Commonwealth Naval Dockyard, the first naval dockyard for the RAN.

A relationship between the Naval Dockyard and Vickers soon developed. The turbines and auxiliary machinery for the cruiser HMAS *Brisbane*, laid down at Cockatoo Island on 25 January 1913, were ordered from the Vickers shipbuilding and engineering works at Barrow in Furness in April that year, and a number of skilled tradesmen and technicians came from Barrow to supplement the Cockatoo Dockyard workforce. Australians were also sent to Barrow for training during World War I.

Amongst the Vickers people who made the move to Australia was John Wilson. Wilson had served his apprenticeship with Vickers at Barrow between 1901 and 1906. He then rose to be assistant chief of the technical department where he worked on many ships including battleships, battlecruisers and passenger liners. He came to Cockatoo Island in 1913 as Assistant Chief Ship Draughtsman. It is quite possible that he brought the *España* launching booklet with him — it was found in the ship drawing office files.

Wilson became Chief Ship Draughtsman in 1914 and Assistant Manager of the dockyard in 1922. He remained at the dockyard after the facility was leased to Cockatoo Docks & Engineering Company in 1933 as the General Manager, a position he held until he retired in 1952.

John Wilson when General Manager of Cockatoo Dockyard
(J C Jeremy collection)



An impression of *España* from the launching souvenir
(J C Jeremy collection)

Another page from the souvenir booklet
(J C Jeremy collection)

Vickers interests in Australia grew during the 1930s and the company acquired a shareholding in Cockatoo Docks & Engineering Company in 1937. Vickers bought the company outright in 1947 and it remained part of the Vickers group until the remaining Australian interests of Vickers were diluted in 1984 and finally sold in 1986. Cockatoo Dockyard's direct relationship with Vickers at Barrow in Furness had ended, however, when Vickers' shipbuilding and aircraft manufacturing businesses were nationalised in 1977.

In Spain, for many years, SECN had a monopoly on naval construction for the Spanish Navy. British shipbuilders continued to advise and work with SECN, even during the Spanish civil war. The Spanish government took control of the SECN facilities in 1936 on the outbreak of the civil war and Vickers' residual financial interest in SECN was not finally settled until 1943.

In 1947 the Spanish government created Empresa Nacional Bazán de Construcciónes Navales Militares (usually known as Bazán) to concentrate on naval shipbuilding. Commercial shipbuilding was undertaken by Astilleros Espanoles S. A. (AESA). The two companies were merged in December 2000 to form a combined entity, IZAR. In 2004 the European Union Commission ruled that €864 million of government aid which had been given to IZAR was not in line with EC state-aid rules and had to be recovered. With bankruptcy of IZAR likely, the Spanish government constituted a new company to rescue the naval shipbuilding activities of IZAR. The transfer of the naval business to this new company, Navantia, was completed in January 2005 and IZAR was put into liquidation the following April.

In October 2007 the Australian government signed a contract with Tenix Defence, in association with Navantia, for the construction of two LHDs for the RAN which subsequently became HMAS *Canberra* and HMAS *Adelaide*. The hulls of *Canberra* and *Adelaide* were constructed by Navantia at Ferrol in Spain.

In June 2008 Tenix Defence was acquired by BAE Systems Australia, which was responsible for the completion of the LHDs after they were delivered by heavy-lift ship to Williamstown in Victoria. BAE Systems Australia is a subsidiary of BAE Systems PLC, a major British company headquartered in London which was formed in 1999 by the merger of Marconi Electronic Systems (MES) and British Aerospace. It employs some 84 600 people worldwide, is one of the world's largest defence contractors, and is one of the sixth-largest suppliers to the US Department of Defence. One of the business units brought into the merged company by MES was the Barrow shipbuilding and engineering works which had been nationalised in 1977, later privatised as VSEL and acquired by MES. Today BAE Systems — Maritime specialises in the construction of submarines and is building the Astute-class nuclear submarines for the Royal Navy. Work on the design of the submarines to replace the RN's ballistic-missile submarines is also underway at Barrow.

Despite being apparently an oddity amongst the papers surviving from Cockatoo Dockyard, the 104-year-old launching brochure for *España* is strangely linked to Australia's shipbuilding industry of the 21st century and the modern Royal Australian Navy.

HMAS *Canberra* entering the water at Ferrol on 17 February 2011, almost a century after the launching of the battleship *España*
(RAN photograph)

HMAS *Adelaide's* embarked MRH-90 helicopter conducts a vertical replenishment transfer while one of *Adelaide's* landing craft conducts amphibious operations in Jervis Bay for their unit readiness evaluation (RAN photograph)